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Iuxtaperiosteal Implants. Evolutions and Revolutions in Severe Atrophic Jaws Implant-Prosthetic Rehabilitation

Emanuele Barbera[1], Amanda Lengo Gomez[2], Maria Diletta Gazzella[3], Zaira Pace[4] and Luca Barbera[*5]

[1]D.M.D, Odontoiatra, Degree at University of Milan, Italy

[2]D.M.D, Odontoiatra, Degree at Università Egas Moniz, Lisbona, Master in Medicina Estetica, Lisbona, Portougal.

[3]Dentistry and Dental Prosthodontics Student in Milano Bicocca University, Italy

[4]Oral Surgery Nurse and Cad Technician, Italy

[*5]Degree in Medicine & Surgery, University of Milan, Italy.

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***Corresponding Author:** Dr. Luca Barbera, Degree in Medicine & Surgery, University of Milan, Italy.

Abstract

Introduction: Iuxta-periosteal Implantology is a technique used in implant-prosthetic restorations for more than 70 years. Dahl from Sweden was the Surgeon who first reported scientific documentation in 1940. It consists of custom-made grids that exploit the architecture of the basal component of the maxillary or mandibular bone on whose surface are juxtaposed instead of penetrating the bone structure itself as is the case for traditional screwed implants. The mechanical resistance the masticatory load is ensured by the resilience offered by the bone architecture and by means osteosynthesis fixation screws that fix the structure to the site where they lay. It is indicated in the rehabilitation of severely atrophic bone bases, replacing the reconstruction-regenerative techniques necessary to allow the use of traditional endo-osseous implants.

Materials and Methods: We will report the most current techniques used for the design and production of these implants. We will illustrate the diagnostic flow from the acquisition to the preparation of the data used. We will show the surgical insertion technique, and last findings on of the immediately loaded prosthetic rehabilitation that follows.

Debating: Implant digital project is related to the jaw anatomy of the patient to be inserted. It is the result of a complex digital workflow that starts from the local bone anatomy leads to the drawing of both the implant and restoration.

Over the years, with the transition from analogical to digital methods, it has undergone changes and improvements in design, production and above all in the functional performance offered. The technique needs a medium-high level of prosthetic and surgical skills, and equally high digital design potentiality skills. Results and Clinical experience, in our clinical practice and as reported by the literature, are comparable to conventional implantology in terms of long-term prognosis. Given the indication of applicability to strongly atrophic bone bases and the rigid respect of inclusion/exclusion criteria, it bypasses all the techniques of bone reconstructive surgery used as an essential prerequisite in rehabilitation on traditional screwed implants.

MODULE TWO TEXTS

1. DEFINITION

a. There have been many nomenclatures and definitions attributed to this type of system, also given by the number of authors who have applied themselves to it over time. Let's start with a concept. An implant structure that rests on a bone surface, precisely on the original basal component of the maxilla. Some names used over time, as we will see, are derived from the production technique used. However, they all share the technical and morphological characterization that distinguishes them. That is, the fact that they are architecturally shaped perimeter structures and therefore have an anatomical situation of SUPPORT on a bone surface rather than interpenetration of the bone structure itself like the same endo-osseous dental implants. It should therefore not surprise us that the prefix "iuxta" or "sub" are currently the most used to complete the term with the derivation "periosteal" to indicate the spatial relationship that these implant structures contract with the periosteum. To tell the truth, the most etymologically correct terms would be "sub-periosteum" or juxta -osseous, precisely to indicate the situation of the implant frame with respect to both the periosteum and the maxillary bone. But let's quickly see what these systems have been called over time

b. Here we are at the first: Dahl 1943. He talks about a metal skeleton implant

c. Let's start from the definition that Bellavia gives. Subperiosteal metallic structure

d. We come to MM Mommaert: he talks about "additively manufactured sub-periosteal jaw implant" even characterizing the production method, in this case with an additive rather than subtractive technique.

e. So in the end how can we define these systems? I would say, if I may, "metallic implant structure with a juxta-osseous and sub-periosteal situation suitable for mechanical resistance to the masticatory load that spreads on the bone surface in reaction to the function of the dental arches in their dynamic functional juxtaposition"; here we find a bit of everything: the description of the position and also the function for which they are responsible.

2. HISTORY

a. The history of these implants is made up of surgeons and technical evolutions. We can state with certainty that these implants represent the most archaic form of mechanical device capable of supporting and stabilizing a chewing load. The real revolution will come with Branemark and the concept of integration. In fact, the osseointegrated screw implant immediately proved capable of "appropriating" a good portion of the application fields held by the Dahl implant. That is, all cases in which alveolar bone remains, an anatomic-biological prerogative of osteointegration. Historically, given the validity of Branemark's teaching, it was considered ethically correct (and rightly so) also to want to treat cases where the alveolar component was reduced with the integrative bone methodology. Here is the spread of surgical reconstructive techniques and all the biomaterials connected to them, of “short” implants. Another slice of cases “ripped away” by juxta-periosteal surgery. This led to a drastic decrease in the cases treated and therefore also to the loss of manual skills on the part of the operator-surgeon towards this method. At this point a question arises spontaneously: why has the "iuxta" topic returned so much to the fore in recent years? Because at conferences and in publications this magic word opens many doors for you. 'why are you here today? Personally, in twenty years of my juxta-periosteal surgical history, I have given myself some convincing answers. And I will report it to you

impartially. But let's not lose the thread of the discussion. We were talking about a history made of surgeons and technical evolutions. Let's start with the surgeons.

b. G. Dahl 1943. The first to report the clinical evidence of the application of these implants in the morpho-functional rehabilitation of the dental arches "On the possibility of an implant shaped like a metal skeleton as a base or retention for fixed prosthesis". This is the title of his scientific work. We are in 1943. Branemark will arrive in 1956 with his epochal teachings. It was then the first modern creation of a dental implant. Before these we had inconsistent news in the 19th century. And before that in the Egyptian era. After Dahl the history of the “iuxta” is somewhat lost. Various authors in the 1950s-1970s successfully completed sub-periosteal experiments on dogs, above all to evaluate their histopathological outcomes. Let's talk about Goldberg and Gershkoff in the years 49 to 57, Nichols in '54; these authors work with vitallium, a steel alloy, all arriving at the same conclusion that the tissue response to the implant is not inflammatory. This presupposed an "acceptance" of the metal fixture by the implanted site. Another scientific achievement: 1954 Hershfus , also working on dogs, and studying the peri-stump tissue; conclusions? No inflammatory reaction, but rather the presence of a squamous epithelium with modest evidence of parakeratosis and acanthosis. Other work that “will open up to the concept of fibro-integration of the metal structure; we are still in '54 Newmann and Vanhujsen give us images of these "micro-layers of connective tissue that surrounds the metallic structure despite the absence of conical phlogistic reactions. In short, the vitallium in the form of a juxta-periosteal implant in the dog is accepted, but most likely fibro-integrated. The tissue reaction to the emergence of the prosthetic connection is also correct. So this type of system can work. Now the time was ripe to go to the operating room. Let's fast forward a decade...

c. We enter the operating room with one of the first surgeons who can be defined as "contemporary". Capozzi. Bellavia reports that this surgeon operates about 800 cases with juxta and most fail. We are in the 70s. Well documented and well controlled cases. Theoretically a disaster.

d. However, again as reported by Bellavia, in this decade the comforting results of surgeons including C. Weiss, A. Huskra, D. Canitz, and S. Schmiedinger are included, doing justice to the method by reporting comforting results 4/10 years after 'insertion. In short, what is done in Northern Europe is good, what is done in Italy is a disaster.

e. But our revenge on the European surgical scene will come in the 1980s with Calogero Bellavia. Not only he reconsidered this method after years of approaching osteointegrated products, but he also drew-up a text-atlas, one of the few existing in circulation. He canonized the modern concept of juxta-periosteal implantology in one of the rare texts entirely dedicated to the topic. Modern for the pre-digital analog era.

f. Let's make another epochal leap. Advent of digital techniques. 3D radiology, Cad Cae, in short, the best for drawing on stereolithographic models. M. Mommaert in 2010. New design, new conception, new digital approach.

g. L. Barbera 2019. Technical Operational Manual. Allow a little self-congratulatory moment.

3. THE DIGITAL ERA

The digital ERA is enough history even if it is important to understand the modern juxta-periosteal system. Let's talk about a passage. The one from analogic to digital. I lived it and applied it to my juxta-periosteal surgery. It was Analog there were no means of previsualization, we worked and drew on what we could touch with our hands. Milling machines, there was still little talk about them. Lost wax castings. Above all, previsualization rendering systems were missing (and I say this in retrospect). It was difficult to achieve the awareness of being "in full indications" as one can do today. However, patient recruitment, objective and 2D radiological diagnosis, first surgery to take impressions of the bone site and perhaps draw some retentive undercuts in the basal bone structure. Second operation to insert the implant frame. It couldn't be screwed on. It was hammered into its seat, making it rest in the natural or designed undercut retentions. Perfect fitting, stability sometimes yes, sometimes less. And the prosthesis cemented on emergencies or juxtaposed with conometric systems. What scared us? The upper jaw especially. Thin metal structures that could sink under high prosthetic pressures.

Digital Era arrived the rendering and the cad. the ability to create virtual 3D models from 3D radiological images and the ability to draw on them. A revolution. Stop the first surgery for the impression. (but absolutely stop?) we'll talk about it... new designs, less fine but above all screwed to the bone surface using osteosynthesis screws. In short, they never come off again. They don't sink anymore. But they cause mucosal dehiscences. Now we have learned and know how to draw connections.

4. FIELDS OF APPLICATION

We have already understood something: we are starting to understand when we can talk about Iuxta. * Severe bone atrophy of the upper and lower jaws * Partial or total edentulism which has matured up to complete dissolution of the alveolar bone process * ASA 1 or 2 health conditions * healthy or at least stable periodontal status.

Introduction

ANATOMY OF THE MAXILLARY BONE BASES

Relativizing the study of the anatomy of the maxillary bone bases to the technical and clinical context of our work on rehabilitation essentially means studying embryology to fully understand the difference between the alveolar and basal bone of which the jaws are composed, studying the phenomenon of atrophy of the edentulous jaws and therefore the surgical anatomy to understand the operational logic of this type of rehabilitation. But let's go in order:

1. OUTLINES OF EMBRYOLOGY OF THE FACIAL SKELETON The development of the head, in particular of the face and the oral cavity, occurs to start from embryonic structures that form around the third month of pregnancy: the first branchial arch, called mandibular, and the second arch, called hyoid. Embryogenesis and post-natal development focus on the following cornerstones:

1 The sites and growth centers; 2 the type of growth that occurs in each location; 3 factors that determine or control that growth For simplicity, the craniofacial complex can be divided into four areas that develop differently:

°) the cranial vault, i.e. the bones that cover the external and upper surface of the brain ; °) the cranial base, i.e. the bony floor located under the brain and which also represents the dividing line between the skull and the face; °) the nasomaxillary complex , made up of the nose, maxillary bone and small associated bones; °) the mandible and the temporomandibular joint.

• **Histogenesis of bone tissues** The ossification of the different skeletal components of the skull essentially occurs through two mechanisms:

• **Direct-membranous ossification** occurs through the secretion of bone matrix within the embryonic connective tissue, without the formation of cartilaginous tissue. It concerns the skeletal units that make up the neurocranium and the splanchnocranium (facial massif). It is that process that allows the expansion of the cranial cavity in the first years of life, as it allows the deposition of bone at the level of the sutures of the flat bones of the cranial vault (new bone tissue is in fact added at the level of the periosteum).

• **Indirect-enchondral ossification** is a mode of ossification that involves the initial deposition of a hyaline cartilage bud. Enchondral ossification is typical of the mandible, but also of some skeletal units of the neurocranium (base bones) and the splanchnocranium (middle ear and styloid process). The maxillary bone, after birth, develops entirely by intra-membranous ossification. Growth does not occur by cartilaginous replacement, but through two main mechanisms: 1) by apposition of bone at the level of the sutures that connect the maxillary bone to the cranial base and the skull; 2) for surface remodeling. The growth pattern of the face requires it to grow outwards beneath the skull, which means that the jaw bone must move forward and downward as it grows, covering a considerable distance from the skull and skull base.

During this downward and forward movement, the space created at the sutural level is filled by active bone proliferation. The sutures therefore remain of the same width, while the various maxillary processes lengthen. Part of the posterior edge of the maxilla is represented by a free surface at the level of the tuberosity. In this area, a superficial apposition of bone is observed which creates the additional space necessary to accommodate first the milk molars and then the permanent ones.

The overall growth represents the result of both a process of translation of the maxilla downwards and forwards and of resorption of the anterior surface. At the level of the palate, this area moves downwards and forwards with the rest of the maxilla, but at the same time there is a resorption at the level of the nasal floor and an apposition on the oral side, thus creating an additional effect of displacement in low and forward of the palate.

Unlike the maxilla, the growth of the mandible occurs through both endochondral and periosteal activity. It can be observed that the main growth sites of the mandible are represented by the posterior surface of the ramus and the coronoid and condylar processes. The growth of these results in the movement of the chin (inactive growth site) forward and downward. The body of the mandible lengthens with a mechanism of periosteal bone

apposition in its posterior part, while the ramus becomes higher with a mechanism of enchondral bone replacement at the condylar level and surface remodeling. Then the mandible moves downwards and forwards, while its size increases upwards and backwards, accompanied by the displacement of the soft tissues that surround it.

Ultimately, the mandibular body grows in length in direct relation to the growth of the branch which grows in the opposite direction to the chin; this occurs by removal of bone from the anterior surface of the ramus and deposition of bone on its posterior surface. The growth peak coincides with the eruption of the upper and lower sevenths in the arch, which are the teeth most susceptible to creating occlusal interferences. Without an adequate increase in vertical height of the ramus, with condylar growth upward and forward, there will not be sufficient space for the eruption of the upper and lower second molars.

THEORIES ON CRANIOFACIAL GROWTH To better understand the different theories on the growth control mechanism it is necessary to distinguish between growth centers and sites. A growth site is just a location where growth occurs, while a growth center is a (genetically controlled) location where growth occurs independently. All centers are also sites but the opposite is not true Genetic hypothesis Brodie hypothesized that cartilages and sutures were under genetic control.

According to this theory, skull growth is predetermined and not subject to external influences. Nasal septal cartilage hypothesis Scott stated that it was solely genetic control that regulated the development of the cartilage of the skull during fetal life and that this control continued even after birth. Particular importance is given to the cartilage of the nasal septum which, in its growth, also determines the growth of the upper jaw. Sutural dominance hypothesis According to the fundamental process in sutural growth is the proliferation of the connective tissue interposed between the bones; if it proliferates, space is created for the growth of the two bony surfaces facing each other. Functional hypothesis Moss 's functional matrix growth theory explains that neither bone nor cartilage are determinants for the growth of the craniofacial skeleton: control is attributed to the adjacent soft tissues. Moss divided the skull into a series of distinct functional components, each consisting of a functional matrix associated with a supporting skeletal unit.

The functional matrices can be: 1) periosteal matrices, microskeletal units represented by muscular structures, whose activity influences the processes of apposition and resorption at the level of the adjacent skeletal units; capsular matrices, microskeletal units represented by the orofacial capsule and the neurocranial capsule, whose activity causes a spatial modification in the position of the bones and therefore their translation. In fact, the volumetric increase in the spaces and masses found within the capsular matrices acts by causing a secondary expansion of the enveloping capsule; following the expansion of the capsular matrices, all the bones must grow to maintain the physiological spaces. In other words, skeletal tissues grow only secondarily to non-skeletal tissues. Growth appears to be, therefore, a multifactorial process in which genetic, neurological and hormonal factors coexist under the influence of function. Van Limborgh's epigenetic factors hypothesis According to Van Limborgh , genetic factors act primarily by determining certain characteristics (e.g. the teeth are located in the jaws); subsequently local feedback mechanisms intervene with inductive action whereby the teeth and muscle formations would give information to the bone and it would respond.

Therefore, genomic information is necessary to allow the synthetic activity of cells capable of osteoblastic and osteoclastic differentiation, while epigenetic information is necessary for the regulation of growth and development processes. It is important to take into consideration the distinct regional modifications which, according to Enlow, exist and occur simultaneously between parts and structural counterparts: the balance of these parts ensures that growth is harmonious; their imbalance leads to disharmony. The Author defined this phenomenon as balanced growth.

However, he admitted that, in reality, perfectly balanced growth never occurs in all parts: during the development processes the imbalances that occur and which impact on the development of the corresponding structure are "physiological". Furthermore, the compensation process plays an important role in development: it causes a certain imbalance in some areas, to compensate for the effects of disproportions that have occurred in other regions, so that a functional balance can be maintained. If each part and its

particular counterpart expand to the same extent, balanced mutual growth will result. The imbalances would, in fact, be produced by differences in the respective quantities or directions of growth between parties and structural counterparts. It is enough to compare the skull of a newborn and one of an adult to realize how many "qualitative" and "quantitative" variations have occurred. Furthermore, the search for the true growth mechanism often leads to forgetting that multiple mechanisms can coexist at the same time; therefore, it is preferable to talk about mechanisms that are more important than others without resorting to exclusionary logic.

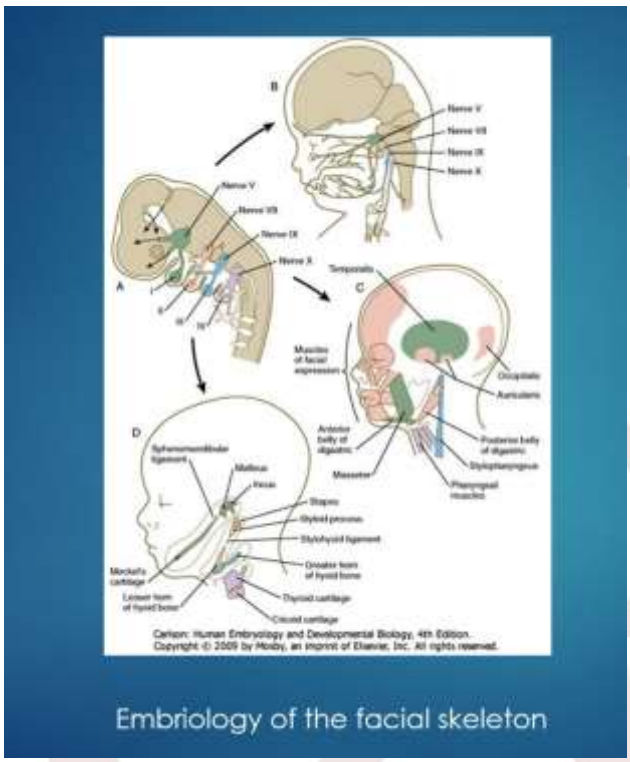


Figure 1: Embryology of the facial skeleton. Steps of development: first and second branchial arches, the mandibular and the hyoid ones originate structures of the skulls and facial complex.

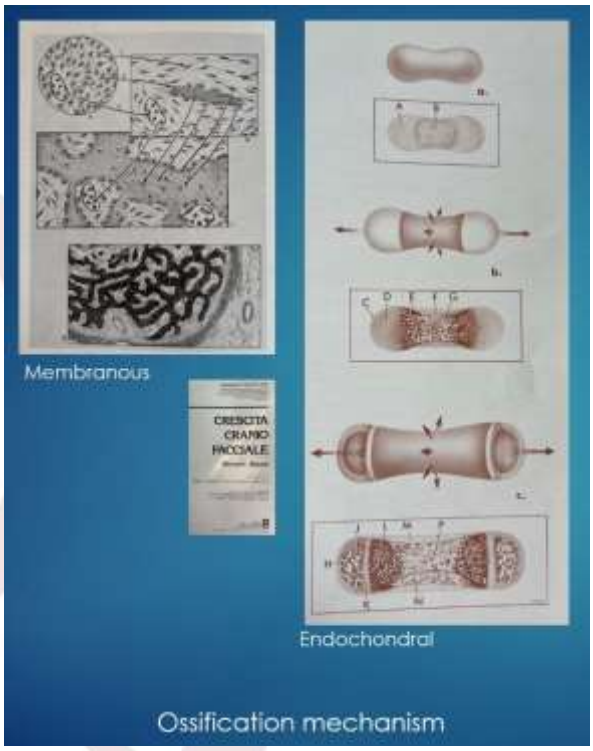


Figure 2: Embryology of the facial skeleton. Type of ossification: direct membranous ossification and endochondral ossification provide both in different condition and site to form bone structures of the skull and the facial complex.

Figure 3: Embryology of the facial skeleton. Craniofacial growth: Theories and authors: post-natal growth of the head and the face undergoes to several theories proposed and supported by different authors during last decades.

2. CLASSIFICATION OF BONE ATROPHIES

One of the foundations for the success of implant surgery is the detailed pre-operative analysis aimed at evaluating the anatomical and dental situation. In particular, the evaluation of bone quality is a fundamental parameter of the analysis that influences both the surgical phase (primary stability of the implant) and the healing phase (bone/implant contact). Physiologically, any bone in the human body is subjected to a remodeling activity composed of apposition (creation) and resorption (loss). Normally there is a balance between the two activities, but when resorption prevails over apposition, bone atrophy occurs. Numerous classifications have been proposed to precisely define the edentulous bone crest from a qualitative point of view. Some of these classifications have focused on the parameter of bone architecture and the density of the tissue itself. Others, however, have favored the morphological aspect.

a. Among the first we have the classification by Carl E. Misch and the one expressed in Hounsfield units. Carl Misch extended Lekholm and Zarb 's classification of bone quality to the entire craniofacial district, based on the macroscopic characteristics of the bone tissue and the quantitative relationship of the cortex and medulla, identifying 5 bone densities: The D1 bone: cortical bone denser and scarcely spongy. It is never observed in the maxilla while it is present in the mandible at the level of the symphyseal region, and in cases of high bone atrophy. It is a bone that is not very suitable for the positioning of implants as it has poor blood supply which significantly slows down its regeneration. D2 bone: bone with thick and spongy cortex with tight mesh. It is observed more frequently in the mandibular body and in the frontal area of the maxilla; represents optimal bone quality. The cortex is sufficiently thick to guarantee primary stability to the fixation means and implants. The good vascularization of the spongiosa guarantees adequate support for bone repair phenomena. D3 bone: bone with thin and spongy cortex with tight mesh. It is very common in the maxilla. Its characteristics are comparable to that of class D2 even if, compared to it, it has a lower spongiosa vascularization. D4 bone: bone with thin and loosely meshed spongiosa cortex. Present at the maxillary level, it is found in 40% of cases in the posterior portion, and only in 10% of cases in the anterior portion, while in the mandible it is very rare. It is a very low-density bone that is poorly suited to any surgical therapy. Its cortex is very thin and does not allow adequate primary stability of the inserted implants. D5 bone in the Misch classification refers to immature and demineralized bone. The bone density parameter can be detected in a more objective and precise way thanks to computerized tomography analyzed with specific programs for dentistry such as Denta-scan and Maxi-scan. CT data assigns each volumetric unit (voxel) a numerical value based on the average tissue density in that specific volume. This value falls within a standardized scale expressed in Hounsfield Units (HU) between the value -1500 and the value +2595, with the value 0 for a density equal to that of water and a value of approximately -1500 corresponding to that of 'air. Bone structures in the Hounsfield scale range in density between +150 and +1500.

b. The classification by Carl E. Misch and K. Judy (1985) reflects the real steps in the progression of bone resorption and introduces the concept of available bone (OD), i.e. the quantity of bone available in the edentulous area for implant positioning. The available bone is classified according to height and thickness/width. Height: it is measured from the top of the edentulous ridge to the opposite inviolable reference point, such as, for example, the floor of the maxillary sinus or the mandibular canal. Thickness/width: is represented by the distance between the two bony thecae (buccal and lingual/palatine), measured at the crest level of the potential implant site. Each category, or division, is then associated, in relation to the characteristics of OD, with three parameters which vary accordingly: Width of the alveolar process: it is represented by the mesio -distal distance measured between teeth or implants adjacent to the atrophic area. Angulation of the implant with respect to the occlusal plane: the axis of the implant should be as superimposable as possible on the direction of the vector of the occlusal forces that will weigh on it. This parameter depends on the width of the crest. Crown to implant ratio (C/I): The height of the crown is measured from the occlusal or incisal plane to the top of the bone crest and the length of the implant from the top of the crest to the apex of the implant. The greater this ratio, the greater the force that will be applied to the bone-implant unit. Based on these parameters the authors identify four divisions: A, B, C, D.

• Division A: OD abundant in all dimensions. Alveolar ridge almost intact, good implant rehabilitation;

• Division B: as bone resorption proceeds, the amplitude of the OD initially decreases at the expense of the vestibular bone theca (centripetal resorption). In this division the bony crest is narrower, but still has sufficient OD for implant placement. It is possible to identify a further subdivision in this division: Bw (width): in which the thickness is inadequate for the implants.

• Division C: as already mentioned, the mechanism by

which the bone is reabsorbed is first in thickness and then in height. Thus, the division B crest continues to resorb in thickness and if the process continues the OD then reduces in height. This picture describes a moderate to advanced atrophic situation. The OD in division C is inadequate in one or more implant dimensions. There are 2 subdivisions of the division C: Cw (width): when the residual ridge is inadequate in width Ch (height): when it is also inadequate in height. The latter category generally denotes a greater level of resorption.

• Division D: continuous bone resorption in this division has led to the complete disappearance of the alveolar process together with an atrophy of the basal bone. We are faced with cases of severe atrophy. The loss of the basal bone leads to a completely flat upper jaw or a so-called "pencil" jaw.

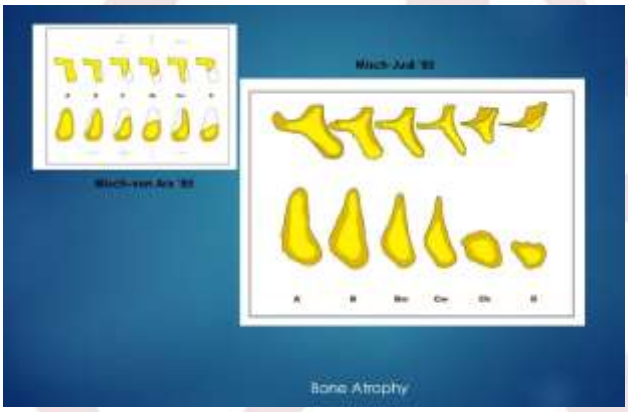


Figure 4: Bone atrophy. Misch & Judy

c. most considered classification in the literature is that of Cawood and Howell (1988). These authors examined 300 dried skulls analyzing the process of resorption of the jaws following the loss of dental elements, with the use of defined and reproducible reference points. They noted that resorption processes follow fairly repeatable patterns despite individual variability. Cawood and Howell divided the atrophy patterns into 5 classes for the maxilla and 6 for the mandible: • Class I: dentition present; • Class II: immediate post-extraction alveolar ridge; • Class III: late post-extraction alveolar ridge with re - ossification of the post-extraction socket and rounded alveolar process but adequate in height and thickness; • Class IV: crest with adequate height but insufficient thickness, defined as “knife-edge”; • Class V: flat crest, inadequate in both height and thickness; • Class VI: (only for the mandible) depressed ridge, with atrophy of the basal bone itself. Furthermore, Cawood and Howell were the first to arrive at the conclusion that bone resorption was also different depending on the site in which it occurred (anterior or posterior maxilla, anterior or posterior mandible). Furthermore, different sectors of the same maxilla can simultaneously present different classes of atrophy. Over time, the edentulous mandible undergoes centrifugal resorption, which reduces the residual bone to just the basal bone positioned more externally with respect to the alveolar crest. Over time, the maxilla undergoes centripetal resorption, which reduces the residual bone to just the basal bone located inside the arch of the alveolar ridge. Overall, the patient edentulous on both arches finds himself in a third skeletal class condition, with the residual mandibular bone positioned vestibularly with respect to the maxilla.

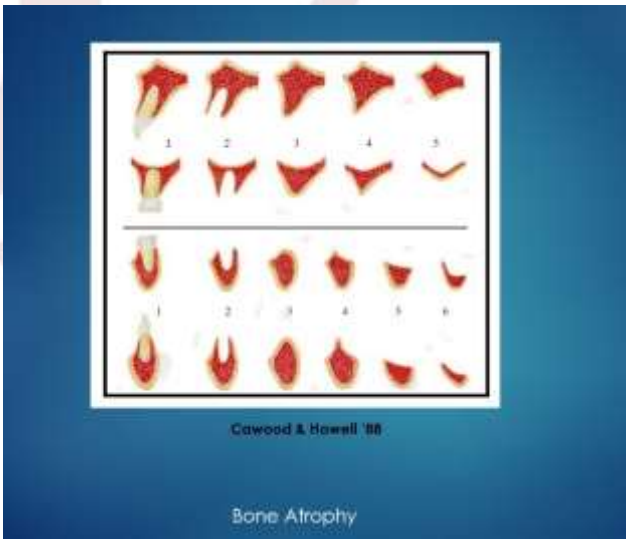


Figure 5: Bone Atrophy. Cawood & Howell

3. OUTLINES OF SURGICAL ANATOMY

The stomatognathic system is made up of two skeletal units, an upper one, the maxillary bone, a skeletal complex with an irregularly parrallelepiped shape which is inserted with its upper face below the anterior and middle cranial base through synostose joints, and a lower part, the mandible, a long irregularly arch-shaped bone which articulates by means of a double condylar diarthrosis in the corresponding incomplete articular cavities, the glenoid cavities, in the context of the middle cranial base forming the so-called temporomandibular joint. This anatomical peculiarity makes possible the intercuspation of the upper dental arches which originates from the alveolar process of the

maxillary bone, and the lower one which originates from the bony process positioned on the body of the mandible.

The movements that the temporomandibular joint allows are of three types: opening and closing, therefore a movement along the vertical body axis; sliding right/left along the transverse axis; protrusion/retrusion along the sagittal one, therefore along a dorsal-ventral direction or vice versa. And these three movements will be the ones on which we will build the morphological parameters of the dental anatomies, which, in turn, will establish the direction and extent of the mechanical stress acting on the implant frames.

Let's start with the MANDIBLE: it is a long bone made up of two right and left hemisections that are not perfectly equal and which merge together forwards in the region called the symphyseal. It consists of a anteriorly developed body with an ovoid section and posterior concavity and two posterior verticalized structures called rami. The ramus has two vertical processes, a posterior one, the condyloid process, anatomical evidence of the mandibular part of the temporomandibular joint, and, anteriorly, the coronoid process, continuing between them in a deep thin incision, the incisura or semilunar margin. The body has a horseshoe shape, has two faces, antero-lateral (external) and postero-medial (internal), and two margins, superior and inferior.

The lateral face is marked along the midline by a light crest, which indicates the mental symphysis, the junction line of the two portions from which the bone is made up in the initial phase of life. This crest divides and encloses at the bottom a triangular eminence, the mental protuberance, whose base is depressed in the center but raised on both sides, forming the mental tubercles. On both sides of the symphysis, just below the incisor, a depression, the incisive fossa, is observed, which gives rise to the mental muscle and a small portion of the orbicularis oris muscle. Below the second premolar, on both sides, halfway between the upper and lower edges, there is the mental foramen, an opening to the outside of the mandibular canal, for the passage of the mental nerve and the vessels of the same name. The roots of the teeth create vertical reliefs called juga alveolaria on the body of the jaw, visible above all at the height of the incisors and canines.

From each mental tubercle another light ridge departs, which is carried posteriorly and cranially, the oblique line, which continues into the anterior margin of the ramus of the mandible. It gives rise to the depressor labius inferior muscle (or quadratus labii inferior) and the depressor anguli oris muscle (or triangulis).

The platysma attaches just below it. The medial surface is concave from side to side. Near the lower portion of the symphysis, there are two symmetrical bony spines, called geniene apophysis, which give rise to the geniusoglossus muscle. Immediately below these there is another small pair of spines, or often a median ridge for the origin of theniohyoid muscle. In some cases the mental spines are fused to form a single eminence, in others they are absent and their position is simply indicated by an irregularity in the bone surface. Above the genial apophyses it is sometimes possible to observe a median hole and canal, which mark the line of union of the two original halves of the bone.

Below the mental spines, on both sides of the midline, there is an oval depression for the insertion of the anterior belly of the digastric. From the lower portion of the symphysis, always internally, the mylohyoid line extends dorsally-cranially, which gives rise to the mylohyoid muscle. The posterior portion of this line, near the alveolar margin, gives attachment to a small portion of the superior constrictor muscle of the pharynx, and to the pterygo - mandibular raphe. Above the anterior part of this line there is a smooth triangular area, called the sublingual dimple, against which the gland of the same name rests. Immediately below the posterior portion of the mylohyoid line there is another dimple (submandibular), also oval and smooth, for the gland of the same name.

The upper, or alveolar, margin, wider at the back, has alveolar cavities, to allow the articulation in gomphosi with the teeth of the lower dental arch. These cavities are sixteen in number and are variable in size and depth depending on the size and shape of the tooth roots they must accommodate. From the external edge, on both sides, the buccinator muscle originates, no further than the first molar. The lower margin is rounded, longer than the upper, and thicker anteriorly. At the point where it joins the lower edge of the ramus of the mandible, there may be a superficial groove, due to the course of the facial artery.

The branches or rami of the mandible, which have a quadrangular

shape, branch off from the body. They form a gonial angle with the body of approximately 115°. They have two faces, medial and lateral, and four margins (superior, inferior, posterior and anterior). Two processes, called the condyloid and coronoid, protrude from each branch. The lateral surface is flat and marked by oblique ridges in its lower portion, giving insertion practically along its entire length to the masseter muscle.

The medial face presents almost at its center the posterior opening of the mandibular canal, into which the vessels and the inferior alveolar nerve penetrate. The margin of this opening is irregular and has a prominent crest at the front, surmounted by a sharp spine, called Spix's spine or lingula mandibularis. It allows the attachment of the sphenomandibular ligament. In its posteroinferior portion there is a notch from which the mylohyoid sulcus runs, which houses the vessels and the nerve of the same name.

Behind this channel there is a rough surface, for the insertion of the interior. The mandibular canal runs obliquely in the ramus of the mandible, moving anteroventrally, and then horizontally forward into the body, where it is placed under the alveoli and communicates with them through small openings. When it reaches the incisor tooth, it moves back to communicate with the mental foramen, giving two small canals that lead into the cavities that contain the roots of the incisors. In the posterior two-thirds of the bone the canal is located closer to the internal surface, and in the anterior third to the external one. The lower margin of the ramus of the mandible is thick, straight, and continuous with the lower margin of the body of the bone. When it meets the posterior margin it forms the angle of the mandible (where the craniometric point occurs gonion), which is marked by rough, oblique ridges on both sides, for the attachment of the masseter laterally and the internal pterygoid medially.

The stylus mandibular ligament is attached to the angle between these two muscles. The anterior margin is thin towards the top and thicker towards the bottom, continuing with the oblique line. The posterior margin is thick, smooth and rounded, covered by the parotid. The upper margin is thin and is surmounted by two processes: the coronoid process anteriorly and the condyloid process posteriorly, separated by a deep notch, called mandibular notch or sigmoid or semilunar notch. It is crossed by the vessels and the masseteric. The coronoid process is a thin, triangular eminence, which varies in shape and size from individual to individual. Its anterior margin is convex and continues downwards with that of the mandibular branch. The posterior one is concave, and forms the anterior border of the sigmoid notch.

The smooth lateral surface gives insertion to the temporalis and masseter muscles. The medial surface also gives insertion to the temporalis and has a crest that begins near the apex of the process and extends anteroinferiorly to the internal margin of the last molar. Between this crest and the anterior margin there is a furrowed triangular area, of which the upper part attaches to the temporalis, while the lower part to some fibers of the buccinator.

The condylar process is thicker than the coronoid process and consists of two portions, the condyle and the narrow portion that supports it, the neck. The condyle has an articular surface, which articulates with the articular disc of the temporomandibular joint. It is convex anteroposteriorly and lateromedially, and extends further on its posterior surface than on its anterior surface. Its major axis is directed medially and slightly backwards, and if extended virtually until it reaches the median sagittal plane, it meets that of the opposite condyle near the anterior margin of the greater foramen magnum. At the lateral end of the condyle there is a small tubercle for the attachment of the temporomandibular ligament.

The articular surface of the condyle is covered by fibrous tissue and interfaces with an articular disc (or meniscus) of avascular, non-innervated fibrous tissue (collagen, fibroblasts). When the mouth is closed, the meniscus is surrounded superomedially by the glenoid fossa of the temporalis. When the mouth is at its maximum opening, the meniscus is moved anteroinferiorly along the slope of the lower portion of the temporal bone, towards the articular tubercle (or eminence), so that it can remain interposed between the condyle and the temporal bone in all possible positions of the jaw. The neck is flattened posteriorly and reinforced by ridges leading downwards from the anterior and lateral portions of the condyle. Its posterior surface is convex, the anterior surface has a depression for the attachment of the external pterygoid muscle.

UPPER MAXILLARY: Presents a more complex anatomy than the mandibular one, either due to the shape itself, or because the

facial mass becomes part of a single bone complex together with the nasal bones, the vomer, the palatine bone, the zygomatic, then coming to merge with the anterior skull base structures including the sphenoid and frontal bone. The upper jaw is made up of two symmetrical but not equal units, right and left, each of these is made up of a central body into which four processes are inserted: the frontal process anteriorly, the zygomatic process laterally, the palatine process on the median side and the alveolar process from its lower margin. The body of the maxillary bone can be described as a triangular pyramid arranged almost horizontally. The base is arranged mesially to form the lateral wall of the nasal cavity, while the apex is highlighted in the upper end of the zygomatic process.

Anterolateral face: vaguely triangular in shape, it has a posterior limit in the zygomatic process forming the zygomatic-alveolar crest as it continues downwards towards the alveolar process. The anterior limit is represented by the lateral and inferior margin of the nasal opening. Keep in mind the position that the canine fossa occupies on this side, insertion of the muscle of the same name above which we find the infraorbital foramen, outlet of the vascular-nervous bundle of the same name. This must absolutely be saved during the elevation of the flap in the case of anterior or full-arch rehabilitations, as it is the origin of the proprioceptive sensitivity of the upper lip.

This face, together with the palatal one, is of great importance for the purposes of juxtaperiosteal implantology, as it is the seat of the major undercut and therefore retentive points, as well as those of the basal bone on which the majority of the suitable support for the implant structures. The posterolateral or tuberositary aspect. The maxillary tuberosity represents its postero-lateral face. Important area for the contracted relationships with the posterior and anterior superior alveolar branches, where we will have to refer for anesthetic infiltration in the case of partial posterior or full-arch procedures.

Generally this part is not related to modern juxtaperiosteal implant structures, unlike what happened with the first grids. Surgical highlighting, in fact, implies a very enlarged exposure with very wide vertical relief lines. The supero-lateral or orbital face such as the Medial or Nasal one are not of particular anatomical importance for our implantology as they are internal faces not reached by implant structures or otherwise. However, very different considerations must be made for the lower face or Palatal Process. Together with the horizontal plates of the palatine bone they form the floor of the nasal cavity, or the vault of the buccal cavity. The fusion of the palatine bone with the maxilla gives rise to a synostosed suture in the context of which an open notch is formed consisting of the greater palatine foramen and the pterygo-palatine canal. These represent the anatomical reference evidence for the anesthetic block of the maxillary nerve, a fundamental requirement for juxta-periosteal surgery. These two formations are the site of passage of the greater and lesser palatine arteries. They must be absolutely respected during the elevation of the mucoperiosteal flap, which must not be pushed so far back. The bleeding that would result from the cutting would be truly massive to the point of compromising the operation itself.

Figure 6: Anatomy of the Maxilla

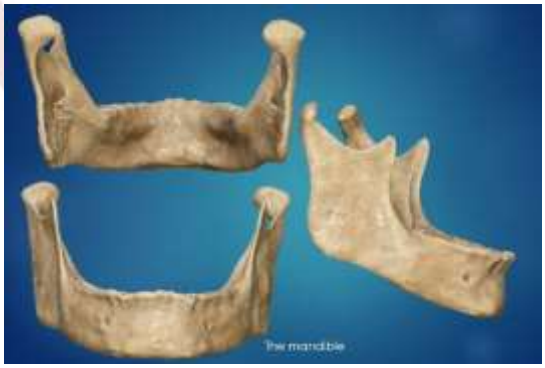
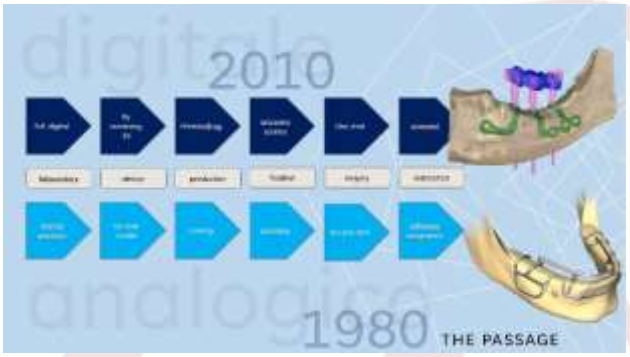


Figure 7: Anatomy of the Mandible

DESIGN

The design of the juxtaperiosteal implant starts from biomechanical considerations which have obviously remained unchanged since we recorded its beginnings with Dahl's works way back in 1943. the technical evolution of the designs has taken on the connotation of modernity since the end of the 90s (we think to the canons written by Linkow), reaching current levels of architectural performance with the work of Mommaert et al.



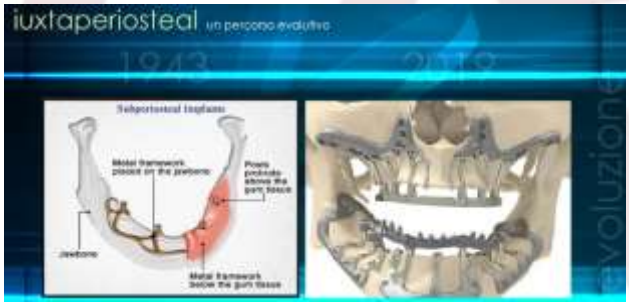


Figure 8: Evolution of the design through the passage from analogical to digital era: translation to digital era from the analogical one, was signed by drastic changes other the in methods used also in architecture of the frame and characteristic of restoration.

Several authors have proposed the rules for arriving at an optimal design of the implant frame. The common effort has always gone towards the need to avoid peri- and post-surgical mobilization and dehiscence, to offer a multipurpose prosthetic connection that would allow prosthesis to be chosen by the operating clinician, and above all to record the positivity of the long-term prognosis in a to be considered, in compliance with the inclusive criteria, as a valid alternative to reconstructive surgery.

Let's see a brief review of the works of these authors. It will certainly be useful to us in understanding how we arrived at the current design that we propose for iuxtaplan. Without a doubt, the first of the modern authors who handed down their construction canons to us is Linkow: from the title of his work " critical design errors in maxillary subperiosteal implant " it can be deduced that in those years the vision of the criticality of this type of implants was clear especially when compared to younger endosseous implants, and how much more this problem was seen for the maxilla than the mandible.

First question: the type of bone of the upper jaw frames the full indications of the subperiosteal fixture worse than what occurs in the mandible.

The author introduces the requirements for a successful maxillary rehabilitation: 1- the adequate design that takes into account the real compact basal areas, the area surrounding the nasal spine, the canine console, the bone of the sinus region, the palatal side of the residual alveolar ridge and the pterygoid ridge.

The precise correspondence of the frame to the anatomical support regions and the greatest possible lightness of the metal structure evoke the most atraumatic surgery possible, introducing the concept of free biological spaces to be left for the reconstitution of the osteo-periosteal anatomical unit.

It also predicts a better interaction of the metal structures with the adherent gum, discouraging the design of lightening holes in correspondence with the areas interpolated with the oral mucosa as they are the site of possible inflammatory phenomena due to the mobilization of this by the masticatory and mimic muscles. When passing metal structures, bony areas with sharp angles must be avoided which would be copied by the frame with curves that could prove too protruding.

Lastly, the bony undercuts of the buccal region should be copied as faithfully as possible as this would result in further final stabilization.

Figure 9: General rules for frames design: pioneers of iuxta periosteal approach teach us and released rules nowadays still valid to draw the perfect implant design.

Another author from the pre-digital era, certainly to be included among the references is C. Bellavia who even hands us down a compendium of subperiosteal implantology: "Atlas of combined subperiosteal and endosseous implantology". The anatomical criteria are the same as those promulgated by Linkow. Bellavia offers us a lighter structure than Linkow's, while canonizing the constituents of the implant frame in much more detail.

External and internal delimiting arms, support arms, connection arms, subgingival prosthetic connection, and supragingival connection, are the components that form any subperiosteal frame, adapting from time to time to the local bone architecture. Dimensional criteria comparable to those proposed by Linkow: thickness between 0.7 and 0.8 mm, width of the structure 2 -4 mm. Same position regarding the " free spaces" which must be maximized to facilitate the reconstitution of normal osteo-periosteal anatomical continuity.

Bellavia also illustrates very well the decision-making process regarding the design of the mandibular frame. Retro-molar trigone, external oblique line, mylohyoid crest, any mandibular tori, genial apophysis and mental symphysis with its apophyses, are the basal support areas that will support the mechanical load to which the frame will be subjected.

Aligned with the first also on the question of the passage of the delimiting arms on the bony prominences at the limit between the vestibular and bucco-palatine aspect depending on whether it is the mandible or the upper maxilla. It is hoped that the passage is designed more in the depressions than on the prominences in order to avoid gingival ischemic phenomena and therefore secondary exposure to necrosis. Particular attention is highlighted in the retro-molar area, where due to the thinness, mobility of the tissues and the pulling action of the pterygoid muscles, these important mechanical dehiscences can very often be highlighted [DIAPO3].

At this point we could move on to the authors of the digital age who have brought back innovative design standards. The leap compared to the analogue era is evident not so much in the arrangement of the bone resistance sites, but in the morphology of the frame and in the fact that it is screwed to the underlying bone consoles as a device to give the system even more mechanical stability.

NC Gellrich “A customized digitally engineered solution for fixed dental rehabilitation in severe bone deficiency: A new innovative line extension in implant dentistry”. We are in 2016. A very profitable five-year period in terms of juxtaperiosteal innovation begins. Gellrich's work appears innovative. Perforated delimiting arms to increase local functional anatomical reconstitution. Screwed frames with variable number of fixing screws. Frankly, I find the architectural canons established by Linkow poorly respected.

Lots of metal, coarse structures. Passages in bony areas with "hard" angles and with the formation of very prominent metal knees potentially the site of dehiscences, especially in the trigone area. We have arrived at the work of K. Kulcsar “Modernization of cortically supported individual implants”. The design returns to have the dimensional characteristics described with reduced section arms, soft passages in areas without sharp edges and large vital spaces left for healing.

The design of the prosthetic connection is interesting, on which it even performs a CAE (Computer Aided Engineering) finite element analysis to detect the areas of greatest stress and predict its mechanical resistance [pict 10].

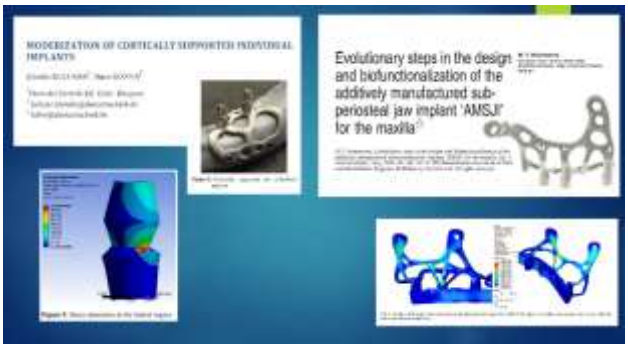


Figure 10: Finite element analysis for metal frames: this essay can show area of stress related to load application during chewing and dental arch dynamic interaction

We now come to an author whose contribution was truly important. Maurice Mommaert. We are in the period between three-year period 2017-2020. “Evolutionary steps in the design and biofunctionalization of the additively manufactured subperiosteal jaw Implants”. He also applies a CAE finite element analysis to his system, which upon careful observation could be the one that most keeps the structural standards sanctioned by Linkow and Bellavia intact. Thin structures, large biological healing spaces, architectural developments that are not exaggerated to make insertive surgery simpler and more atraumatic. Connection arms without shoulders that are too prominent or protruding in order to avoid traumatism in the sliding of the oral mucosa due to the action of the buccal muscles and the floor. Reduced number of fixing screws to simplify the procedure.

Beveled edges and dimensional criteria compliant with the average of other authors. Let's now move on to consider our drawings which however follow architectural canons deriving from the study of the authors we have just considered. In general principle we prefer the designs of single-beam structures with continuous and alternating distribution between the buccal and lingual sides with crestal passages through osteotomies if the passage tops are characterized by sharp corners or anatomical angularities which would translate into structural knees that are too thick in relation to the overlying soft tissues.

We will take as an example two cases upper and lower. For each of the two bone sites we will first of all analyze the anatomical site, identifying the anatomical reference structures, the areas of development of the implant structure; we will characterize them in relation to the degree of atrophy presented and the reconstructive prosthetic needs. We will demonstrate that the final design will be a structure responding to the highlighted mechanical needs.

1. **MANDIBULAR DRAWING:** 59 year old patient. Requested rehabilitation of sector 25-27 following implant failure (rehabilitation carried out approximately 14 years ago. Time elapsed since implant reclamation and plastic socket - without reconstructive steps - 9 months. He desires fixed prosthetic restoration. Classic radiological and intraoral diagnostic recordings are performed, from which the 3D renderings are deduced which are subsequently aligned with each other. The bone rendering provides us with some very important data.

First, we are faced with class IV Cawood-Howell bone atrophy class Ch according to Misch-VonArx (vertical loss with preservation of the horizontal dimension). The anatomical examination of the sectional rendering of the implant site shows some peculiar characteristics of the residual atrophy. First of all, the extreme lingualization of the axial reference section with inclination of the residual alveolar section in the buccolingual direction on the transverse reference plane. The result is a bone axis that is completely misaligned with the reference dental one

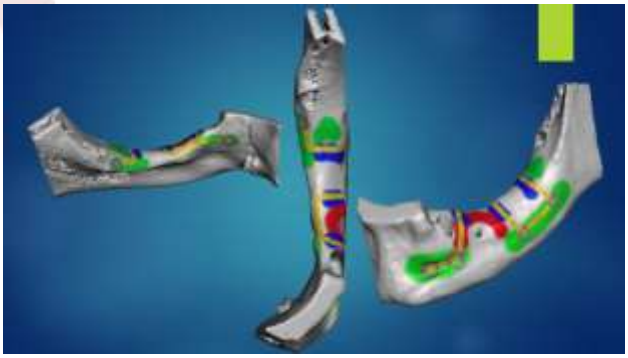


Figure 11: Vto of implant site: this step allows us to recognise few fundamental areas where to reach implant stability and resistance to load.

The bone rendering examination clearly highlights the position of the genie tubercles, of the internal oblique line that appears, causing the extremely superficial atrophy. This always appears not very evident in its anterior section. The external oblique line appears well highlighted in its stretch of origin from the basal part of the upright branch, becoming increasingly blunt as it progresses towards the mental foramen. The temporal crest is also clearly evident in giving continuity in the cranial direction to the internal oblique line. Pits, tubercles and mental protuberance appear very well represented. The residual anatomy appears to be "difficult" especially in its lingual aspect. The practically absolute absence of a coronal basal structure with respect to the internal oblique line makes it difficult for us to draw the internal delimiting arm, an important element of resistance to the translational stresses resulting from the occlusal laterality. We will eventually also have to take this into account when designing the occlusal reliefs.

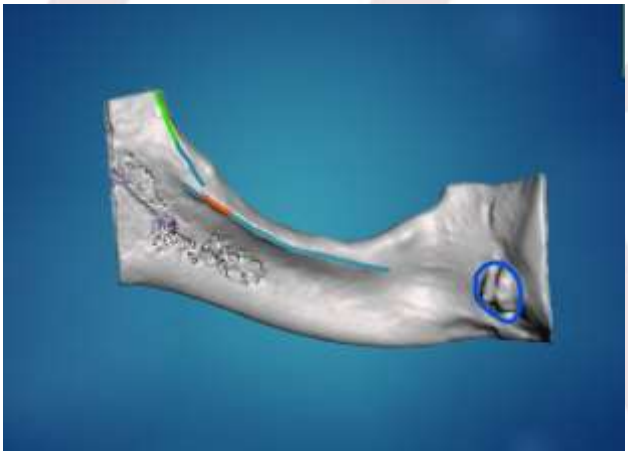
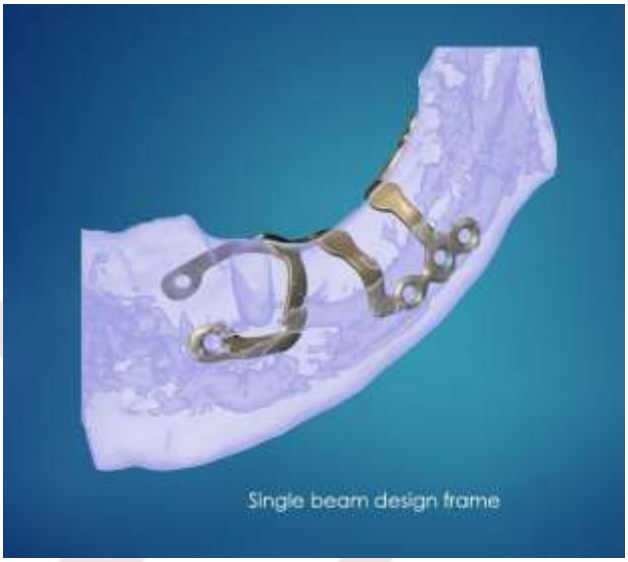


Figure 12: Difficult design for mandibular frame: the design of the implant frame on the lingual side of the mandible is particularly difficult in cases of severe atrophy, due to the almost total absence, often, of cranial basal support, compared to the internal oblique line.

The final design will depend, once the anatomical structures have been highlighted, on the recognition of the areas suitable for positioning the different components. Therefore we will highlight the support ones for the internal and external delimiting arms, the passage ones for the joining arms which will support the prosthetic emergencies and the retention ones for the torsional stability of the frame. We remind you that we decided to design a single-beam structure with continuous and alternating distribution.



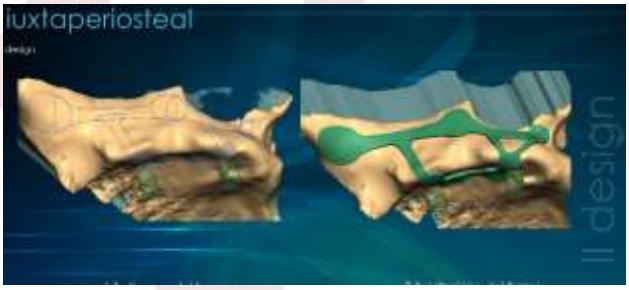


Figure 13: Single beam design for structure: an architectural approach that allows to save and increase the free spaces for revascularization in case of severe atrophy (class 5 sec Cawood Howell)

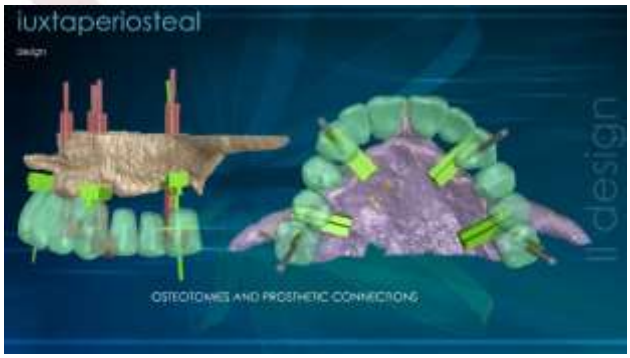


Figure 14: Prosthetic connection and final design: the position of the prosthetic connections must absolutely consider the position, situation, and orientation of the dental

elements to which they refer.

The various components that we are now going to design must have characteristics such as to fulfill the task for which they are designed on the site where they are to fulfill their function. In this case the internal delimiting arm must offer resistance to translational movements and, at the same time, must not interfere with the musculature of the floor of the mouth which obviously exerts a pulling action during its contraction and therefore could represent an interfering element with the normal trophism of the oral mucosa locally. The internal delimiting arm could represent a point of greatest risk for the appearance of gingival dehiscences. It must therefore necessarily have a beveled profile and a minimum thickness, not forgetting however that it must accommodate the seats for fixing with the osteosynthesis screws.

It will be made up of two parts, a distal one which will push as much as possible towards the temporal crest, and a mesial one which, having passed over the present torus, will descend with a disto-mesial course and apical crown up to the vicinity of the genial apophyses where it will provide a seat for a fixing screw.

The external delimiting arm will also be divided into two distal and mesial sections whose respectively mesial and distal parts will be at a suitable distance from the emergence of the chinrest in order to avoid interference of the structure with the soft tissues, during their mobilization by the action of the buccinator muscles of the labial ones. The structure may have a greater thickness also in relation to the function of discharging axial forces entrusted to it almost entirely.

Given the architectural characteristics of the soft tissues, the support arms will rest almost completely in close relationship with the oral mucosa and a small band of keratinized tissue; for this reason it will be good for them to maintain a beveled profile and a section that is not excessive. We will continue directly with the mesial and distal sections of the internal and external delimiting arms for the characteristics that the requested frame will have. The width will be that corresponding to the minimum diameter of the subgingival portion of the prosthetic connection.

The support arms will be arranged along the disto-mesial axis so as to coincide with the center-tooth of elements 34 and 37. The prosthetic connections will have the shape we have already talked about with a hint of a double-conical flare in the lower part and trans-gingival. The actual connection is represented by the PLAIN connection already used in endosseous implantology in Sweden. The positioning above the support arms will obey a location along the vestibule-lingual axis corresponding to the best relationship it can contract with the band of local keratinized mucosa. In this regard, given the clinical situation, a local vestibuloplasty would be indicated to increase the adherent area. The position of the prosthetic connection obviously cannot ignore the position of the dental element to which it refers.

2. UPPER MAXILLARY DRAWING: 64 year old patient upper arch; requested full-arch rehabilitation following the failure of implant-prosthetic rehabilitation such as all on outside according to the Malò technique performed approximately 9 months before our check-in. Classic radiological and intraoral diagnostic recordings are performed, from which 3D renderings are deduced which are subsequently aligned with each other. Bone rendering provides us with some very important data. First, we are faced with Cawood-Howell class IV bone atrophy class Ch according to Misch-VonArx (vertical loss with preservation of the horizontal dimension). The patient wears a total mobile upper prosthesis and a prosthesis screwed onto Toronto bridge-type implants in the lower arch. The upper prosthetic product, once the renderings have been aligned, highlights a very evident third class sagittal intermaxillary relationship with even transverse contraction of both the mucosal and bony planes. The alveolar section of the three districts taken as evaluation is well oriented (orthogonal) with respect to the reference palatine bone plane.

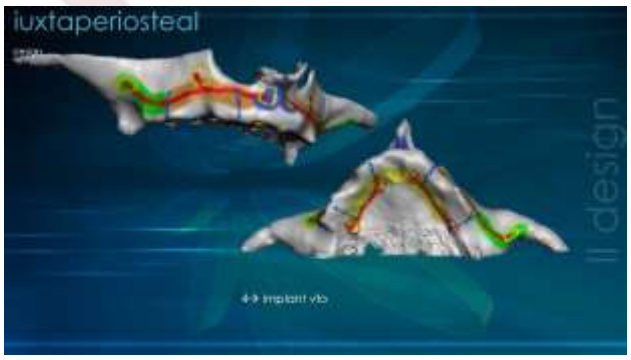


Figure 15: Implant site vto for an upper full arch

rehabilitation: prosthetic rehabilitation relativized to the spatial situation of the reference bone sector.

The design of the implant structure in the upper jaw is a little more complex, in principle, given the general architecture and distribution of the basal structure of the upper jaw. Let's start with some general considerations and then apply them to the case we are presenting. Let's start from the fundamental anatomical consideration that the upper jaw can be considered as organized in a central body of a pyramidal shape from which 4 processes depart, frontal, zygomatic, palatine, which have relationships with the homonymous bone segments and the alveolar one which, as the name suggests, same seat for the dental elements of the upper arch.

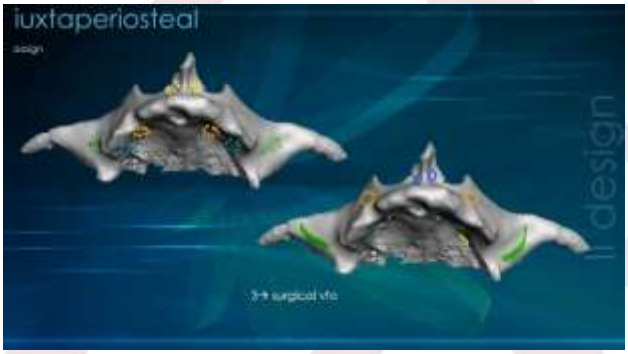


Figure 16: Undercuts area and fixation screws: the bone undercut areas contribute, together with the fixation screws, to maintaining the static and dynamic stability of the implant frame.

The central body has a pyramidal shape with a base with a triangular section, i.e. the medial or nasal face, and three faces of which, a superior one, the orbital face or supero-lateral face, an anterior one, the antero-lateral or malar face, and finally a posterior one, the postero-lateral or tuberositary surface. This architectural organization gives rise to support zones or areas and areas under squaring. Among the former we remember the anterior nasal spine, the canine fossa, the palatal compact, the malar area and the root of the zygomatic process, and finally the pyramidal region of the palatine bone and that of the maxillary tuberosity. The under-squared areas instead include the depressions of the incisal-canine area, the vestibular side of the tuberosity region and the palatine side of the alveolar process when still represented (even minimally). The areas under squared, although important, today take on a marginal role, given the use of micro-fixation screws.

For the upper jaw we use a single-beam construction scheme with continuous vestibule-palatine distribution with a tapered structure and eyelets for the passage of the micro-fixation screws. Precisely in relation to this characteristic, we generally do not include the tuberosity region in our drawings. This also involves a notable surgical simplification and a lower possibility of intra- and peri-operative haemorrhagic events. The delimiting arms, whether vestibular or palatine, will appear continuous with the insertion of the connecting arms either single-beam or doubled depending on architectural needs.

Sometimes the internal delimiting arm can be drawn divided into two sections, one mesial and one distal, continuing directly with the corresponding connecting arm. In this case, the knee represented by the area of union of these two will be provided with an area suitable for the passage of a micro-fixation screw. We perform trans-crestal osteotomies, if the case requires it, always keeping ourselves coronal to the equator of the bone section and apical to the muco-gingival line.

The direction on the transverse plane of the osteotomies has a radial trend with an ideal center corresponding to the posterior nasal spine. As regards their inclination with respect to the coronal section, it will correspond to the reference dental axis (i.e. the tooth that will refer to the corresponding prosthetic pillar). The connecting arms will also be tapered along their circa-alveolar path to take on the diameter of the prosthetic connection in correspondence with this, fusing directly into its base. At the insertion on the delimiting arms, they may retain a single-arm conformation, or split and become divergent. The prosthetic connections will consist of a neck and the actual connection. Of these two, only the connection will emerge from the gingival crest, the neck remaining completely within the keratinized gingival thickness. The neck will be directly extrapolated from the aligner system used for positioning. The four connections will be parallel to each other. They will have an axis that is as vertical as possible, compatibly with the design, in the case of full-arch systems, of the corresponding prosthetic restoration. Also for the upper jaw we foresee the possibility of corrective muco-gingival plastic surgeries in case of inconsistencies in the trans-gingival path of the connections themselves. Thickness and width of delimiting and joining elements corresponds to the classic ones with a range

between 06 and 09mm for the first and 3-4mm for the second.

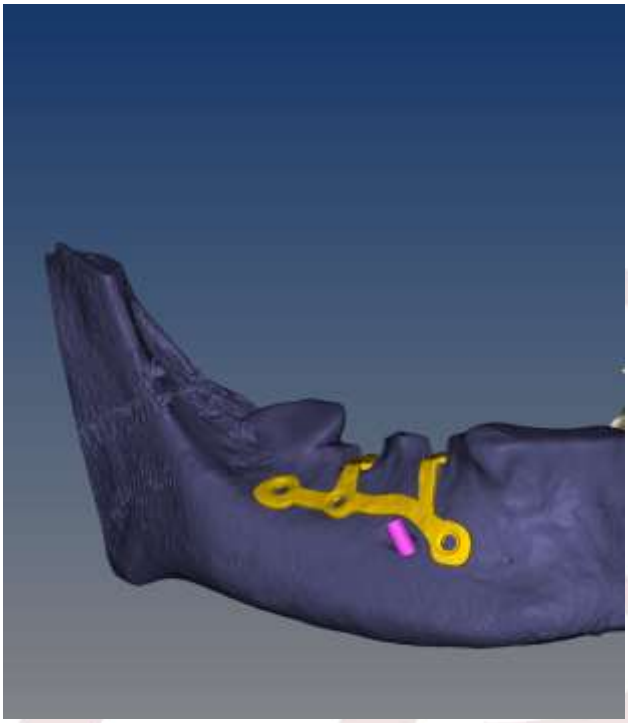


Figure 17: Dimension for frame parts: thickness and architecture of the parts constituting the implant frame depend on the bone area to which these parts refer.

As with the jaw, we pay particular attention to the problem of free spaces. As anticipated at the beginning of this module, the peri-operative healing of the surgical wound will be greatly influenced by the relationship between free spaces and spaces overlaid by metal structures. This factor takes on particular importance in the connection areas between the delimiting elements and the connecting arms and in those between the latter and the prosthetic connection structures. In principle, the ratio between covered area and free area must not be less than 1:4. This is related to the part of the anatomical site where the metal structures pass.

In case of unfavorable dimensional ratios, we prefer to abandon, even only locally, the single-beam structure and move on to split sections with surfaces equivalent to the single-beam one, in order to increase the corresponding development area and bring the ratio back within values considered safe for prompt reconstitution of the anatomical and functional biological continuity of the bone surface/mucoperiosteal tissue interface.

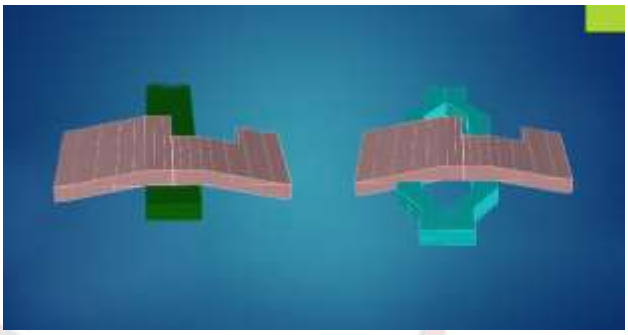


Figure 18: The ratio concept of metal covered vs free bone spaces: a way to provide good revascularisation pattern during wound healing peri operatory steps.

3. BIOMECHANICAL CONSIDERATIONS AND DESIGN OF THE PROSTHETIC RESTORATION: talking about the design of both upper and lower implant frames, we have introduced the concept of anatomical characterizations of the areas of resistance and those of resilience, the former characterized by areas of high bone density capable of withstanding the transfer of the load from the teeth to the bone in the form of compression, the latter architecturally recognizable in retentive subframes opposing the "tearing" forces, allow the term, resulting in the non-axial forces with respect to the prosthetic connections.

Furthermore, the fixing screws that are currently used are also opposed to this purpose today. This last fact, however, does not cancel the set of tangential, not axial, forces that act on the fixtures, exerting an action that tends to diastase the implant in one point and to hypercompress it in the opposite point with respect to a fulcrum of application of the force itself. Let us therefore introduce the concept of applicability of the masticatory force to juxtaperiosteal frames. Let's start with a comparison with teeth.

First difference, teeth: independent single elements connected to the alveolus via a shock-absorbing system, the periodontal ligament. Juxtaperiosteal implants: single element arranged over the entire arch or at most on one hemiarch. The load transfer

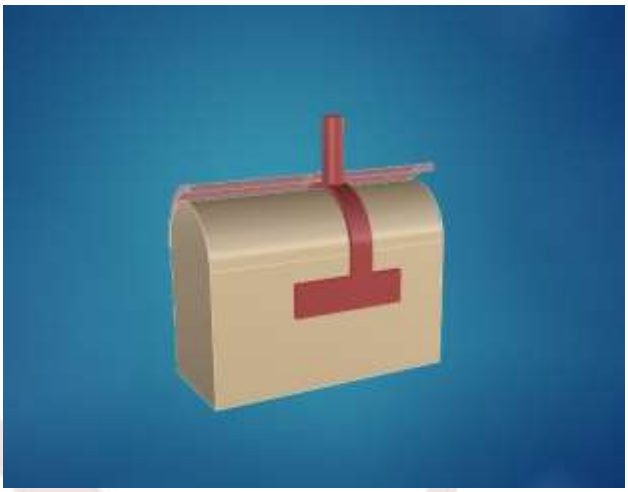
systems are represented by the individual teeth and the prosthetic abutments, joined together by the arms joining the delimiters etc. etc. therefore the occlusal forces, whether axial or tangential, manifest themselves a few elements close to its point of application in the case of the natural dentition and to the entire structure in the case of the implant frame (or hemi-frame) thanks also to the adoption of milled bars extra-gingival at the junction of the two implant units (obviously in the case of full-arch rehabilitations).

On the latter, the axial forces transmitted by the opposing arch are well distributed and tolerated, whereas the case of the tangential components of the occlusal forces, transmitted during the protrusion and lateral movements, is different. Another necessary consideration to understand the unfavorable biomechanics of these movements. Since these are severely atrophic bone bases, we will be faced with centripetal resorptions for the upper jaw and centrifugal resorptions for the mandible.

This APPARENT movement of the bone bases forces relative corrections with the prosthetic stumps which will have to be inclined in the opposite direction to the reabsorption tendency, therefore in a centrifugal way for the maxilla (vestibular overtipping of the connections) and in a centripetal direction for the mandibular frames (lingual overtipping of connections). Considering the mandibular kinematic movements during chewing, we will conclude that A PRIORI the maxillary implant geometry will withstand the tangential shear forces of protrusive and lateral sliding movements worse than, in fact, the mandible.

The point of overcoming the overbite both in laterality and in protrusion represents the fulcrum of a lever arm which manifests itself with a compressive zone and an obviously opposite traction-type one.

The intensities of these forces will be directly proportional to the extent of the overbite to be overcome and will result in compressive forces on the frame contralateral to the direction of slip and traction forces ipsilateral to the slip. This will lead to a tendency for the contralateral implant structure to sink and tear ipsilateral to the direction of sliding.



This phenomenon was particularly evident in the predigital era when frames assumed stability solely from their relationship to undercut areas. First concept to assimilate and not forget.

Figure 19: The continuity of anatomical unit bone, periosteum, and gums

But let's move on and see how these "biomechanical fragilities" can be overcome. The problem, as anticipated, persists above all in the upper structures due to the centripetal atrophic process. This and the architectural compensation constituted by the vestibular tipping of the prosthetic connections, generates a generalized movement forward with respect to the median sagittal plane of each single dental element between 14 and 24 in their component intersecting the absolute median sagittal plane passing through the anterior nasal spine. This resultant will obviously be different in magnitude depending on whether it is a protrusive or lateral movement. Obviously, again due to the levers that are generated, the resulting extractive destabilizing movement will manifest itself on the two caudal ends of the frames.

For this reason, in the pre-digital era we looked for the minimum undercuts, always present at the root of the residual alveolar process. Sulcus of the palatine artery, buccal side of the tuberosity and buccal compact of the palatine vault are areas that were appropriately used for the purpose of neutralizing these residual extraction forces. Dental anatomy also helps us to cancel out these residual biomechanical components.

Basically it is a question of designing cuspal anatomies in such a way that overcoming the 0verbite occurs with simultaneous support on all the dental elements so that the resulting contralateral extraction forces are adequately canceled by the static and dynamic occlusal contacts contralateral to the direction of disclusion. Furthermore, as proposed and now universally accepted, rehabilitations in soft material easily subjected to erosive action by the antagonistic anatomies are hoped for.

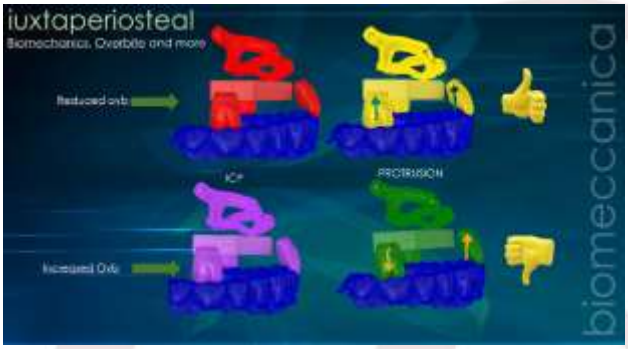


Figure 20: Biomechanical concepts: an incorrect design of the dental overbite of the prosthetic restoration could cause residual forces compromising the stability of the complex implant-prosthetic connection-dental restoration.

Figure 21: Material for restoration: juxta-periosteal rehabilitation occurs in adulthood. therefore, designed for a naturally eroded articulated delta. prosthetic materials with reduced hardness coefficients, similar to those of natural teeth, will allow physiological erosion, together with changes in the natural dental structure, possibly residual.

INCLUSION CRITERIA

1. The objective anamnestic considerations that fall within the great chapter of indications for juxta-periosteal surgery range from general medicine to special dentistry. Furthermore, given the current social context, many character and social considerations come into play which go into building or not the Patient's Compliance and therefore his Expectations. Compliance and expectations are related by a direct proportionality relationship, as as the former increases, the latter will also increase exponentially. Let's not forget the level of surgical invasiveness, which, despite having seen a constant and evident decrease in recent years, still remains on average high; the latter is "forgotten" by the Patient in exchange for markedly positive and above all long-lasting results. A technically very complex work like this therefore presupposes a truly rigorous application of the technical canons, recognized as the only "sine qua non condition" for achieving clinical and human success. First of all, therefore, we always hope for a rigorous application of the inclusive criteria in order to grasp cases with a full clinical indication.

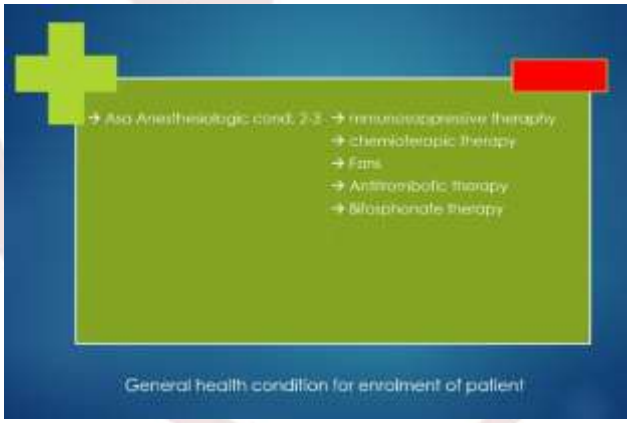


Figure 22: General health condition affecting patient's enrolment and target: the strict application of the inclusive criteria to candidate patients will allow the most suitable cases for this method to be selected. rigorous application of the indications will also make it easier to identify the reasons for any failures.

Let's start from the technical consideration; for the same treated site, the surgical intervention for the positioning of the Juxta-periosteal frames implies an exposure of the operating field which is on average larger than that necessary for the positioning of traditional endo-osseous implants. This results in generally longer operating times, therefore increased infectious potential and sometimes more evident anesthetic needs. For these two characteristics, the so-called "physiological" inclusion criteria must be carefully evaluated. Let's start by evaluating the purely General Practitioners' choice criteria

2. GENERAL MEDICAL CRITERIA in a general sense, a priori of any surgical procedure, and as an inclusive or exclusive criterion, all factors that can negatively influence tissue healing must be taken into account [Ministry of Health - clinical recommendations in odontostomatology]. The general anamnestic medical criteria are used to evaluate three orders of risks that are equally important to each other.

a. Infectious Risks: I quote an excellent work by [F. Gatti et al. of 2012] “oral surgery: Systemic pathologies and risk of infection”. Oral surgery has an inherent infectious potential related to the contaminated environment in which it takes place as well as the fact that it is often performed on an outpatient basis and therefore potentially less protected than hospital surgery. Furthermore, the accuracy of the anamnestic investigations carried out is not maximum, potentially leading to the misrecognition of pathological conditions predisposing an environment less protected from local and sometimes systemic iatrogenic infections. It is therefore very useful to know the close correlation that may exist between local or systemic pathologies and the risk of post-surgical infection. [pict 23,24].

Figure 23: Local factors condition affecting patient’s enrolment or exclusion. Some pathological condition may severely affect outcomes predictability of rehabilitation.

Figure 24: General health conditions and risk of infection: here are the pathologies that increase the risk of infection. these should also be included among the absolute contraindications. Perioperative infectious events must be absolutely avoided to promote healing by primary intention. some therapeutic regimens largely increase this risk and therefore should be considered as absolute contraindications.

Let's start from the first condition that determines an increase in infectious risk: treatment with immunosuppressive drugs . In return, all patients undergoing transplant surgery must be treated with the utmost caution. Chemotherapy drugs for the immunosuppressive action related to the antineoplastic action carried out should also be included in this chapter . All neoplastic pathologies must be included in this category with particular reference to hemo-proliferative and myelo-proliferative conditions, conditions in which a marrow transplant is expected (and therefore all the considerations made above regarding immunosuppression and antiblastic therapy).

The same consideration applies to therapies with steroidal anti-inflammatory drugs. Both of these classes of drugs block the immune system, making the patient more receptive to septic contamination of the operated site. Immunosuppressants and

corticosteroids being taken can be considered an ABSOLUTE CONTRAINDICATION to surgical procedures. Antineoplastic positivity represents an absolute contraindication only in the first year after intake, becoming relative for longer periods of time. The discussion on DIABETES MELLITUS deserves particular consideration. It is the belief of clinicians that diabetes is associated with an increased risk of infection. In vitro studies have demonstrated alterations in neutrophil function, antioxidant systems, and humoral immunity.

Furthermore, there are not many studies that have quantified the infectious risk in diabetes. Bone, liver and lung tissues appear to be the most receptive to these septic phenomena. In terms of immuno-depressed patients with increased risk of infection, it would be good practice, and we consider it to be a mandatory inclusive criterion, to have the haemocytometric count of white blood cells. Particular attention must be paid if this falls below 1,500-3,000 cells /mm3 compared to the normal level of 5,000-10,000 cells/mm3, since this condition makes the patient unable to counteract a possible infectious attack.

A patient of this type, with values between 1,500 and 3,000 cells /mm3, requires broad-spectrum antibiotic coverage, while in the presence of values < 1,000 cells /mm3 a specialist medical consultation is essential. The evaluation must also refer to the cause of the immunosuppression (HIV infection, cyclosporine therapy, etc.)

b. Anesthesiological Risks: The ASA scale is a classification system of the patient's physical status; was developed to offer anesthetists and patients a simple numerical scale categorization of a patient's overall situation, which can help predict surgical risk. It is named after the American Society of Anesthesiologists and, for over 60 years, it has been a tool used internationally to assess a patient's suitability for undergoing surgery. The purpose of the system is to assess and communicate a patient's pre-anesthesia medical comorbidities.

The classification system alone does not predict perioperative risks, but used with other factors (e.g. type of surgery, frailty, level of deconditioning), it can be useful in predicting risks. Assigning a physical status classification level is a clinical decision based on multiple factors. Although the physical status classification may be initially determined at various times during the preoperative patient evaluation, the final physical status classification assignment is made on the day of anesthesia care by the anesthesiologist, after the patient evaluation.

Figure 25: Asa classification for anaesthesiologic risk evaluation

[pict25] as a parameter certainly already respected by all of us here today, we will only treat patients classifiable no later than class 2.

c. Hemorrhagic Risks: as anticipated, juxta-periosteal surgery appears to be, for the same site treated, more invasive than that for the positioning of traditional endosseous implants. Furthermore, let's make another consideration: in the national protocols in use by local health authorities, oral surgery is included in the group of ENT procedures and classified as INTERMEDIATE RISK [photo].

The evaluation of the bleeding risk therefore takes on great importance, especially in cases of full-arch rehabilitations of the upper arch.

An assessment which must however be made a priori on any candidate patient. The hemorrhagic complication has never occurred in our clinical practice, however it must be taken into consideration, either for some pathological conditions which in themselves predispose to increased bleeding, or for some secondary therapies to pathological conditions which favor its

appearance.

We are talking about anticoagulant, antiplatelet and/or fibrinolytic therapy. Once again, the medical history is of fundamental importance in the general medical evaluation of the patient. Let's consider which pathological states can manifest themselves with an increased bleeding risk.

Figure 26: Pathologies and risk of bleeding: To date, there is much discussion about the need to modify antithrombotic therapeutic schemes in patients undergoing oral surgery. the decision is delicate. the site and the extension of the operating field to be obtained for implant insertion must be taken into consideration.

First of all, hemostasis diseases such as purpura and telangiectasia which have a tendency to increased bleeding (therefore considered as relative contraindications). Anemia, on the other hand, can be associated with a high bleeding tendency so we will pay particular attention to it.

The same applies to leukemias which are particularly dangerous from a haemorrhagic point of view, so much so that they constitute an absolute contraindication unless one is in a remissive phase. Myelomas and lymphomas are associated with a simple increased tendency to bleeding.

Another pathology associated with an increased bleeding tendency is liver cirrhosis complicated by the fact that this pathological condition is often associated with diabetes. Let's now talk about the intra- and peri-operative bleeding risk associated with the various antithrombotic therapies. Let's start by looking at some numbers: the incidence. The work of Parretti et al.

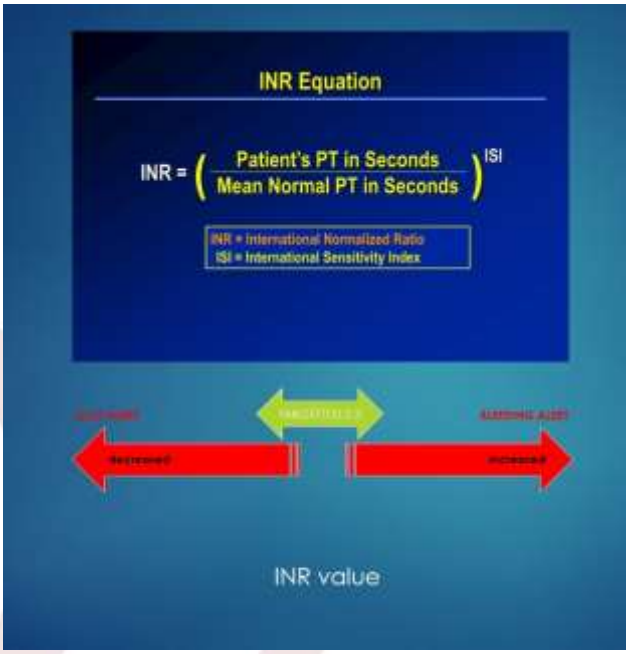


Figure 27: Parretti's work

[pict 27], which I share with you, is very beautiful. Incidence value underestimated at 1.5/2% of the entire national population. Distribution in the age range between 49 and 80 years (what is the age range of the juxta-periosteal patient?). a small step-back... why so much consideration of these inclusive criteria? For that small statement that we find in the guidelines of our ministry of health. The surgeon's task is to promote tissue healing in the recovery time.

Therefore, avoid conditions that may undermine the healing of the surgical wound by primary intention. The control of infections and secondary bleeding (those that can occur when the patient is discharged) will be of vital importance. the management of anticoagulation takes on an increasingly prevalent role for several reasons: increase in prevalence of pathologies with indication for anticoagulant therapy also due to the increase in the average lifespan of the population, improved diagnostic procedures and improved capacity for early diagnosis, greater appropriateness prescriptive with a consequent increase in the prevalence of treated patients, and above all the entry of new drugs, NOACs, which has led to greater effectiveness and above all greater safety in treated patients.

It will therefore be the task of the oral surgeon to master this topic well also by virtue of the fact that the preparation of the decoagulated patient and the related post-surgical follow-up will be conducted in close collaboration with the doctor, often associated with centers that specially manage this chronic therapy. Our task will be to best orient ourselves on the indicators of our patient's blood coagulation status at the time of surgery.

Therefore we will have to ask the doctor for a level of blood fluidity that can be assessed with the now well-known serum values pt ptt and inr. An INR value higher than 2.5 – 3 could create problems both during and in the post-surgical recovery phase.

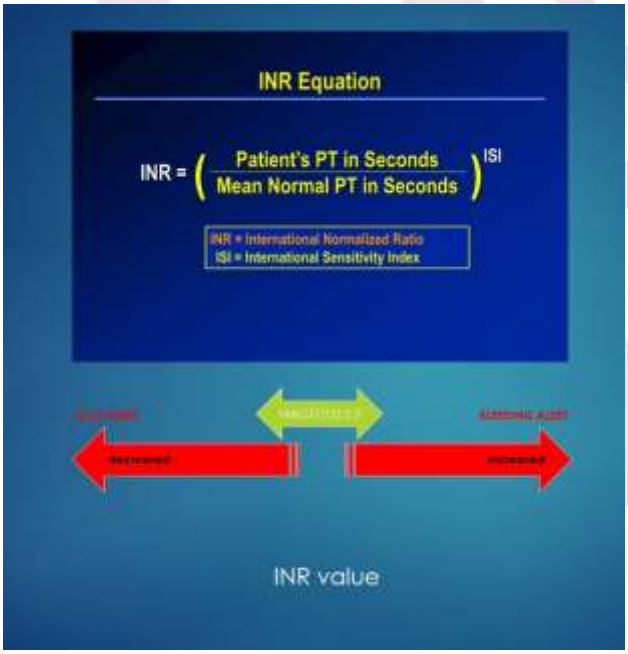


Figure 28: The inr value: a parameter affecting decision on sustainability of a surgical procedure by patient

Usually the decoagulated patient is bypassed to a heparin treatment from the day of surgery with a graduated heparin wash out and return to the original ac treatment.

3. SOCIO-ECONOMIC CRITERIA: the decisive considerations regarding the socioeconomic status of the candidate patient are few but important.

a. Dental culture: since it is a morpho-functional rehabilitation of the stomatognathic system, we will have to understand from the patient the willingness to subject the work performed to careful clinical-technical monitoring by the operating team. The patient must be available, but above all he must appreciate and feel the need for the maintenance work which must be carried out both from the point of view of periodontal monitoring and from the technical point of view of the prosthetic restoration.

As regards the first aspect, we will have to communicate and make the patient understand the open mentality towards maintaining oral hygiene performed both at home and professionally. The control of the peri-implant gingival status also presupposes a rigorous control of the prosthetic functionality aimed not only at occlusal rebalancing but also at the protective function carried out by the dental anatomies towards the gingival tissues relating to the implant site.

It is a fact that circa-implant gingival tissues are continually evolving over time. The patient must be well informed of this in order to make him participate and aware of the usefulness of continuous clinical follow-up. Social conditions, unfortunately, have a major impact on the patient's conscience/awareness regarding their oral hygiene and the absolute need to keep it high continuously over time. Therefore the identification of the lack of this awareness could represent an absolute contraindication to rehabilitation.

b. Economic Conditions: it is useless to talk about costs associated with implant-prosthetic rehabilitations. Generally comparable to those performed with endosseous implants. In principle, as the patient's economic potential decreases, expectations in relation to averagely high economic amounts increase. This is also a consideration to take into account in the overall evaluation of the patient.

4. OTHER HISTORY CRITERIA: there are some patient habits that must be considered among the contraindications. Smoking is first and foremost a case of partial edentulism associated with an uncontrolled periodontal status in a smoking patient, for example it constitutes a non-negligible absolute contraindication.

A patient who smokes no more than 4/5 cigarettes per day on a full-arch rehabilitation with a periodontal biotype could

often safely be enrolled for this type of rehabilitation. Another particularly delicate condition is the habit of drinking spirits, as this is often associated with liver disease and diabetes. The literature on the subject is still unclear due to the epidemiological statistical biases associated with this type of study.

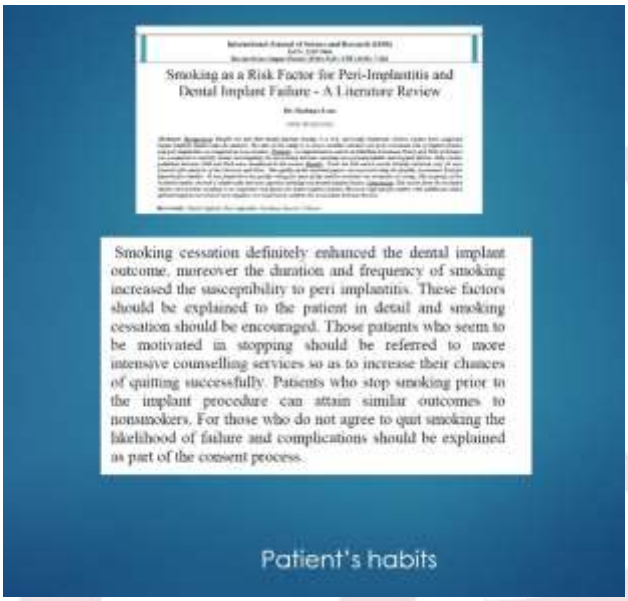


Figure 29: Patient's habits and enrolment: do smoking and alcohol assumption, effectively affect response of patient to surgery and healing recovery time?

5. SPECIAL ODONTOSTOMATOLOGICAL CRITERIA: Let us now consider the purely technical aspects that take part in the classification process of the patient eligible for IUXTAPLAN. For clarity of explanation we will differentiate four parameters currently used: an architectural one referring to the receiving implant site; a functional biomorphological one referring to the cranio-maxillary structural scheme; a mechanical one connected to the dental anatomy to be restored and to any residual anatomy; one finally connected to the periodontal biotype.

a. Maxillary Base Architecture: "the juxta-periosteal implant must be inserted into the anatomical context of the basal compartment of the two maxillae, and designed in such a way as to respect the parameters or dimensional limits placed on the three planes of space" [cit. BELLAVIA 1989].

Thus the key indication of the sub-periosteal implant is canonized: making contact with the basal component of the maxillary bone. This is related to the fact that the implant exerts a pressure force in the support area. This force would be absolutely poorly tolerated by the alveolar bone component, which, exposed to the action of a compressive force, undergoes co-directional reabsorption with the applied pressure. Applied biology and physiology teach us that the alveolar bone is part of the periodontal tissues related to the development and existence of the dental element. From this it can be deduced that in the edentulous maxillary arch, this component disappears with the loss of the dental element. Here, then, is a second inclusive criterion. The edentulous condition over time of the patient's clinical history. Not less than a year to consider the normal process of complete resorption of the alveolar process completed. Except for resective alveolar surgery in the case of dental reclamation associated with odontogenic resorption of an infectious nature. maxillary and mandibular atrophies are referred to the classifications according to Cawood and Howell and that of Minsch.

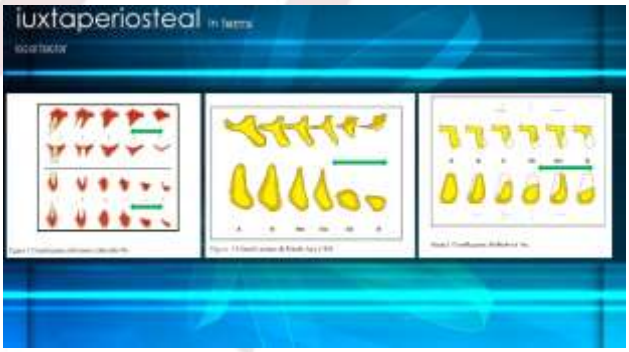


Figure 30: Bone atrophy classifications

The application concept underlying the clinical indications originates from the great chapter of therapeutic alternatives: endosseous implants and bone reconstructive techniques. In our opinion there is no discussion in the choice between juxtaperiosteal and endosteal. Also because the respective operating ranges are clearly different. This is also true in the case of the evaluation of short systems, where however a different application context remains.

However, the comparison with alveolar reconstruction techniques is different. However, in this case the considerations that must be made are of two types. First of all, a choice linked to

the effectiveness of the bone surgical techniques in relation to the degree and type of atrophy found; reconstructive techniques require expensive materials, high surgical skills and long recovery times. This presupposes a high patient expectation regarding desirable results.

b. Craniomaxillary Structure: the analysis of the architectural characterization of the facial mass and its situation with respect to the cranial base provides us with important information on mechanical schemes that can be favorable or unfavorable to the design of implant frames [DIAPO9].

Let's start from the analysis of the situation of the bone bases with respect to the sagittal plane and precisely from the reciprocal situation in the mesio-distal direction of the two maxillae and the relative situation of each with respect to the cranial base. As taught to us (Enlow -textbook of craniofacial growth- 1986), the evolution of the atrophic process of the maxillary bases following edentulism (we are talking about total edentulism) is towards a third class sagittal relationship. As BELLAVIA 1989 also suggested to us, it is the alveolar processes and the teeth contained in them which, in their evolution-development, compensate for this natural predisposition to a third class spatial relationship of the two basal bones (maxillary and mandibular).

Having said this premise, and without prejudice to the possible anatomical variations that can be found, we will recognize as potentially unfavorable, for example, a "full arch" rehabilitation of an upper jaw in the presence of a mandible that is not yet edentulous or with fixed prosthetic rehabilitations in place. This is for the angular moment of forces that would act on the front part of our implant product. The case "today's common thread" is a clear example of this.

It is also interesting to consider the situation of the bone bases always on the sagittal plane but with a cranio-caudal perspective. We are talking about the mutual rotations of the mandible and maxilla, as well as that with respect to the skull base with respect to the skull base. as regards the former, we mean the conditions of intermaxillary hyper/hypo divergence and which mechanically give an idea of the position of the occlusal fulcrum, i.e. where, along the dental arch, the maximum functional pressure is concentrated. In principle, as the intermaxillary angle increases we will have a backwards displacement of the occlusal fulcrum. This is an important data for its interpolation with the prosthetic site requiring rehabilitation. The coincidence of the prosthetic site and the occlusal fulcrum will be synonymous with a mechanically more complex situation to manage, either in terms of greater stability that the implant structure will have to support, or in terms of the design of the dental anatomies which will have to adequately discharge the axial forces and cutting on it.

However, as regards the rotation of the maxilla and mandible in relation to the cranial base, we speak of growth in pre-rotation for angles tending towards closure and in post-rotation for angles tending to increase. This data gives us an indication of the degree of compensation offered by the dentition to any sagittal discrepancy of the bone bases that goes towards the second rather than the third class. This also depends on the dental arch considered (upper or lower).

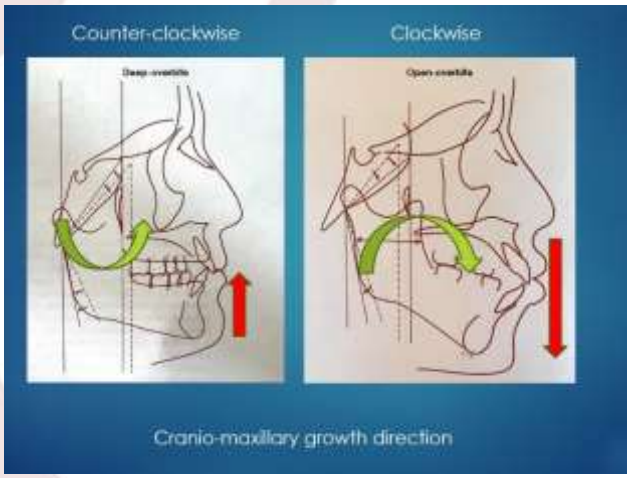


Figure 31: Cranio-maxillary growth path: the type of growth of the maxillary bone bases and, therefore, the presence or absence of compensations of the occlusal plane (therefore of the dental arches) is a very important parameter which we consider in establishing the masticatory biomechanics which will be, depending on the case, favourable or not to maintaining the stability of the implant-connection-prosthetic restoration complex.

c. Mechanical Biotype: Taking up what has just been said in terms of intermaxillary divergence, we will consider cases of

posterior partial rehabilitation of the maxilla in hyperdivergent subjects as a relative contraindication. On the contrary, in case of hypodivergence, the contraindication of partial frame of the interforaminal mandibular sector will be relative.

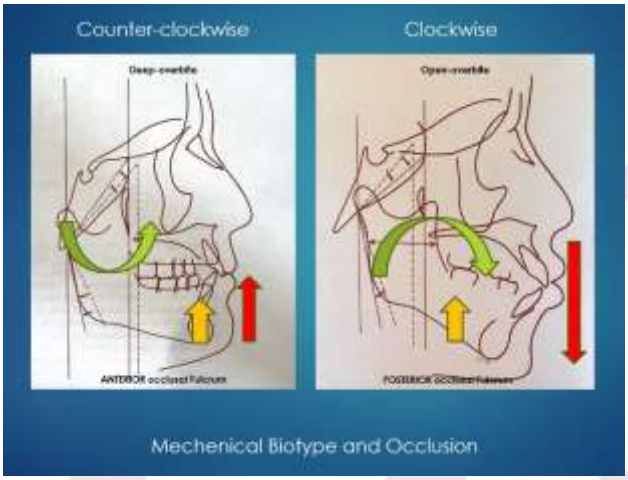


Figure 32: Mechanical biotype and occlusion: the occlusal fulcrum, and therefore the point of application of the greatest mechanical pressure during chewing, varies according to the type and direction of craniofacial growth. this data must obviously be related to the type and extent of the rehabilitation requested.

d. Periodontal biotype: the periodontal biotype is of particular importance in the prognostic evaluation that must be carried out in the diagnostic phase. First of all, the predisposition to gingival thickness could be seen as a negative prognostic factor given the greater probability of the formation of early gingival dehiscences (i.e. affecting the 30 perioperative days). In this case, this data must be interpolated with the prosthetic pre-visualization; in fact, it will be necessary to build a very protective prosthesis at the cervical level in order to protect the surgical suture as much as possible from the trauma of food and from the mechanical action exerted by chewing mm and tongue. Another important data to interpolate with the thin gingival biotype will be the edentulous time. This must be moderately longer than that required for a thick biotype (18/20 months for the former compared to the 12 required for the latter). The gingival biotype often does not pose particular problems, with the exception of the condition of extremely large bands of keratinized tissue. In fact, the ideal situation involves a condition of

keratinized band no more than three millimeters thick exceeding the diameter of the prosthetic connection.

Figure 33: Periodontal biotype: another very important factor for the prognostic evaluation of perioperative recovery

THE PROJECT

1. GENERAL CRITERIA: At this point in our journey we have now well consolidated the concept of a custom-made juxta-periosteal implant, i.e. conformed to unique technical and architectural specifications for the bone site, and therefore for the patient, for which they are requested. This refers both to the implant frame(s) and to the prosthetic rehabilitation applied to them. In this regard, let's immediately anticipate the basic concept that in our way of seeing it, and therefore in the design work-flow that we have developed and currently use, it is a prosthetically guided rehabilitation.

The technical specifications of the "core" product of our rehabilitation, the juxta-periosteal frame, will inextricably depend on the prosthesis that the edentulism encountered requires, and on the architecture of the bone site. The construction canons that authors such as Dahl, Bellavia and Mommaert reported in the literature converge on the univocal belief that prosthetic restoration and bone architectural site intervene and interact in determining the customization of a frame which will have to be dynamically resistant to the mechanical load of mastication. This is true even if the work of these three authors spans a time span of more than eighty years. From this we can obtain the first basic information: the bone site must be as faithful as possible to the real situation; let's not forget that we are dealing with digital techniques and therefore we work on Rendering or 3d images

obtained from scans (in this case radiological).

2. **Second**, we will have to have the possibility of drawing up an extremely accurate prosthetic program also based on 3 d rendering, in this case deriving from optical scans of the intraoral environment. With these two data, indexed together, we will be able to predict the fundamental architectural characteristics that our drawings must have. Indexed to each other means that they must be dimensionally and spatially referable and comparable to the real situation. We are talking about a digital recording and planning system. We record data and design structures starting from data collected with an electronic approach: scans.

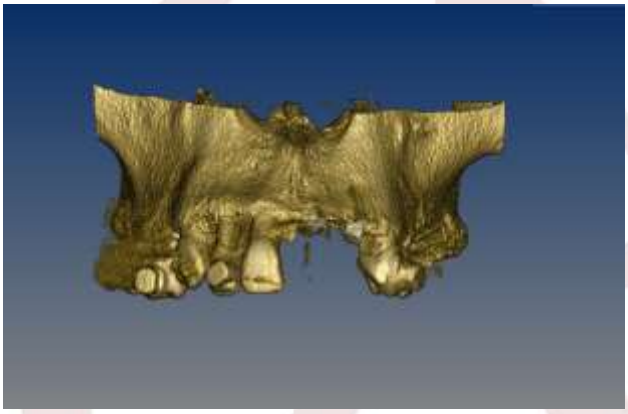


Figure 34: Radiological and intraoral scans

However, on an educational level, it is important to understand how it was done when the approach was completely analogue . Consider that I am not talking about such remote times. Just go back 10-15 years. The first more than obvious difference was that the implant structure and corresponding prosthetic rehabilitation could not be pre-visualized at the same time and spatially contextualized with each other during the design phase.

The operational sequence included an initial surgical intervention to expose the bone site and imprint it (phase corresponding to the radiological scan and subsequent rendering of the site in 3D file format). on this model the technician, and sometimes the surgeon, designed the implant structure, based solely on the site and without having contextualized (and therefore oriented) information on where the correspondence between the implant structure and the prosthetic structure should be. The frames were designed envisaging four prosthetic connections (then they were conometric connections or from cemented prosthesis). After the surgical phase (the second) in which the frame was inserted into its bony seat, once healing had taken place, the impressions of the prosthetic emergencies were recorded and we proceeded with the design and creation of the prosthesis. Another obvious advantage acquired in the digital age, and made possible by matching, the procedure that allows us to spatially align the various scans with each other in a way suited to the real situation, consists in the possibility of previsualizing and therefore optimizing the design of the fundamental unit represented from the complex bone site/implant frame/prosthetic connection/gingival mucus site/dental anatomy. This represents an inextinguishable advantage, despite the complexity that the approach to digital design highlights [pict 35].

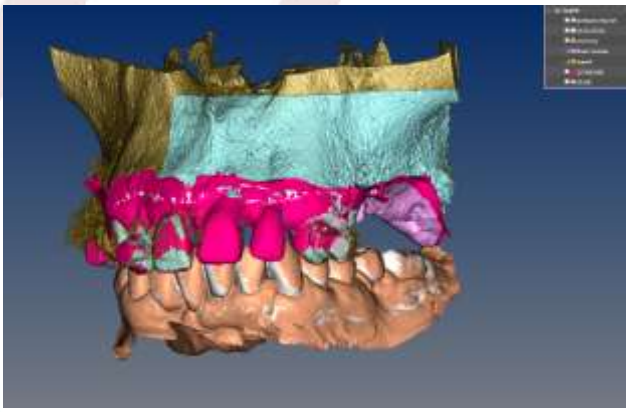


Figure 35: Matching of scans: the correspondence of the orientation of our three-dimensional renderings to the real situation of the patient allows us to design suitable and functional surgical and prosthetic devices.

So in summary, to remember as a fundamental assumption, digital technology allows us to work on all data simultaneously biometric data of the case, necessary for the implant-prosthetic project, made congruent both dimensionally and spatially to the real situation of the patient. We said that the design of the implant frame is prosthetically guided; therefore, let's start from the pre-visualization of the prosthetic restoration. We will be able to move on to the first drawing, that of the prosthesis, once the necessary renderings have been prepared and aligned with each other. Two absolutely fundamental phases, which will give us

images, let's repeat it to focus it well, dimensionally congruous and spatially oriented in a similar way to the patient's intraoral reality.

3. BONE RENDERINGS: bone data represent the most sensitive diagnostic data as the accuracy of the entire design process will depend on the correctness of acquisition. The acquisition of bone data must be carried out taking into account 1 the differences in density between basal bone and alveolar bone and the representation of each of these components in each individual case 2 the difference in constitution and therefore density between the upper and lower maxillary bases 3 of the presence of radio-reflective material (metallic structures) and the scattering phenomenon caused by them for the purposes of the post-processing action that must be performed on the bone section being worked on to make it suitable for the design of the implant frame. Where possible, it will be better to perform 3D radiological scans without intraoral metal artefacts in the area to be scanned.

The exams to be performed for the two jaws are different: in principle for the upper jaw, given the general lower structural density, a traditional tomographic exam (dentascan CT scan) will be preferred. In case of unavailability, we will opt for a CBCT scan on the condition that we can have an exam performed at no less than 110kV as, at lower voltages there would be the risk of losing important anatomical details; for the jaw, however, given the greater density of the basal bone component, a cone-beam CT scan will be sufficient. in this case the working voltage can go down to 90kV without losing the necessary anatomical definition. Obviously, for both cases, the principles of optimization and justification that are binding in the execution of any radiodiagnostic investigation on a patient cannot be overlooked.

Any radiological scan must also contain data relating to the alignment system chosen by the team. This will be discussed in detail in the chapter relating to the design phase. The scan of the bone site is provided to us in the form of dicom files. The post-processing of these files involves passing through some software that transforms the dicom files into stl files. That is, they reconstruct a volume starting (forgive me for the elementary way of defining it) from the "slices of x-rays" that make up a three-dimensional CBCT exam. Practically a series of axial tomographies ordered and spatially separated in a precise way. Nowadays the rendering of a CBCT exam is a common operation, included in the most valid software used for the guided implantology project. However, there are dedicated softwares, Invesalius/ Itk Snap/ Slicer, to name a few, which perform the task very well, giving us models with the specifications just considered. These softwares all work by recognizing the radiological structures belonging to a gantry range (i.e. gray densities with very precise values) established by us. In short, an algorithm. The result will be the creation of a mesh.

An editable three-dimensional surface formed by a set of triangles whose area, increased or reduced as we choose, will determine the density of the mesh itself; therefore, the precision with which the details of the reproduced volume will be returned. [pict36].

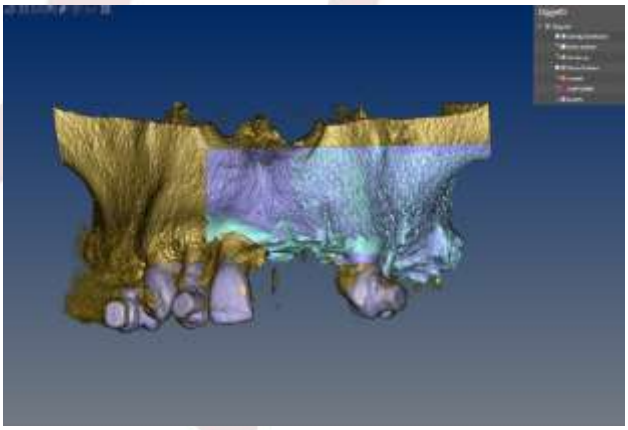


Figure 36: Bone rendering: the bone rendering must ensure absolute dimensional correspondence to the real anatomical piece to which it refers. type of examination performed, and presence of radio reflective material can alter its characteristics. rendering is a procedure to be performed with extreme caution and precision.

The data returned must also contain information regarding the alignment aids used and which we will discuss extensively when considering the matching methods.

4. INTRA-ORAL RENDERINGS: let's change register; now we are in the intraoral field and the radiological scans become optical. The object of the investigation are the gingival

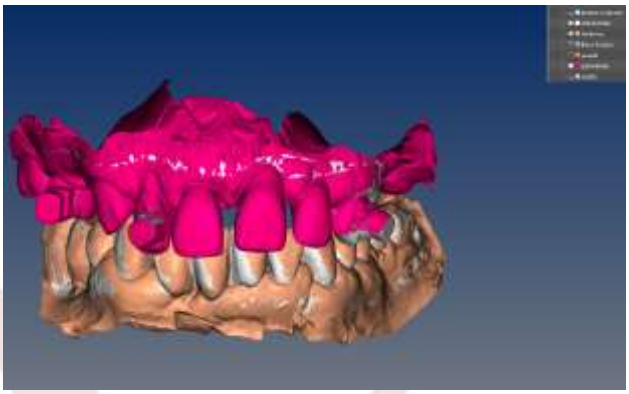
and dental tissues. Since these are structures in movement and with a reference position, the maximum intercuspation ICP (Inter Cuspal Position), dimensional fidelity will no longer be enough as a prerequisite for our recordings; we will also need a safe positional reference: the final position of maximum intercuspation, in fact. In this case, the digital approach does not have to be primitive. The scans, in fact, can be performed directly in the patient's mouth if conditions permit, or derive from plaster models obtained from traditional impressions, scanned in the laboratory with the aid of bench scanners.

The results will be exhaustive in both cases. Regarding intraoral scans, the data that is more fundamental and decisive than the others will be that relating to the soft tissues. This is in relation to the fact that the soft tissues are the local intermediary of the prosthetic connection systems between the implant frame and the prosthetic restoration itself. Obviously this data must be spatially oriented both with respect to the dental arches and the bone surface of the implant site. The imperfect correspondence of this data to the real situation will lead to errors that are difficult to compensate for in the perioperative phase and therefore in the preparation of the definitive restoration.

We will see in the next step dedicated to matching how to arrive at objectively precise and therefore useful data for the purpose of profitable planning. Also in this case the data returned will be in the form of an stl file and the volume will correspond, as in the case of bone data, to a mesh-type surface with variable density. The meshes resulting from dental scans must accurately report the data relating to the occlusal and cervical surfaces; the latter will be of useful reference in designing the aesthetics of the rehabilitation that we are about to design.

The scanning sequences are the usual ones with vestibulo-occluso-lingual/palatine pattern that we all know well. As in the case of bone data, the scans must contain, in a manner appropriate to reality, the data relating to the alignment systems deemed suitable for the current case. Particular attention will also be paid to recording the spatial position of the arches in maximum intercuspation. It is very easy for the patient to move from the correct position during the (minimum) time required for the registration itself.

The operator, therefore, must pay particular attention to ensuring that the patient maintains his ICP position during the vestibular scan of the natural closure of the dental arches. The intraoral data also includes those relating to removable prosthetic



devices, if these are used either as temporary or as intraoral stents (therefore as an alignment system.

Figure 37: Intra-oral scans

5. MATCHING: Matching, as the term itself says, is the action of pairing bone scans and intraoral scans together in a way that spatially corresponds to reality. This is achieved by using reference systems, i.e. volumes with defined geometry that can be incorporated into both bone and intraoral scans. These reference systems, given the stable position and "recordability" in both radiological and optical scans, will be profitably used both in the software that provides for the alignment of the scans, and in manual alignments always done using markers or stents as a safe spatial reference.

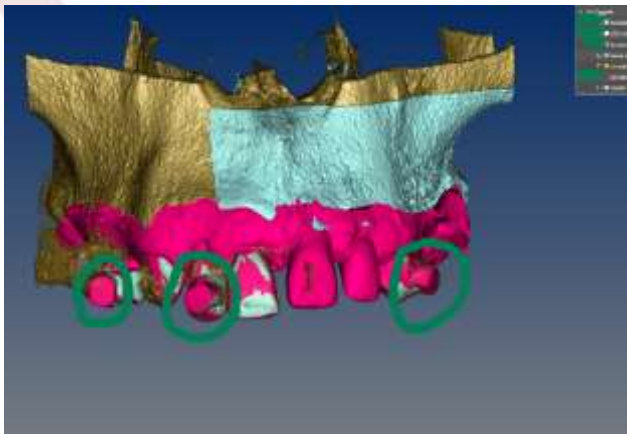


Figure 38: Matching devices: Radio opaque markers and radiographic stents, used in both intra-oral and radiological scans, make it possible to spatially align the 3D

renderings in a way that corresponds to the clinical reality of the patient.

The choice of the reference system is of particular importance for the purposes of a good relative spatial orientation of the digital scans. The difficulty is given by the fact that the radiological artefacts (scattering so to speak) deriving from any metals present in the patient's mouth at the time of diagnostic recording, can hide the matching systems which, by definition, must be radiopaque but not give scattering. Therefore, an in-depth evaluation of the intraoral situation is absolutely necessary, in order to be able to better plan the use of reference systems and both radiological and optical recording methods.

It is very difficult to categorize a universally valid decision tree for choosing the ideal optical/radiological centering system; unfortunately, the selection criteria still remain very case-dependent and operator-dependent, therefore still very dependent on the clinician's experience. However, there are some general principles that are universally valid and useful to know; Let's see what they are. First: in order to be considered "scandable", the implant site must be cleared of the presence of metals of prosthetic origin or dental residues including radiopaque materials for at least a year, the implant site must include the presence of alignment systems whose visibility would be compromised by radiological scattering.

The bone site must be healthy and not show the presence of areas of lysis or thickening such as to compromise good reading with the gantry levels chosen during the rendering phase. Second: in principle, partial edentulisms will be "marked" with intraoral markers, not failing to ensure the absence of radiopaque materials in the vicinity of one of these. The positioning will take place with a planar scheme with offset points so that the markers can allow the identification of at least a certain plane of spatial reference.

However, in the case of Total Edentulism, the Stent associated with radiopaque markers will be the most suitable reference system; do not forget that a total (or partial in the case of partial edentulism) “metal free” removable prosthesis, appropriately relined and equipped with markers, constitute one of the most profitable spatial centering systems imaginable. keep in mind that, in this case, the scan of the base of the device just described, will be of fundamental importance for the definition of the biological space occupied by the gingival tissues.

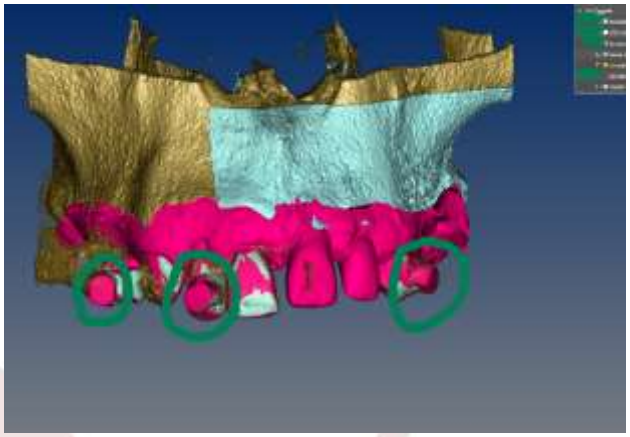


Figure 39: Soft tissues rendering: rendering and orientation of the scans relating to the soft tissues prove to be of fundamental importance for the positioning of the prosthetic connections and the parts constituting the entire implant frame.

The “point based” matching mode is the one we currently use associated with a final review algorithm which the software we chose (Meshlab) is equipped with. The result will be the return of an all-inclusive three-dimensional model that is dimensionally and spatially superimposable on the real situation of the case in the design phase; to understand the logic we will have to "see" the preparation of a sort of virtual dental laboratory in which we will be able to design any type of device, be it surgical or prosthetic.

Figure 40: Virtual dental articulator

Figure 41: Prosthetic rehabilitation layout and comparison on bone arch: the dental and bone arches must be absolutely harmonized with each other to obtain the greatest mechanical stability of the dental-implant complex.

6. THE PROSTHETIC DESIGN: the "juxta-periosteal" design is prosthetically guided. So the prosthesis will be the first element to be designed. Precisely, prosthetic rehabilitation is designed in two distinct stages. In the early phase as the first reference element and late, the implant frame is designed, for the final definition of the occlusal anatomies and the extra gingival stabilization systems, you want them to be screwed metal bars or frames with standard anatomical reductions.

In the Early phase, particular attention will be paid to the spatial arrangement of the dental elements considered from a volumetric and overall organized point of view in a dental arch system. As an arch, the occlusal plane will be taken into careful consideration (for this reason the optical registration of the bite in ICP is particularly important). Its inclination will be contextualized to that of the basiccranial and intermaxillary reference planes. The normalization of these values must be respected at all costs (even if some modification of the opposing arch becomes necessary) under penalty of the occurrence of dangerous "transfer of load" dynamic conditions for the frame-bone support interface.

As a reference of the dental elements, this drawing will be used to early evaluate the potential position of the prosthetic emergencies relative to the architecture of the available bone surface. We tend to look for extreme supports without contemplating extension elements for partial rehabilitations and a 6-3-3-6 scheme for full arch ones. This early design phase is achieved by means of pure graphic CAD software. Exocad remains the absolute reference in terms of speed, quality of STL mesh rendering and versatility in the use of design sequences. We also find the use of Meshmixer very profitable, obviously starting from standard morphologies that are poorly characterized according to the personal parameters of the case under analysis. Particular attention in this phase is given to establishing the correct inclination of the dental axes as these will act as a reference for the orientation of the bone cutting planes of any planned osteotomies.

In this phase, the discrepancy on the sagittal plane between the drawn dental arch and the bony arch referred to a crestal level is also carefully evaluated. This data will be used to evaluate the most appropriate type of rehabilitation and above all the type of extra gingival connection system most suitable for the specifications encountered.

7. THE POSITIONING OF THE PROSTHETIC CONNECTIONS: It represents a delicate phase of the entire design process, as we are still in the process of searching for inclusive criteria. This means that the evidence of an absolutely unbalanced position of the prosthetic connections could represent an absolute contraindication to the execution and therefore to the favorable prognosis of implant rehabilitation. For this phase we move into the environment of a semi-parametric CAD, or mixed if you prefer. Rhinoceros to be precise. We start from the reverse engineering of the original Sweden mathematics which we align according to the axial body axis in correspondence with the dental elements chosen as the location of the prosthetic emergency and therefore, in return, as the location of the fixing screws of the extra gingival structure to (or) the implant frames.

All prosthetic emergencies must be parallel to each other to avoid overtension and non-passive fitting of the metal structures. On the transverse plane, the emergencies will initially be positioned halfway along the stretch between the center of the tooth and the relative center of the bone crest. This is to facilitate the final prosthetic design. The ideal situation of the prosthetic emergency is considered to be the best spatial relationship between centre-ridge/centre-tooth/centre-keratinised gingival band.

This condition would obviously correspond to a first class

skeletal and dental situation, a situation which in the clinical context of these rehabilitations appears very rare if not impossible to encounter. Anatomically speaking, the bone and gingival sites always appear quite aligned with each other. The deviation generally occurs, on a spatial level, between these two and the center of the tooth. Still on the transverse plane, with aging and edentulism this discrepancy is represented by a movement towards the anterior vestibule of the center-tooth in the upper arch, and a posterior-lingual one in the case of the mandible.

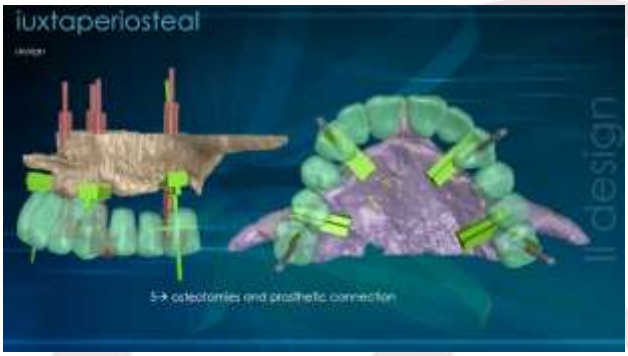


Figure 42: Positioning of prosthetic connection: the emergence of the prosthetic connections will be harmonized in relation to the gingival tissues, the dental curve, and its position relative to that of the bony arch.

Undoubtedly the most important reference criterion will be the position relative to the gingival anatomy. The neck of the prosthetic emergency must certainly be positioned in correspondence with the keratinized band, in order to avoid mucositis phenomena or early symptomatic gingival dehiscences.

8. PREPARATION OF THE BONE SITE: the work that must be done on the bone site, once rendered, will not be burdensome. In principle, it must be prepared and made congruent with the design of the implant frame. First of all, the errors included in the newly formed mesh with rendering will be corrected and any scattering still present will be eliminated. An original version will be kept, to verify that the new mesh resulting from the design steps does not deviate from the original volumetry.

This first step will be conducted through the use of a graphic CAD. By moving to a semi-parametric CAD environment, bone rendering will be associated with that of the prosthetic design and with the oriented rendering of the soft tissues. This operation will be necessary if it is necessary to design crestal bone sites suitable for the passage of any communicating arms. The decision whether or not to perform these osteotomies will depend on the crestal morphology (generally necessary in the case of atrophies with a severe horizontal component such as the Cw sec classes, both the mandibular and maxillary Misch classification where obviously it will not be possible to perform reconstructive surgical schemes). In this regard, the design of the osteotomy margin in relation to the mucogingival line and above all to the architectural equator of the bone section in correspondence with the cut takes on particular importance.

The cutting plane must always be above the bony equator to avoid excessively pronounced angles assumed by the prosthetic plate-communicating arms transition. Furthermore, the osteotomy margin must always be positioned below the mucogingival junction.

The existence of both of these conditions constitutes a sine qua non for judging osteotomies to be performable. If they are necessary and executable, again in the Rhinoceros environment, osteotomy volumes will be positioned appropriately associated with volumetric aligners. These will be aligned as much as possible to the corresponding dental axes (the same elements where the prosthetic connection is located), obviously not to the detriment of the positional prerequisites we have just talked about. The virtual osteotomies will be performed using subtractive Booleans and will be the site of the design of the prosthetic support plates which we will talk about later.

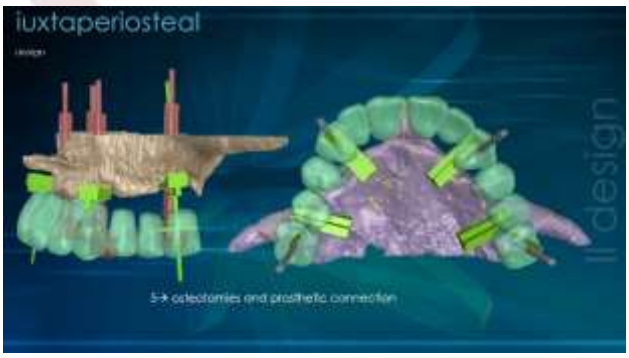


Figure 43: Osteotomies: the plane of the osteotomies must assume an ideal inclination to transmit the load of the

corresponding dental element in a favourable manner to the bone plane in order to avoid compression reabsorption and therefore the risk of dehiscence.

9. THE DESIGN OF THE IMPLANT FRAME: in principle we can say that the different components of the implant frame are designed in different CAD environments and then assembled together. At this point in the project we find ourselves having already established some of the parameters necessary for the implant design. Precisely, we will already have an idea of the prosthetic restoration and its functional characterization in terms of points of greatest stress. From this we will deduce where it will be necessary to apply the greatest mechanical resistance.

Again in relation to the prosthetic pre-visualization we will have established the position of the prosthetic emergencies and the situation/position of any osteotomies which will be the physical point where the support plates of the prosthetic emergencies will be placed. The available bone rendering will allow us to identify the basal consoles useful both for fixing the frame through the osteosynthesis screws and for the passage of the structures that will act as support for the implant. The general premise of the design is to have a structure as thin and narrow as possible which leaves as much space as possible for a bone-periosteal interface free to recreate the original anatomical continuity.

The Delimiting Arms will be designed in their entirety only on the vestibular side of both the mandible and maxilla. They are plotted in a graphic CAD environment (Meshmixer) with a maximum offset of .01. the average width never exceeds 3 mm with the exception of the points where the synthesis screws pass where the width reaches almost 5 mm. The thickness can vary from .7 to .9; similarly, always in a graphic environment, the Prosthetic Plates are drawn and extruded with the same offset and thickness values. A second graphic CAD (Exocad) is useful for the design of communicating arms which can usually be drawn as a single bar structure or as a pair of bars of constant thickness and cumulative width not exceeding the default value of 5mm.

The first part of the assembly ends with the additive Boolean of all these components. Finally, the necks that will host the prosthetic emergencies are assembled and welded to the structure again using an additive Boolean. A subtractive Boolean will instead be used to create the passageways for the osteosynthesis screws, normally in numbers between 5 and 7. A greater number is rarely envisaged. the process is completed by checking the mesh to free it from any errors or distortions produced during the assembly phases and by a very light final smoothing. Generally, the meshes produced with this system will be characterized by very dense wireframes and therefore of excellent graphic and structural quality.

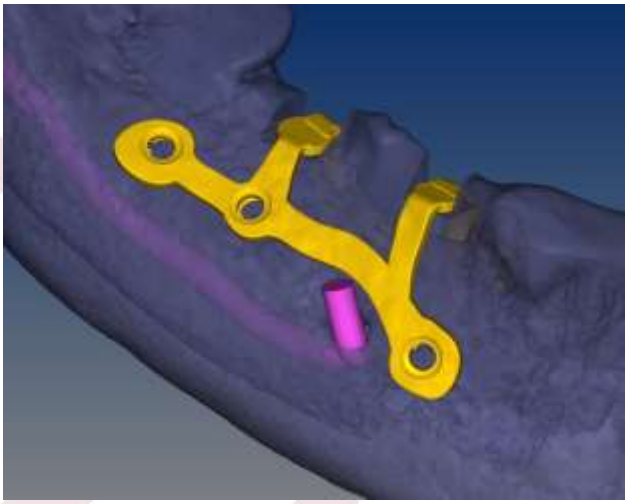


Figure 44: The frame: the frame will be drawn entirely in its corresponding parts, localizing each component as best as possible, to explain its function.

10. THE EXTRAGENGIVAL STRUCTURES: among these we include the connection systems which can be shaped like a bar or a reduced pontic depending on the clinician's choices. Both of these start from the definitive design of the dental anatomies. Also for this phase we are in the Exocad environment.

The starting request to start the design flow consists of a position of the scanbodies corresponding to the prosthetic emergencies. we obtain this information from the alignment system that we have previously used with the alignment systems of prosthetic emergencies, one component of which consists exactly of the original scanbody.

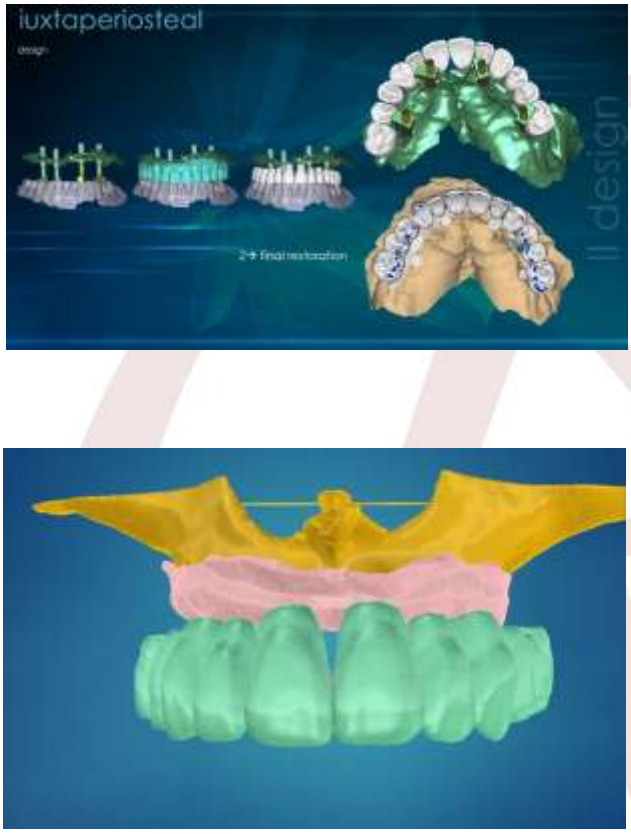


Figure 45: Final restoration design: the design of the cuspal anatomy will provide a corresponding function suited to the resistance offered by the implant frame.

The combination of the 4 scanbodies corresponding to the prosthetic emergencies with the gingival tissues creates a sort of digital imprint, requested by the CAD as a starting point for the design flow.

Once a virtual articulator has been created, the four positions relating to the virtual scanbodies will be recorded and then we will proceed in a guided Wizards which will draw the bar in a very limited time allowing the technician to make all the required changes. At a later stage, in a technical environment different from ours, both the temporary prosthetic structure and the connection system screwed to the bar itself will be designed.

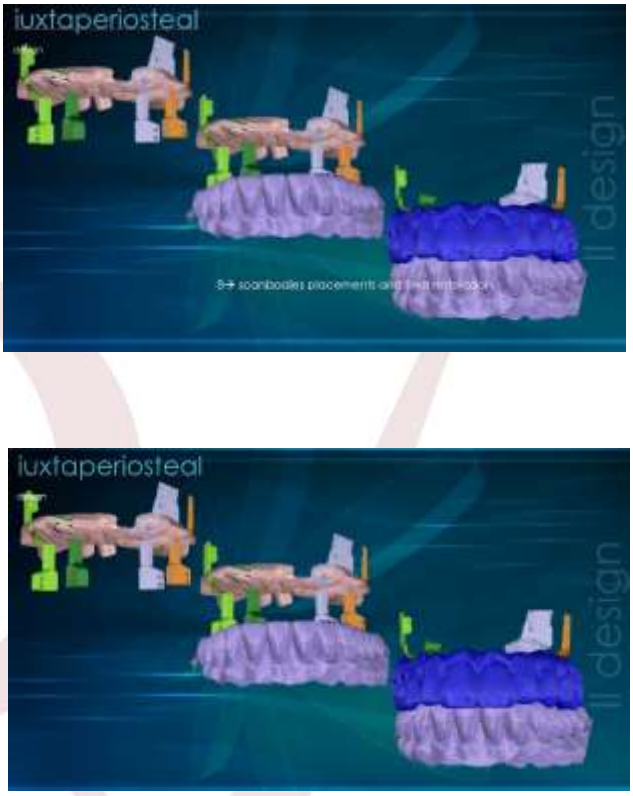


Figure 46: Scan bodies placement

11. THE PROSTHETIC RESTORATION: constitutes the final step of this design path, but not for this reason the least important. This phase is also managed by Exocad starting from the mobile prosthesis or partial prosthesis module depending on the needs. in this phase the occlusal and cervical anatomies are treated with the utmost attention. The former to guarantee soft disclusion pathways with very well balanced group contacts, the latter to guarantee the best anatomical interface between the dental element and the mucus-gingival site.

The design of the dental equator, in this sense, assumes fundamental importance regarding the protective action that it can exert in the transmucosal passage area of the prosthetic connection, a protective action from the trauma of food during chewing. Also in this case the flow is very simple and always very well guided by the software.

The files produced are of excellent quality. Once complete, they are sent to the internal company production center, which will carry out the general review of the project, the preparation of the CAM phase and the production of what is requested.

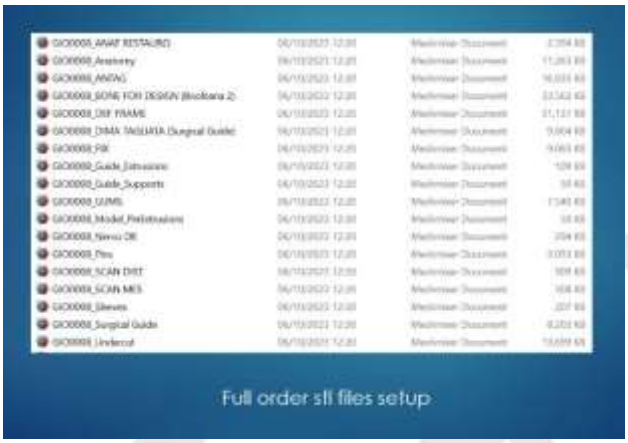


Figure 47: The complete order set up: the different components of the final project will be translated into stl files to be sent to the chosen production center.

The project is shared with the relevant clinician who may request changes and updates.

DENTAL MATERIALS

Talking about dental materials means facing a double argument. Technique, concerning the biological and biomechanical characteristics of the materials themselves which will come into intimate contact with the vital tissues that make up the rehabilitation site and also concerning the production techniques that allow their use. Practical argument, secondly, about costs and production logistics associated with each of these. The evolution of materials, in this case materials associated with surgical-rehabilitative techniques, is the epiphenomenon of a truly impressive cognitive process, which originates from the clinical examination of the successes and failures linked to that technique, and is articulated in hypotheses of work aimed at resolving the problems encountered, to arrive at the resolution of the original problem, in this case mediated by the choice of new materials, increasingly performing and responding to the clinical needs prefigured in the adverse event recorded. But let's see what this approach to the clinical problem has led to. Which materials are proving to be decisive in the field of "juxta-periosteal" implant-prosthetic rehabilitations? for sure titanium and pmma-graphene.

The technical evolution marked by the transition from the analogue to the digital era has manifested performance requirements regarding both the implant frame and the prosthetic restoration with regards to the implant structure, the experience accumulated in terms of osteo-integration and biocompatibility in the field of endosseous implantology, has meant that cobalt-chromium was supplanted in favor of the latter.

The evolution of the digital approach, then, has found fertile ground in titanium and its alloys for the application of new production techniques such as additive or subtractive ones, and for a custom product such as the juxtaperiosteal frame, this has proven to be successful both in terms of costs and precision achieved; but we will talk about it in detail later, always in this module. Prosthetic restoration topic. We said rehabilitation of patients in developmental age, therefore occlusal assets mechanically different from those of young ages, occlusal biomechanics to be "lightened", in short a biological condition of the implant site and mechanics (the transfer of load) linked to the implant itself which have made It was necessary to use a "soft" material that would undergo the physiological process of erosion in a similar way to the natural dental element.

Here are pmma and graphene. Two materials which combined together, as we will see, will give the prosthetic restoration the necessary characteristics of hardness, flexibility and aesthetic performance. So a module, perhaps even a little boring apparently, which will talk about materials, production techniques, costs and bio-functional performances. The future, in

short. We will also talk about how we have made everything that comes from the pen of our projects "ready to use". Let's start with titanium, let's start with surgery.

1. **TITANIUM:** there is tons of literature on this metal, especially on the metal alloys derived from it. Let's start with a job. More than enough to introduce you here. 2022, Cell Press E. Hoque et all. “Titanium and titanium alloys in dentistry. Current trends, recent developments, and future prospects” [1].

Historic. The growth of titanium as a surgical material began extensively in the early 1980s. It is officially recognized as a biomaterial for its recognized properties and internationally recognized use and applicability. Low elastic modulus, low specific weight, extraordinary corrosion resistance, extraordinary weight-hardness ratio, extraordinary tribological properties.

In short, all it takes to become the first choice in the surgical field, regardless of sector and application. Even if the application sector is very clear. Reconstructive prosthetic surgery. Other reasons for the success of this material? Certainly one above all. The manufacturing of prosthetic products. Precisely because of their "prosthetic" characteristic and therefore more or less extensive customization, the need was created to be produced with techniques of digital origin.

And titanium has been seen to lend itself well to this. One in particular, linked to the cad-cam world, will prove to be perfect: additive technique; let's call it what we want. 3d printing, Additive Manufacturing.

This innovative technique has proven effective and indicated. Let's talk about biocompatibility. That is, effects caused by the release of metal ions. Toxicity, carcinogenicity linked to the release of metal ions following the corrosive processes undergone by the metals themselves and hypersensitivity are reactive modules. Bio-corrosion and tribo-corrosion are the fundamental mechanisms. This elicits the normal inflammatory reaction mediated by lymphocytes and macrophages which mediate the release of cytokines and metalloproteases.

In this regard, 3D printing has shown the ability to make a product that meets the requirements necessary for the biocompatibility of the product to be guaranteed. Let's briefly look at the characteristics of titanium. First of all, the one used in medicine is an alloy of titanium and not pure titanium.

Figure 48: Characteristics of titanium

BIOCOMPATIBILITY The absolute absence of inflammatory or immune-mediated reactions of titanium has long been demonstrated. Depending on the tissue behavior in the vicinity of a titanium implant, we define the material as "bio-tolerant" when distant osteogenesis interactive with the metal at the bone-implant interface is noted. “bio-inert” when there is contact osteogenesis and “bio-active” when there is contact between metal and osteogenesis. Both of these characteristics are the prerogative of titanium alloys used in medicine.

HARDNESS: The ability to resist pressure forces before deformation and breakage. The various titanium alloys have different hardness and therefore resistance modules.

FLEXIBILITY: The ability to deform and return to the original shape once the applied deforming force has ceased. The biomaterials that interact with the bone tissues must have elasticity modules absolutely comparable to the bone ones in order to avoid reabsorption secondary to the transfer of the load through the applied metal structure.

MAGNETISM: Titanium is non-magnetic. This is particularly useful in the case of nuclear magnetic investigations, which irremediably heat the ferrous and therefore magnetic components.

Relatively low **COEFFICIENT OF THERMAL EXPANSION** compared to other metals. Characteristic that makes it compatible with interaction with glass-ceramic materials.

SHAPE MEMORY The characteristics of the Nickel-Titanium alloy used for the construction of endodontic instruments and orthodontic wires are well known.

EXCEPTIONAL CHEMICAL PROPERTIES are the resistance qualities of titanium to corrosion in the "intraoral" environment. The resistance to the corrosive action of biological solutions in the intraoral environment is due to the formation of an oxidized surface layer (TiO2).

WEAR RESISTANCE The Young's modulus of titanium and its alloys is relatively low and comparable to that of steel. For this reason, it shows particular resistance to erosion. In [DIAPO2] we can see the values of the physical parameters, compared to the different titanium alloys.

OSEOINTEGRATION I believe it is useless to discuss this characteristic as it is now an established fact, such as the surface treatment of titanium, modifying its "hydrophilic tension".

HYDROPHILIC TENSION a hydrophilic tension >30mN/m characterizes surfaces defined as hydrophobic. However, if the value is <30mN/m the surface is defined as hydrophilic. Obviously this condition is preferable to hydrophobicity due to the greater predisposition of the surface to attract and retain biological liquids such as blood and fibrin serum, the first step in achieving ideal integration.

ANTIBACTERIAL PROPERTIES precisely in relation to its hydrophilic properties, is biologically exposed to bacterial colonization and this concept comes to us from the study of peri-implantitis. However, surface treatment with silver, titanium chloride (cl)nitrite (TiN), hydroxyapatite and hyaluronic acid counteract this trend very well. Let's now look at the titanium processing methods.

FUSION: the melting temperature of titanium is high, more than other alloys used in dentistry. Furthermore, since titanium oxidizes easily at high temperatures, an inert gaseous environment must persist. Its low density also implies the need for fusion to occur at a controlled pressure regime.

ADDITIVE TECHNIQUES The additive method is based on the use of metal powders deposited and melted with a "layer upon layer" approach. This type of technique has developed within the flourishing of the digital method of acquiring bone volumes and beyond. From scans, through volumetric renderings processed by CAD software, passing the information into a CAM (computer aided machining) environment to control the "printer" responsible for the work.

The reason for the success of this production method is inherent in the ability to reproduce extremely complex shapes from three-dimensional renderings, with optimal metallurgical characteristics when related to the purely surgical use for which they are intended.

All at an engineering and production cost that is low compared to, for example, subtractive techniques. Various methods are part of this technique. The one that best suits the production of surgical devices of small dimensions and complex shapes is the so-called PBF (power bed fusion) where a high-power, high-density laser beam sinters the metal starting from a powder, with an LBL (layer by layers).

The technique is versatile and usable for a wide spectrum of alloys, for which, sometimes, subtractive techniques cannot be used. The only weak link could be the maintenance of the structural uniformity of the printed model, a problem however largely mitigated with the latest generation printers.

SURFACE TREATMENTS Very important and operable with different techniques, surface treatments are carried out to "set" characteristics such as hydrophilicity, adhesiveness of glass-ceramic materials and biocompatibility.

We distinguish different levels of treatment approach depending on the scale of action with respect to the size of the surface to be treated, i.e. Large, micro and nano-sized treatments. The fields of

application are truly multiple and range from orthopedic prosthetics to maxillofacial surgery. Especially in Dentistry we find different fields of application, all consolidated in common use.

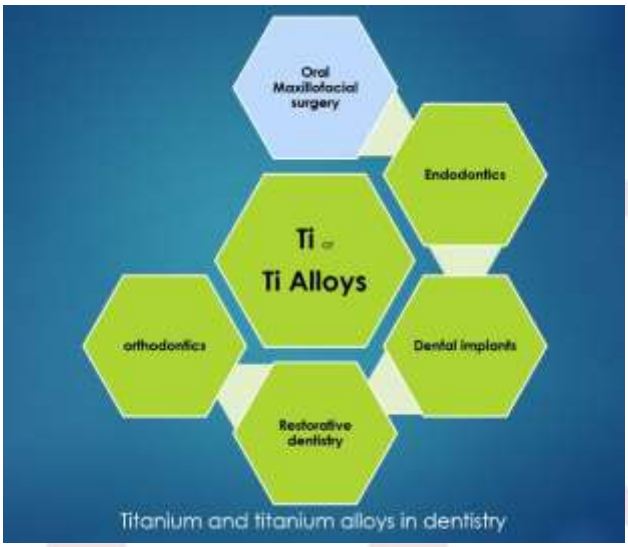


Figure 49: Fields of use for titanium in dentistry

2. PMMA: A wide range of polymers are commonly used for various applications in prosthetics. Polymethyl methacrylate (PMMA) is commonly used for dental prosthetic applications, including the fabrication of artificial teeth, denture bases, dentures, fillings, orthodontic retainers, temporaries or temporary crowns, and for the repair of dentures. This is in relation to the physical and mechanical characteristics including low structural density, good aesthetic characteristics, and ease of processing. Resistance to pressure and bending increase its usability for the construction of prosthetic products. The history of this material dates back to the mid-nineteenth century, when it was synthesized starting from acrylic acid. Its use in dentistry dates back to 1940.

From here it began a constant growth as a synthetic material for dental prostheses up to the present day where, with the combination of graphene, it reaches truly high performance levels. It is a synthetic polymer prepared through the addition of free radicals and the polymerization of methyl methacrylate to give poly methyl methacrylate. Condensation to solid can occur, depending on the type of polymer, hot, cold, or via ultraviolet light.

Dental use requires that it retains its basic characteristics net of adverse toxic reactions in contact with tissues and biological liquids or free from mutagenic or cytotoxic phlogistic power. However, it must remain highly insoluble in contact with saliva, not cause release of toxic substances in contact with food and show excellent adhesion qualities with dental tissues. the elastic modulus must remain high and stable over time [pict50].

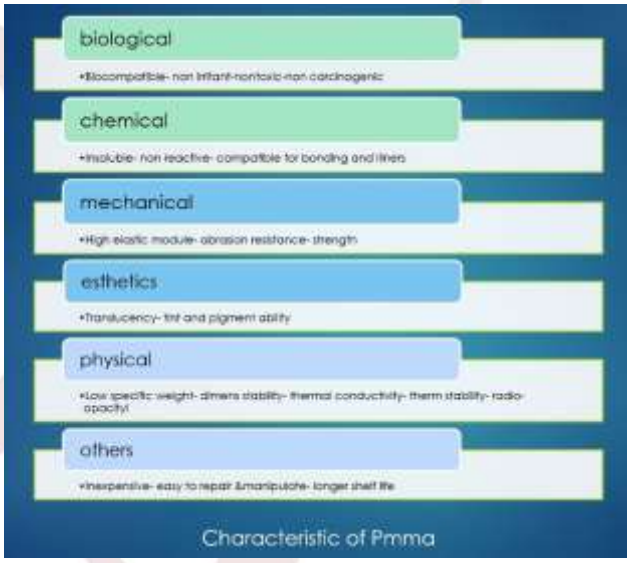


Figure 50: Characteristics of pmma

The presence of residual unpolymerized monomers could cause gingival irritation. This could depend on an incorrect use of liquid monomer during the cold mixing phases. Pmma absorbs biological fluids due to the molecular polarity that characterizes it. This also influences its reduced dimensional stability. The thermal conductivity of PMMA is low and this could prevent the patient from recognizing the temperature of the food chewed and then ingested. Photocurable PMMA showed minimal monomer retention and shrinkage during polymerization. The modulus of rupture as well as the surface hardness depend on the type of PMMA considered. The teeth in this material are produced industrially using pressure or injection techniques. Hardness, elastic modulus and wear resistance are lower than those of porcelain and natural teeth, making it a suitable material for our prosthetic restorations.

3. GRAPHENE: With the development of nanotechnology, nanomaterials have been used in the dental field in past years. Among them, graphene and its derivatives have attracted great attentions, due to their excellent physicochemical properties, morphology, biocompatibility, multi-differentiation activity and antimicrobial activity. Graphene is a two-dimensional monoatomic nano-structure made of carbon. It is currently considered the hardest and thinnest structure ever synthesized. It is a compound originating from sp2 hybridized carbon atoms organized in a two-dimensional honeycomb structure. It is synthesized from carbon through various methodologies, including the best known, direct synthesis and chemical vapor deposition (CVD chemical vapor deposition).

The study of this material on its applicability in the biomedical field obviously starts from the evaluation of its biocompatibility or its cytotoxicity. Several prospective studies demonstrate its dose-dependence and precisely, for concentrations lower than 20microg/ml a very low cytotoxicity coefficient occurs, which becomes more evident at concentrations higher than 50microg/ml.

Furthermore, it has been demonstrated that the phenomenon of surface activation (referring to the cell surface) has no effects on cell viability. Let us now look at its salient characteristics as done for titanium. In vitro studies [1,2.3.4.5] have demonstrated and highlighted numerous characteristics of this material; **MULTI-DIFFERENTIATION** understood as osteogenic and regenerative properties on the dental pulp. Bone marrow cells, mesenchymal stem cells would be susceptible to this differentiation-stimulating action. In this regard, graphene has been used as a scaffold for the reconstruction of bone segments of jaws and skull, at an experimental level in laboratory animals.

ANTIBACTERIAL PROPERTIES Since 2010, the antibacterial properties of graphene have also been confirmed, especially when associated with Carnosine (GO-carnosine), GO-carnosine-Hap hydroxyapatite, demonstrating the ability to reduce the bacterial load of Str. Mutans by up to eighty% compared to the original one.

ADDITIVE MATERIAL We now come to the prevalent use in the dental field: additive to PMMA in the construction of dental prostheses. graphene is currently added to PMMA, a material widely used in the construction of temporary and permanent mobile prosthetic devices. Very versatile in terms of ease of processing and cost, it has characteristics that make it suitable for its intended use, including the low modulus of elasticity, the chromatic characteristics that make it an aesthetic material and easy repairability. The limitations instead consist in the poor resistance, the large coefficient of contraction with polymerization, and the imbibition by biofilm. Graphene compensates for the strong imbibition of PMMA, confers antibacterial qualities and increases its hardness. The question remains what is the right concentration of graphene in order to improve the mechanical characteristics of PMMA, also taking into consideration the fact that the black color of graphene could negatively influence the aesthetic performance of the resulting material. It must be concluded that studies on the properties of the pmma-graphene association are still at an early stage and that many more need to be conducted.

However, the characteristics of this association have given promising results in the field of prosthetic rehabilitation, especially in relation to the peculiarities that the prosthetic material itself must have in relation to rehabilitations on juxta-periosteal implant structures.

Figure 51: Pmma and graphene association

4. THE IUXTAPLAN PRODUCTION: the key concept on which the entire IUXTAPLAN program is developed is the so-called One Shot Approach, that is, assembling the entire

rehabilitation, both implant and prosthetic in the same session, in order to immediately functionalize the inserted implant and re-establish correct mechanics masticatory. We will therefore deduce that the patient will undergo procedural steps in the order: surgical, to install the implant and the related prosthetic connection systems, then prosthetic, to mount the prosthesis in its definitive location, and finally periodontal, to guarantee the correct asset of the prosthetic restoration-gingival tissue interface, so as to promote healing by primary intention.

Each of these phases requires materials to be completed correctly; hence the fundamental need to equip the clinician and his medical and paramedical team with everything necessary for the correct carrying out of the individual steps just listed. It will be the manufacturing company's task to think about what is necessary for the first two operational phases, therefore for the surgery, obviously excluding the materials used, and for the assembly of the prosthetic restoration. The periodontal finalization phase only requires materials commonly found in operational clinical units, therefore, having already spoken about it previously, it will not be discussed here.

The [DIAPO5] illustrates everything that is provided to the clinician, therefore what will be assembled on the patient. Let's see it in detail:

a. SURGICAL KIT: we will describe the materials used following the procedural order used in the operating room:

i. Sterolithographic model apparently not useful, it turns out to be of fundamental importance for evaluating the final position that the implant frame will have to assume in its seat. It generally derives from an additive process by printing from photopolymerized liquid methacrylate resin "layer by layer". Subtractive production from a solid wafer is rare, due to size and obviously cost problems.

ii. Osteotomy templates same additive procedure used for stereo lithographic models. Polymethyl methacrylate with liquid immersion and photo-polymerized printer.

iii. Implant frame here we are with grade 5 titanium, precisely the Ti-6Al-4V alloy, tensile strength coefficient 954MPa; yield coefficient 729Mpa; elongation coefficient: 10%; hardness 346 VHN. Full-digital procedure. Hdens Standard Triangulation Language formed by semi-parametric Cad transported into a CAM environment. PBF (power bed fusion) additive process sintered by high density laser with LBL approach. Subtractive recovery on a numerically controlled milling machine for prosthetic emergencies, and to give a "machined" effect to the surface approximal to the overlying soft tissues. Classic decontamination treatment and delivery to the Clinic in non-sterile conditions.

iv. Extra gingival connection bar has same procedure, same materials. The subtractive shots also aimed at creating the seats for fixing the prosthetic restoration.

v. Fixing screw kit for subtractive production with CNC lathe. Both for fixing the implant frames to the bone sites and for fixing the prosthetic components.

Figure 52: Positioning of prosthetic connection: the emergence of the prosthetic connections will be harmonized in relation to the gingival tissues, the dental curve, and its position relative to that of the bony arch.

b. PROSTHETIC KIT: essentially consists of the prosthetic product. Similar procedure used for the implant frame, therefore full-digital approach, additive construction procedure starting from poly-methyl-methacrylate with GO added in a concentration < 20microg/ml. [SLIDE6].

CLINICAL ASSEMBLYMATERIALS

Arriving at the moment of surgical assembly of a juxtaperiosteal implant means being at the culmination of a path, a cognitive and application process which, starting from a

complex cognitive investigation on the patient's conditions, through the application study of a precise data acquisition strategy clinical and a complex and articulated design flow, leads to the design, and therefore to the production of a custom implant-prosthetic product with the essential requirement of "function". Furthermore, do not forget that already in the planning phase, the expert clinician with his CAD designer will be able to "outline" an ad hoc surgical strategy for the current case.

In fact, in our clinical practice, the designer's work on the computer never ignores the very close interaction with the surgeon and the operating room technician, who will now identify the strategies suitable for preparing the implant site in the way most suited to the design outlined by the technician cad, they will now ask for modifications dictated by technical-executive difficulties in relation to the size and situation of one component of the implant frame rather than another.

Only such "integrated" team work will lead to the first determinant of rehabilitation success: the perfect design of physiological and functional rehabilitation. But it will be in the operating room that the culmination of this first great technical effort will take place. And it is precisely the operating room, its meticulous preparation, the technical phases and the interaction of the surgical team, all oriented towards perfect synchronization and organization, that we are going to talk about in this module. Personally, I have arranged for the surgical team of which I am part to ALWAYS carry out a pre-operative and a post-operative briefing; in the first, the case will be presented to the team, any anamnestic facts will be highlighted which may highlight problems related to the primary healing of the wound, or negative findings regarding potential bleeding problems.

The rehabilitation project and the implant and prosthetic artefacts will be presented, an opportunity to highlight technical criticalities in the operational steps, both to the second operator and to the first instrumentalist, who will translate this information into an operational strategy regarding any changes to the standard plan of use of the surgical instruments, in relation to particular requests from the operators. Particular attention, in this first technical approach, will be paid to the anesthetic strategy in relation to estimates of the duration of the procedure and to any patient requests regarding strengthening of the anesthetic phase through pharmacological sedation of different types and depths. The choice in this regard is up to the two operators, however it is taken together by the entire surgical team in a manner suited to the requests and expectations of the patient to be operated on, obviously safeguarding his general health by not exposing him to potentially dangerous or ineffective treatments.

A fundamental premise in defining the operating room conditions for this type of surgery is the fact that the patient candidate for surgery does not have conditions of local sepsis due, for example, to periodontal diseases that are not perfectly controlled and resolved; from this derives, in addition to the fact that a metal structure is implanted in the patient's body, the need for absolute compliance with the strictest possible asepsis rules, either in the oral cavity, therefore in the exposed operating site, or in the operating room itself precisely regarding the handling of fixtures and implant components which from the external environment must be positioned under the patient's gums. From this derives a strategy, and therefore, the implementation of actions on the operators, on the room and on the patient himself, aimed at protecting the achievement and maintenance of these absolute aseptic conditions. But let's see in detail the preparatory phases of the room, patient and surgical team, to then follow the standard operational steps we use.

1. **OPERATING ROOM LOGISTICS:** As anticipated in the preface of the module, in the moment before surgery, all attention must be paid mainly to preventing cross infections, as contact with blood and saliva increases the biological risk factor. The term antisepsis defines a set of methods that prevent the proliferation of existing bacteria or the pollution of exogenous bacteria. Using an Aseptic technique is the most sophisticated level of preparation and is ideally implemented with 2 or more assistants. It guarantees high levels of sterility, and eliminates the possibility that contaminants can invade the operating field, putting patient safety at risk. Thus, the task of the non-sterile assistant will be to prepare the Operating Room, the instruments, the patient and the operators, arranging the Room so that the steps between the various characteristic phases of this typology can be carried out in a fluent, easy and timely manner. of complex intervention.

a. **THE OPERATING TABLE.** The first thing to do will be to protect the surgical table with a cover to protect materials such as Betadine and Rifocin which could accidentally fall and irreversibly dirty the seat, then move on to applying protective

barriers on surfaces and handles. We respect the principles of ergonomics, implementing the rules of elementary movements, and the economy of movements, but by choice and in agreement with the team members, we prefer to carry out this surgery standing. To ensure adequate vision of the field and comfort for Medical and Paramedic personnel, given the duration of 60 -90 - 120 minutes, once the patient has been seated, the seat will be positioned completely in a horizontal position and at the maximum height or in any case at sternum height of the clinician, parallel to the head, knees and feet, maintaining a working distance of 35-40 cm

b. LIGHTING We will position the light beam of the surgical lamp parallel to the direction of vision with the aim of obtaining beams of light without shadows and which generate depth lighting, with a good balance between the lighting of the working field concerned and of the oral cavity as a whole.

c. THE MOTHER AND SERVANT TABLES We will set up the mother table and servant table near the operating table with all the necessary instruments available, therefore we will have our mother table and servant table with everything necessary arranged on it, in a sequential manner, such as:

- Optragate Regular or small mouth opener – ampoules with Anesthesia inside a container containing chlorhexidine + short needle / long needle, Carpule syringe and Paroject syringe already assembled – long handle blade holder with scalpel blade 15 already assembled and 2 or 3 blades at hand, Langenbeck retractor and Minnesota retractor, Molt elevators, Prichard, 24gsp, Willinger, bone drills, suture, Castrovejo and CrileWood needle holders, scissors, Adson surgical forceps and Cushing surgical forceps.

- Osteosynthesis kit with drill and dedicated screwdriver to fix the microscrews - Container with betadine in which to place the components of the juxtaperiosteal fixuter and attached microscrews.

- GAUZE - syringe containing Rifocin - Tranex syringe - Toradol syringe and sodium chloride syringes to be used for washing.

- implant motor with straight handpiece to make passage holes for fixing the palatal or lingual screws

- Red Ring or Turbine with cylindrical bone cutter already mounted

- DIATHERMOCOAGULATOR + bipolar forceps > ball electrode for possible haemostasis

- Approach and sealing suture with 5 or 6/0 thread or 2 or 3 threads

- Active multiparametric monitor and with ancillary devices

• **ROTARY AND PIEZOELECTRIC INSTRUMENTS** In our surgery we often use rotary instruments especially when the bone site is very dense, these instruments, as we all know, transform electrical energy into cutting action using the sharp edge of the cutters, these cutters generate a considerable amount of heat in the cutting area which must be minimized through irrigation, for this very reason, in some cases we prefer to use the approach to transcrestal osteotomies with piezoelectric devices for selective cutting on hard tissues, this will result in greater accuracy given the lower necessary force to be applied to the handpiece during its use and less invasiveness

d. THE SURGICAL TEAM

It should be kept in mind that in the operational preparation for surgery, the shortest time possible must be allowed to elapse between the arrangement of the sterile instruments in the field and their use, to reduce the risk of contamination. Using the envelope opening mode with this procedural order, the non-sterile assistant opens the envelope by separating the 2 sheets and the sterile assistant extracts the contents - it is inadvisable to let the contents fall from above. Once the operating room has been prepared, we move on to the PREPARATION OF THE OPERATORS which is carried out with the help of 2 assistants, a non-sterile or circulating assistant and a sterile assistant. The non-sterile assistant sets up the room, handles the non-sterile material, helps the sterile operators to prepare and prepare the field; First Operator/Second Operator and Instrumentalist - after wearing headgear, shoes, mask and glasses, they proceed with washing their hands with antiseptic soap, drying their hands with sterile towels - detached hands facing upwards, before putting on the

sterile gown.

Any type of sterile gown can be worn correctly if it is kept in mind that the internal part and the back of the gown are considered non-sterile and can therefore be handled by the non-sterile assistant. Sterile gloves can be worn with open technique or closed technique, taking care not to contaminate them in any step. Once sterile gloves are worn, medical personnel can no longer handle anything that is not sterile.

e. THE PATIENT At this point, the preparation protocols for the surgical operation have been followed, the non-sterile assistant before seating the patient in the area intended for surgery will be asked to take off tight or heavy clothing and will be asked to wear disposable shoes, headgear and gowns. Once seated in the armchair, you will be rinsed with 0.2% chlorhexidine-based mouthwash for one minute. The monitoring devices will then be connected (pulse oximeter, sphygmomanometer, etc.), a possible venous access will be created, where necessary, and the preparation of the aseptic field will continue.

The patient's eyes will be protected with a mask or with gauze or with dedicated glasses, and the perioral skin will be disinfected with a solution based on Povidone Iodine (Betadine), using centrifugal circular movements starting from the lips and extending to the area cheeks, chin, nose, therefore the entire area that will not be covered by sterile sheets. Two sheets with an adhesive edge will then be placed to delimit the operating field. The suction or micromotor cables previously covered with sheaths will be fixed to the sheets.

2. THE SURGICAL PHASES

a. ANESTHESIA: the anesthetic strategy obviously depends on the duration of the insertion surgical phase of the implant product. Consider that the subsequent assembly phase of the prosthetic restoration is absolutely painless, and therefore does not require any anesthetic support. Let's first look at the duration. Obviously it will depend on the type of intervention or the extent of rehabilitation. Generally, the assembly of a partial frame lasts approximately 60' in all its phases, which becomes 90-120' in the case of full-arch rehabilitations. Surgeries involving the upper jaw are a little more complex and therefore longer lasting than mandibular ones, usually due to the greater difficulty of exposing the operating site.

However, without prejudice to the estimated times, the anesthetic conduct will also take into account the hemorrhagic factor, usually more profuse in the upper arch than in the lower one. Bleeding, given that the patient has a normal blood coagulation status, even in the upper arch only lasts a few minutes, generally 1 or 2, unless there are injuries due to careless manoeuvres. Nonetheless, the bleeding, even if physiological, depletes the reserve of local anesthetic with which the surrounding surgical tissues will have been infused. For this reason, it is preferable to rely on a truncal anesthetic pipeline reinforced, if anything, by the loco-regional one. This will ensure the correct duration for both treatments. In the case of partial rehabilitation of the upper jaw, in particularly calm patients, a plexus infiltration can only be performed, provided that the highest dosage of vasoconstrictor can be used.

In order to shorten the bleeding time secondary to the exposure of the field, the muco-periosteal elevation, we perform local washings with anti-hemorrhagic antifibrinolytics [UGUROL / TRANEX], an action which further reduces the physiological bleeding time of the field, thus counteracting the depletion of the anesthetic infiltrated locally. In the case of the mandible, we will proceed with the posterior truncular infiltration of the nai with one vial on each side, followed by the plexus infiltration [1 or 2 tf] if it is unilateral (in which case, obviously only the nervous trunk of the affected part will be infiltrated) and full-arch (case in which the truncular injection will be performed bilaterally. In the case of rehabilitation of only the anterior mandibular sector, the truncular infiltration will be performed in correspondence with the nervous emergence from the mental foramina.

Such an anesthetic procedure ensures coverage generally of no less than 120', unless there is profuse and uncontrolled bleeding. Once all the surgical phases have been completed, a reinforcement-bridging of the local anesthesia can be performed by plexus inoculation of one tf per side. This method ensures a further duration of the anesthetic effect of approximately 120 This practice usually interrupts the chain of immediate post-surgical pain, also reducing the chain of pain deferred to the hours following the surgical procedure performed. As regards the upper jaw, the same rules apply. In case of full arch rehabilitation we will proceed with truncal infiltration of the superior posterior

alveolar nn and the infraorbital one. The nasopalatine nn will also be infiltrated.

A local plexus reinforcement will guarantee a good duration of the anesthetic effect and reduce bleeding at least in the early surgical phases. In the case of partial rehabilitations, however, it will be possible to opt for a totally plexus-type anesthetic approach.

Figure 53: Surgical instruments for iuxta periosteal assembly: the necessary surgical instruments will be organized in trays corresponding to the different operational phases.

The practice of "bridging" plexus anesthesia is also valid for the upper jaw to counteract the onset of peri-operative pain. The chapter on anxiolysis or operative pharmacological sedation deserves a separate discussion.

Both are practices connected to the elimination of the state of anxiety associated with surgical practice in some particularly sensitive and emotionally unstable patients [1,2,3]. Procedural sedation and analgesia are practices that involve the administration of a short-acting hypnotic or dissociative sedative agent, associated or not with analgesic drugs; they aim to remove the patient's anxiety connected to the surgical procedure, relaxing the patient and therefore also reducing movement during the procedure; remove, which is not insignificant, the memory of the procedure from the patient himself who will not be able to maintain an unfavorable impression of it.

It is performed by a surgeon or certified operators. Monitoring involves surveillance of airway patency, oximetry and basic cardiological/ haemodynamic parameters. Hemodynamic instability, hypersensitivity to drugs, chronic obstructive pulmonary disease (COPD), obesity, chronic liver and/or kidney disease, age > 60 years with CP decompensation, obesity and a positive history of suspected difficulties in possible intubation constitute an absolute contraindication. The key and fearful complications associated with this procedure are respiratory depression and hemodynamic decompensation. In our experience we proceed with a bolus of en x os followed by intravenous titration of benzodiazepines (valium) through direct feedback from the patient. We obtain a discreet and sufficient level of sedation for a calm conduct of the procedures. Obviously this does not take place regardless of a full local anesthetic scheme. Cases at risk or with anamnestic facts that are a relative contraindication are monitored and followed by an Anesthesiologist.

b. INCISION AND DESIGN OF THE FLAP: obviously the incision will depend directly on the design of the flap designed according to the ease to be given to the procedures of site preparation, testing, positioning and fixing of the frame(s) depending on whether they are sectoral or full rehabilitations - arch. Insertive and fixation technical maneuvers generally require the preparation of an operating site moderately larger than the size of the frame in question. The incision is carried out via the crest as a general reference, even if strictly speaking it must be carried out on the same ideal line of positioning of the prosthetic emergencies (which are not always in the centre-ridge) the design of the incision also takes into account the extensibility of the two resulting flaps during the suturing phase.

Obviously this finds immediate confirmation in the case of the upper jaw where, as we well know, we will have a flap on the palatine side that cannot be extended unlike that on the opposite vestibular side. Different situation regarding the mandible where the maximum extensibility of the flap is found on the lingual side. The first phase also involves the creation of vertical relief incisions which in the case of the upper jaw can be conducted posteriorly (dorsal) in the area of the tuber maxillae, or anteriorly (ventral in correspondence with the anterior nasal spine, even if these are not always performed due to the proximity of the delimiting arms which always lie close to this region.

The incision will be performed by applying adequate pressure to penetrate the entire mucoperiosteal thickness without having to return to it, under penalty of obtaining a frayed cutting edge and therefore problematic in relation to the subsequent peri- and post-operative healing. Often, we trace the limits of the incisions on the intact mucosa, through the use of a dermographic pen.

Figure 54: Anaesthesia

A good anesthesia will offer a vasoconstrictive level such as to result in a very modest bleeding, quietly controllable by swabbing with gauze (personally preferred by the authors)

c. MUCO-PERIOSTEAL ELEVATION: we are at one of the most delicate phases of the entire procedure. Respecting the anatomical integrity of the tissues that we are going to elevate to expose the operating field will result in a much more effective peri-operative healing than a situation in which, by roughly elevating the flaps, an anatomical discontinuity between the constituent layers will be caused, and precisely between the mucogingival structure and the periosteum.

Clinically we find it much more difficult to achieve this objective in surgeries involving the upper jaw than in the mandible. In fact, the more "spongy" bone consistency creates bonds between the bone surface and the muco-periosteal layer that are much tighter than what is found in the case of procedures on the jaw.

Furthermore, the elevation of the palatine site of the mucoperiosteal structure will be particularly difficult given the thickness on this side. In principle, in the case of the mandible we will start by elevating the soft tissues from the vestibular side with initially thin instruments and then move on to progressively wider ones. Once we have obtained a good and precise separation of the vestibular side, without prejudice to the attention in isolating the mental trunk very well and delicately in its bony emergence, we will move on to the lingual side, which is usually much simpler to isolate.

In this phase we will be careful to reach the upper edge of the floor in correspondence with the insertion of the mylohyoid muscle, taking great care not to disconnect the tendon raphe from the mandibular bone crest of the same name, under penalty of profuse bleeding and surgical entry (absolutely useless) to the inside the floor region of the buccal cavity. This maneuver, in fact, besides being useless for the purposes of loosening the lingual flap already increased with the elevation maneuver just described, would expose the surgeon to the risk of intercepting formations to be respected including the main vessels of the floor and the main salivary ducts, creating a potential entrance for intraoperative bacterial contamination, a potential site of blood collections that are rarely detectable during the post-surgical healing phase.

This is also in relation to the danger of mediastinal diffusion through the neck bands of both blood spills and bacterial contamination. As far as the upper jaw is concerned, the separation of the mucoperiosteal layer will begin from the palatine side. The difficulties in this regard are greater than in the mandible as the consistency of the palatine and vestibular layers are very different; thick and firmly attached to the palate, thin, delicate and easily detachable vestibularly. The techniques and tools to be used will be different; we usually start from the palatine side for greater ease in finding a cleavage plane without running the risk of tearing the anatomical integrity of the site. Therefore, starting from this already skeletonized side, it will be simple to undertake the elevation of the vestibular sector.

Here, care must be taken not to damage the anatomical unit between the mucosa and the periosteum. Especially at 15-17 25-27 a not very delicate maneuver could accidentally penetrate the buccal region which hosts the Bichat bubble, a not serious event but to be avoided with care under penalty of septic events affecting an area, the malar one, also responsible of the somatic characterization of the external region of the cheek and the

zygomatic prominence. On the palatine side, care will be taken to safeguard the region of the nasopalatine foramen with its vascular-nervous trunk. In fact, the architectural evidence of the frames we design allows us to save their anatomical and therefore functional integrity, especially by virtue of faster healing of the surgical wound.

The same goes for the palatine side for the emergence of the posterior nerve-vascular trunk, which must absolutely be avoided under penalty of very severe bleeding, ischemic strokes of the tissues served with the formation of areas of necrosis during the healing phase. Even for the upper jaw, when the tissue elevation phase is carried out correctly, there will be no significant bleeding and in any case it can be controlled by simply swabbing with sterile gauze. In the case of full-arch rehabilitations, whether the maxillary palatine or mandibular lingual flaps, they will be sutured together to facilitate visualization of the sites without unnecessarily occupying the hands of a second surgeon or instrumentalist. The same caution is useless with regards to the vestibular flaps.

Figure 55: Incision

d. POSITIONING OF GUIDES AND OSTEOTOMIES: once the operating field is exposed, we will wait a few moments to appreciate the natural extinction of the residual bleeding. The site will then be washed with plenty of physiological saline possibly added to an antibiotic solution. Then the remaining periosteal tissue residues will be carefully removed with the aid of mucoperiosteal scrapers (or elevators) and sterile gauze. Once a bloodless and clean bone site has been obtained, the osteotomy templates will be positioned for the design of any planned osteotomies. These will be obtained with the aid of piezoelectric or rotary instrumentation depending on the operator's habits, keeping in mind that with the former the cuts will be much more precise than what can be obtained with traditional rotary instrumentation. This action is absolutely bloodless and lasts only a few minutes. The surgical diems can be screwed into their seat and even dismantled into two overlapping parts, if the cut must be made in two different directions. In the case of surgical diems not screwed to the bone seat, they will be held in place by the hands of the second operator. In this situation the instrumentalist will take control of the devices suitable for surgical aspiration.

e. TESTING AND ADAPTATION OF IMPLANT FRAMES: once any osteotomies have been obtained, and the bony insertion site has been judged ready, the perfect adaptation of the frame will be verified. Taking into account the tolerances established during the design phase, it may not immediately sit perfectly in its seat. This is a time when a bit of technical malice is required on the part of the team. In fact, the operator will have to verify that, once the frame has been positioned, there are no residual rocker movements or deep gaps between the bone surface and the implant structure. Sometimes very small adjustments to the bone surface itself are necessary in order to guarantee the best contact of the structure with its seat.

In the case of full-arch rehabilitations with the frame divided into two contralateral sections, we will proceed by testing each part individually, then, once the precise juxtaposition has been ascertained, the frames themselves will be joined with the possible extra-gingival connection structure (the screwed prosthetic bar, for be clear), remembering to tighten the respective fixing screws well, and the check will be carried out again once the structure is completely assembled. In fact, it may happen that although the individual frames are perfectly positioned in their locations, once joined together, they show further small positional inconsistencies.

These too will have to be eliminated and corrected until the complex frames-connection bar is perfectly adapted to the site without residual rocker movements. At this point, before fixing the frames with the osteosynthesis screws, the prosthetic restoration can be assembled on the connection bar and, sending the patient into closure, verify the positional stability of the system in its entirety. This will make the passage of masticatory forces from the prosthetic restoration to the corresponding bone

surface absolutely passive. This operative phase, as already mentioned, requires a certain amount of malice and surgical expertise from the team. In fact, the fine adaptation operations of the assembled implant system to the bone site are carried out by 4 hands by the two operators with, also in this situation, the work of the instrumentalist who takes on the role of third operator by providing for the suction of the cooling liquids of the rotary instruments or piezoelectric devices used to carry out any adjustments to the receiving site [pict56].

Figure 56: Flap elevation

f. FIXING TO THE BONE SITE: at this point we will have the implant-prosthetic system perfectly adapted to the bone site, and we will have verified the absence of dislocations or rocking during the articulation movements of the relative prosthetic restoration with the antagonist arch (or with the sector corresponding dental in the case of sectoral rehabilitations). Already in this condition we could find a relative stability of the system, especially if in the design phase undercut retentive areas were sought in which to rest the delimiting arms (or at least part of them).

However, we will proceed without delay to fix the frames with the microscrews foreseen by the project. The ideal situation will be to send the patient into closure so as to guarantee the achievement of the condition of maximum stable and passive support of the implant system, then fix the frames starting from the vestibular sides and proceeding alternately on both sides in the case of full-arch rehabilitations. Once the fixing of the first vestibular points has been completed (at least two per side and as far apart as possible from each other), we will proceed with the insertion of the palatine/lingual fixing screws until all the foreseen sites are extinguished (usually two per frame), to finish on the buccal side again until all the fixing screws provided have been completely inserted. At this point the work will be evaluated as a whole, closing any small inconsistencies between the fixture and the bone site with biomaterial. This practice, according to our clinical experience and what is reported in the relevant literature [1], does not pose a clinical problem in the healing phase, rather it counteracts the formation of dehiscences due to small empty spaces existing between the structure and the bone surface.

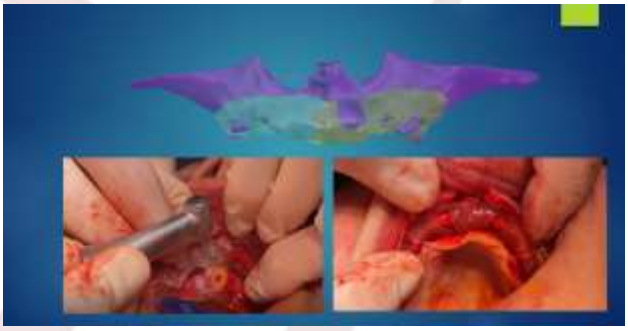


Figure 57: Osteotomy guide

G. CLEANSING: cleansing plays a fundamental role in the procedure as it is performed, first with 0.9% NaCl saline solution <8 physiological solution) then with surgical Betadine, then, after a final abundant rinse, with concentrated antibiotic solution (rifampicin). At this point, once the adequacy of everything has been verified, it will be possible to proceed with the release of the flaps previously sutured together and the evaluation of the best strategy for the suturing phase.

h. SUTURE: the very important evaluation to be made at this point concerns the existence of the condition of absolute passivity that the mucoperiosteal flaps must have once they have assumed their final position joined together in the suture performed. The action of positioning the flaps will be conducted by the second operator under the direct control of the first. It will be up to the team to decide whether or not to remove the extra gingival stabilization bar to facilitate the suturing operations.

Personally we are used to not removing the latter, even if this

involves a greater technical difficulty. Generally, if a condition of perfect passivity of the flaps does not exist, transverse incisions will be made to release the buccal flap, especially in the upper jaw and this in relation to the complete inextensibility of the palatine flap. In the case of the mandible, however, given the great "compliance" of the lingual flap prepared in the way described above, this action will almost never be necessary. The flaps are sutured starting with detached "mattress" type stitches in the areas of the prosthetic emergencies in order to guarantee the absence of positional warping of the two opposing flaps. Once this has been done, after a further check of passivity we will proceed with the end of the suture along the entire incision line.

Generally we use a 4/0 multi-filament nylon suture for the initial attachments of the flaps to the respective prosthetic emergencies, and a 5/0 nylon monofilament for completing the work. If we were to find frequent breakages of the latter we would consider the tension of the edges excessive for their attachment, starting the preparation work all over again. At the end of this phase we will proceed with sub-gingival inoculation of IM painkiller (Tora dol) and antibiotic (Rifocin). An excessive escape of these from the suture rim would be an expression of having conducted it in an inappropriate way, forcing us to reinforce it [pict58].

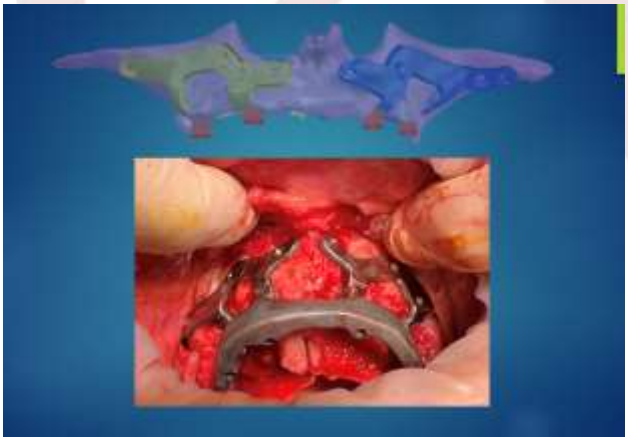


Figure 58. Frame positioning

3. THE ASSEMBLY OF THE FIRST PROSTHETIC PRODUCT

a. POSITIONING OF THE PROSTHETIC RESTORATION: in our clinical practice, once the suturing phase is completed, we find ourselves faced with the complex frames-stabilizing bar already assembled and tested. The perfect correspondence between the sutured edges and the lower edge of the milled stabilizing bar will be assessed. Possibly it will be possible to modify the matching by performing sutures with protruding edges again to raise the level. The prosthetic restoration is fixed to the bar using fixing microscrews (generally six in number for a complete arch). Since this is a restoration screwed onto a milled bar, we will first of all have to note that the margins of the prosthetic restoration are slightly compressed on the newly sutured gum, provided that they do not interfere with the sutures. This situation favors the protection of the suture line from food trauma. If necessary, the edges can be sealed with soft silicone religner, to be removed at the first check in 21 days.

b. OCCLUSAL CHECK: as introduced in the module relating to the design of implant-prosthetic rehabilitation, the cusp design and therefore the mode of load transfer during masticatory dynamics will be decisive in maintaining the functional homeostasis of the newly assembled system. Therefore, depending on the inactivation of excessive compressive forces and residual extractive forces, the residual anterior overbite will be reduced to a minimum and completely group disclusion paths will be provided. In principle these concepts are applied in the definitive design phase, therefore the "chairside" occlusal finishing during the assembly phase is never particularly burdensome.

The contact in ICP must assume a "self-stabilizing" pattern like that used in the case of total mobile prosthetic devices, therefore with contacts on the lingual cusps and equally distributed over the entire extension of the arch. The occlusal check will be repeated at all checks included in the follow up program

POST-SURGICAL FOLLOW-UP

To fully understand what we mean by post-surgical follow-up and why we treat it with so much emphasis, we must introduce and focus very well on the concept of evolutionary dynamism of an implant-prosthetic rehabilitation. Let's start from the key assumption of all Medical Physiology; an organ, a constituent unit of any system, is formed and maintained based on the function performed. This means, put in other words, that it is the

function that directs and maintains the structural and functional characteristics of the organ responsible for carrying it out. Now we bring this fundamental concept into the context of implant-prosthetic rehabilitation of any type. The function, in this area of mastication and phonation, changes over time, and as already seen on several occasions in this work, it changes over the years. But not only. It also changes as the age at which functional rehabilitation is performed changes. This means that, if traditional and juxtaperiosteal implants find indications in different epidemiological classes of patients, they will have to satisfy functional needs and therefore also different functional evolutions.

In this sense, gingival tissues, bone support and masticatory biomechanics may undergo an evolution over time. And this evolution will need to be monitored and supported over time. This is the follow up. Both for rehabilitations on "iuxta" and for those on traditional implants. We are in the field of the surgical clinic, or even better the dental clinic, that is, the discipline that deals with the evolutionary symptoms associated with any type of rehabilitation, whether surgical or prosthetic. In fact, our follow-up work will focus both on post-surgery and long-term periodontal maintenance, ending with the prosthetic restoration performed. So three areas in which we will demonstrate our control action. Monitoring of surgical wound healing (t=0 t=21d); monitoring of the evolution of the mucogingival site (t=22 days t=180 days); monitoring of occlusal mechanics (t=0 t=300 days). [pict59].

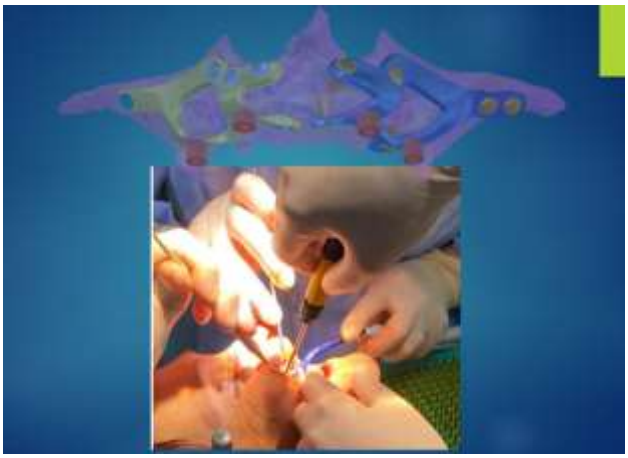


Figure 59: Frame fixing

Let's start with the surgical wound

1. SURGICAL WOUND: what is the scenario in which surgical wound healing occurs? Let's try to imagine: 1 a wide exposure of the operating field therefore an interruption of the osteo-periosteal (and therefore gingival) vascular continuity. 2 an implant positioned right in the interspace between the bone and the mucogingival vascular support with a reduction in the revascularization surfaces 3 variable flap margin apposition tension. 4 gingival pattern varying between keratinized and loose on the incision line 5 mechanical trauma caused by chewing (remember that the patient is immediately provided with a fixed functional prosthesis).

Here, in this context, we must hope for and obtain healing by first intention, under penalty of the potential formation of mucus-gingival dehiscences and exteriorization of the frame or part of it. How to do it or, better yet, what to monitor? How to recognize an adverse evolution of healing? How and when should we intervene? Let's start with the normal healing processes of a surgical wound [1;2;3]. It is now well established that wound healing can be identified in evolutionary steps characterized by recognizable and temporally well-spaced anatomical-histological changes. Let's see them.

a. HEMOSTASIS represents the first minutes of the repair process. The first objective is to stop the haemorrhagic phenomena originating from the damaged vessels. Vasoconstriction, platelet release and fibrin release are the three mechanisms that slow down local blood extravasation and trigger the clot formation processes. Cytokines and platelet-derived growth factors will trigger the onset of the inflammatory phase.

b. INFLAMMATION The inflammatory phase lasts 4-6 days and is characterized by the presence of typical clinical signs , i.e. rubor , tumor , pain, heat. Neutrophils are one of the main cell lines involved in the mechanisms of contrasting the bacterial load contaminating the wound, secondarily replaced by macrophages responsible for eliminating bacteria and cellular debris. Macrophages produce chemotactic factors and growth factors, which are necessary for tissue repair, stimulating fibroblast proliferation

c. PROLIFERATION granulation and re-epithelialization represent the proliferative phase, the third stage of the tissue

repair process. It manifests itself, under normal conditions, in a period of time between the 6th and 21st day. the fibroblasts, a key cellular element, will provide for the formation of the cellular matrix in which the granulation tissue will be organised. Granulation tissue consists of macrophages, fibroblasts, immature collagen and blood vessels. While the granulation tissue develops, the fibroblasts stimulate the production of collagen, which can be interpreted as the first structural matrix of the tissue in the process of formation.

d. REMODELING Remodeling or also known as the maturation phase is the fourth and final phase of wound healing and can develop up to two years from the start of the repair process. It manifests itself with the synthesis of collagen as a structural element of tissue reinforcement [pict60].

Figure 60: Sutures

In light of the evolutionary sequence of surgical wound healing, we can reconsider the scenario we were talking about earlier, relating to the surgical wound that we have just recomposed with the suture. First: First of all, we will have to leave as few "empty spaces" as possible between the two joined edges. In our clinical practice, a suture with everted edges heals better than one with juxtaposed edges. Obviously this refers to juxtaperiosteal implants. Such a juxtaposition of the free margins seems to counteract the physiological retraction that occurs in the remodeling phase. Second: we will have to ensure stability to the sutured area, freeing it, where possible, from the tractions physiologically exerted by mimic and masticatory muscles, a condition that can be achieved with safety stitches far from the suture line performed with a "mattress" type approach and multi-stranded braided threads made of larger gauge nylon (3-4/00). Third: we will protect the suture from contamination and the mechanical action of food so as not to stress the action of neutrophils and macrophages in the early inflammatory step. These three actions will allow us to promote healing by primary intention, which is absolutely desirable in this type of surgery. The peri-operative evolution of the surgical wound must be characterized by an objective appearance free from excessive swelling and bleeding lasting beyond 15-20' after the end of the procedure. Starting from the 6th/7th day the margins must not show obvious signs of inflammation or swelling due to blood and/or purulent collections.

The stitches must be clearly visible and everted and no pain or paresthetic symptoms must be reported. Our clinical practice has demonstrated the usefulness of protecting the surgical wound, once the prosthesis has been assembled, by sealing the interface between the cervical part of the prosthetic restoration and suturing with soft silicone for relining the mobile prosthetic artefacts. This expedient protects the suture margin and frees it from contamination by food residues. The described procedure is maintained in situ for the first 21 days, until the sutures are removed. If necessary, it is replaced during check-ups.

2. EVOLUTION OF THE MUCO-GINGIVAL SITE: we are in the monitoring phase of the remodeling of the healed tissues and which we consider in the interval between the removal of the sutures (21st day) and the 180th day. Our experience has shown us that, after the first six months following surgery, we can consider the morphological and structural changes taken on by the gingival tissues to be stable. The evolutionary phenomena that we will have to monitor are a physiological contraction of the suture rim with a tendency towards thinning of the gingival attachment margins and septic complications.

1 In this period of time, biologically there is a natural tendency towards retraction of the peri-implant gingival tissues. This is in relation to the maturation of the fibro-connective tissues formed, in the early healing phases, in the interstitium between the implant frame and the overlying gingival tissues. This phenomenon could manifest itself with the appearance of dehiscences, especially in the transgingival passage areas of the

prosthetic connections. We must distinguish this eventuality, so to speak "idiopathic" and usually not associated with mucositic-type phlogistic phenomena, from the formation of dehiscences due to the outcome of primitive and pre-existing gingival frenulums, which resume their traction action on the mucous tissues, or frenulums secondary to the suture performed (generally due to excessive traction of the flaps) which are distinguished from primary frenulums by the concomitant presence of even limited areas of local inflammation. In the event of the presence of these frenulums, we will proceed with their immediate cutting, associated or not with a gingival plastic surgery to deepen the vestibular fornix. This treatment, if early, will favor the regression of the dehiscence. 2 clinical monitoring must also concern the possible appearance of septic phenomena, whether localized only to the gingival components (mucositis), or extended deeply to the implant structure (peri-implantitis). By surgical wound infection we mean any clinical event of a septic type that occurs within thirty days of surgery or within one year of the insertion of surgical prosthetic implants [4].

Contamination of the wound may occur simultaneously with the surgical procedure or subsequently, in specific case secondary or primary to the occurrence of gingival dehiscence. The clinical signs of contamination of the surgical wound are those connected to an inflammatory phenomenon which may be associated with tension due to the collection of sero-purulent exudates. From what has been said it is clear that, in the first six months after surgery, periodontal monitoring is actually important. A well-organised and regular check-up, fortnightly in the first two months and then monthly in the following months, will lead to the identification of any problems at an early stage, when they are still easily manageable. [5].

Periodontal surveillance, as the months pass, will move more and more towards oral hygiene control, carried out by a professional at regular intervals not exceeding, generally 4 months apart.

3. PROSTHETIC-OCCLUSAL MONITORING: prosthetic monitoring has the aim of monitoring the "integration" of the prosthetic restoration in the rehabilitation performed. A restoration is considered integrated into its site when it satisfies certain characteristics:

1 fulfilling the masticatory/phonatory/aesthetic function for which it was designed, produced and assembled; 2 integrate as best as possible into the site which is the object of the rehabilitation. This means recreating the functional anatomical homeostasis necessary to maintain a state of health for as long as possible. The checks that we will therefore carry out will concern a general examination of the restoration in its site and a detailed occlusal check

a. General examination: the integration of the prosthetic restoration and connections in the mucogingival bed to which it refers must be evaluated. In order for the restoration-connection-gingival site unit to be in a homeostatic condition, it will be necessary that the gingival tissues do not present areas of inflammation or proliferative reactions (granulation tissues).

The fibromucous labrum surrounding the prosthetic emergence must be pink and in good contact with the entire perimeter of the prosthetic neck. The muco-gingival area relating to the projection of the overlying prosthetic dental element must not show swelling or signs of phlogistic infilling.

The presence of these signs testifies to an insufficient protective action exerted by the dental equator towards the underlying tissues. We will also monitor any secondary frenulums formed with the maturation process of the surgical wound in the months following the treatment. in checks in the first 60 days following the surgical procedure, they must not involve dismantling the product from its seat, i.e. the prosthetic product can be removed only if it is attached to a milled extra-gingival junction bar.

If, however, the support bar is "embedded" in the dental structure itself (a Toronto bridge type restoration, so to speak), then we will refrain from removing the prosthesis. This concerns residual microtensions (not perfect passivation), which could be present and which could make reassembly of the product difficult. In the case of a Toronto type restoration, you will have to wait at least 6 months before removal, a period in which all checks and maintenance operations will be carried out with the artefact fixed to the connections of the implant frames.

The disassembly of the prosthetic restoration will allow us to evaluate the state of health of the gingival passage of the prosthetic connections and the presence of areas of granulation, clinical evidence of areas of excessive prosthetic compression.

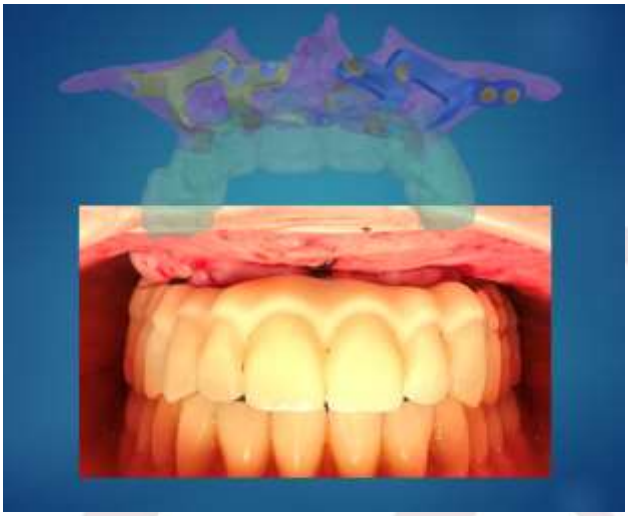


Figure 61: Prosthesis positioning and check

The inspection of the prosthetic site will extend to a large area surrounding the projection zone of the structure. The subgingival reliefs corresponding to the projection of the implant structure will be palpated, detecting any painful areas or ischemic areas corresponding to areas of excessive pressure on the soft tissues

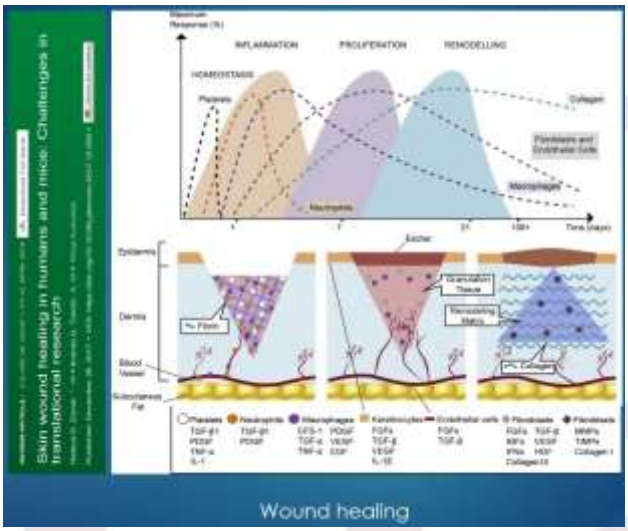
b. Occlusal checks: as we have already observed and described, this type of rehabilitation corresponds to a very specific period of the patient's evolutionary life and therefore must respond to the precise functional characteristics associated with it. The occlusal pattern must be as similar as possible to that of the wear occlusion universally considered to be the natural physiological evolution, with age, of the human dentition. This means that we will have to set up the prosthetic restoration, built with "soft" easily eroded materials, and designed with occlusal patterns, which are not very "steep" and aggressive, characterized by soft and group disclusions, and by anterior overbites reduced to the necessary minimum. Prosthetic surveillance will be fundamental to identify the appearance of wear facets, synonymous with pre-contacts, and to verify the existence of the pre-established occlusal scheme. We will proceed with normal occlusal checks and the tightening of both the prosthetic restoration and the extra-gingival connection bar will be verified. A loosening of the tightening of these structures must always be considered as clinical evidence of pre-contacts or, in any case, of excessive axial and shear occlusal pressures. If this is found, you must proceed with a complete and accurate occlusal check, in order to remove any irregularities that may have arisen.

Figure 62: Layout for follow-up: follow up remains one of the most delicate phases of the entire rehabilitation procedure. a well-organized and articulated clinical check in the various disciplines that enter the field will serve to monitor the perioperative healing phase, to evaluate the correct late maturation of the soft tissues and the static and functional adaptation of the prosthetic restoration.

4. FOLLOW-UP PROGRAM: for clarity, we report the follow-up schedule used on our patients. The temporal sequence is expressed in days and starts from considering the day of surgery as t=0. The follow-up program is divided into two main moments. 1 the post-surgical period which extends from t=0 to t=180 days. It represents the phase that we believe consists in the healing and maturation of the gingival site operated in this phase, generally we maintain the first prosthetic restoration, adapting it, where necessary, to the changed conditions of the gum. The sutures are generally removed between t=21 and t=28 depending on the needs and the state of local healing. Professional oral hygiene sessions are usually not performed in the first month.

Once the sutures have been removed and we have verified that they have healed by primary intention, we schedule monthly check-ups. On the occasion of these we carry out a cleaning with spray of fine powders at very low pressure of use, and we proceed

with a complete occlusal check, verifying the closure of the ICP and the translational and lateral movements. We look for any signs of phlogistic and/or septic evolution. In the case of positive findings we proceed with local sealed antibiotic treatments. In the period between t=150 and t=180 we work to replace the temporary prosthetic product with a definitive one. 2 the post-prosthetic which extends from t=180 to t=360. During this period, three checks are carried out at progressive intervals of 30 – 60 –



90 days respectively. During these checks we proceed with the disassembly of the prosthetic product, cleaning with very low pressure fine powder spray, and a complete occlusal check.

Figure 63: Wound healing process

CLINICAL RESULTS

For professional correctness we could also anticipate that there are no, or very few, reliable, or significant, clinical epidemiological data, if you prefer, regarding the morbidity of juxtaperiosteal implants. First of all, let's consider what morbidity is made up of; What are the adverse events encountered with this rehabilitation method? I would say 1) peri-operative

septic/hemorrhagic complications. 2) medium-long term dysfunctional complications. 3) dehiscences.

Figure 64: Clinical evaluation for soft tissues and restoration

Therefore, there is little reliable data regarding this panorama of adverse events encountered. Let's try to understand the reason, apparently a contradiction given the impressive number of authors and surgical interventions performed using this technique. Some factors contributed to the genesis of this evidence. 1 first of all, these are full-custom rehabilitations, where the design of the frame, the connection system and therefore the prosthetic restoration are absolutely customized to the architecture and personal mechanics of the individual case. The fact therefore that there is no fixed characterizing element, a priori, prevents us from ascribing with certainty any event, whether positive or adverse, to a given action or conformation of the product designed, constructed and implanted in a biological site and therefore to unique and non-replicable priori.

Already from this consideration, the practically impossible choice of technical, architectural and executive parameters emerges, to which to refer or compare the data objects of a possible statistical study. Let's take an example: we would like to associate the onset of gingival dehiscence with the design of the arms joining the prosthetic connection. Statistically it would be impossible to draw up a significant answer as we would not be able to have any equal parameter for all the cases taken into consideration. Difference in site, difference in position of the prosthetic emergence, difference in suturing technique, difference in occlusal load... in short, how could we make the use of non-repeatable or comparable parameters scientifically validating? Certainly impossible. 2 we consider the historical evolution of this technique. The context in which they were "delivered" to the scientific community was that of the 1940s.

The endosseous implants will have to wait another ten years before Branemark delivers them to us "ready and so versatile" for daily clinical use. So a first period, let's say "archaic" where very few authors, very good surgeons after all, noted its compliance with "narrower" fields of application than those that would later belong to the endosteal surgeons, while maintaining an important technical difficulty. Result? Big numbers, little experience, a pioneering approach and, consequently, absolutely uncomforting data. With the advent of traditional implantology and its

"technical maturity", we are at the turn of the Eighties/Nineties, we witness the work of great (and few) surgeons, who undertake more scientific and structured work, giving us comforting data, apparently well structured and above all very comforting. Then we arrive at the turning point, with the advent of digital techniques.

Even in this period we are witnessing the "light" of really good surgeons, we will see some of them in this section; obviously the numbers are decreasing, due to the versatility of the endosteal implants and, let's face it, the pressure of the companies, for which it was easier to sell implants of standard shape and size and reconstructive materials.

Furthermore, research seems to focus exclusively on the design of the implant frame and scientific works lose the "verve" of their predecessors. The prosthesis, for example, loses much of the biological and biomechanical emphasis it boasted in the period of the "great masters" such as Bellavia, to name one.

This "cultural impoverishment" could also be at the basis of the specialized cultural void of this period. 3 to date, clinical work on this type of rehabilitation is extremely partial; a fairly small number of cases distributed across a large number of operators if considered on a European rather than global scale.

This greatly affects both the quantity of statistical references and the quality. In short, little is written. We write by bringing epidemiologically unreliable, but above all irrelevant (given the lack of significance) data regarding the drafting of technical and behavioral guidelines that can be used and, above all, transmissible (I mean in terms of teaching).

In this regard, let's think about the education offered to the market regarding endosseous implantology, compared to that relating to the "iuxta" topic.

Figure 65: Occlusal check: occlusion must be considered as a bio-function that is not static but dynamically subjected to change over time. therefore, the control of the morphological adaptation to the functional variations of the occlusion will be of vital importance.

All this leads us to make some considerations, before analyzing the actual numbers. First: what opinion has been created? I feel I can answer this question with good certainty, given the role I carry out in relation to the clinical research that, professionally, I am called upon to carry out, in addition to the surgical activity on the patient. Definitely a negative opinion. "I have removed a lot of them", or, "they move and hurt", even "they get infected easily", up to "they are too expensive" and so on. Second: the common opinion on which sample of patients does it refer to? This question can also be answered easily.

To those operated on up to the 80s if referring to answers offered by serious professionals, dedicated to surgery in a specialist and not generalist field. And we could certainly find confirmation in the writings of the great pre-digital authors. Third: what sample of professionals do these opinions refer to? As anticipated, and this is a certain fact, to the surgical specialists to whom these cases of clinical failure converged. It is commonly believed that removing a juxta is a complicated and devastating procedure for the patient. None of this, however credible that these failures all ended up in expert and capable hands.

Unfortunately, even failures are useful; when one is able to analyze them, and more often than not, these "surgeons-problem solvers" were not able, and perhaps did not have the slightest desire, to analyze what really happened. So a mass of useful data lost in thin air. Fourth: what solution can exist to this problem of the unreliability/truthfulness of statistical data? Well, certainly,

the existence of reference centers, where these cases can be brought together, with large numbers behind them and therefore great experience spread across all rehabilitation factors, therefore surgical, prosthetic, periodontal, would be an effective solution. In practice we are outlining a purely operator-dependent technique. And this is an absolute reality.

The technique is finely operator-dependent and this means that successful management requires highly developed technical mastery, a skill possessed by very few author-operators. Another factor that could invalidate the statistical data. Here in Italy we are witnessing a peculiar phenomenon which consists in the fact that often those who deal with the surgical assembly are not within the clinical context where the service is provided; this means an interruption of that professional chain which is the basis of that skilled group that we were talking about as a fundamental requirement for the success of the job. But we leave these considerations to the final discussion, while admitting that such a management method leads to a dramatic loss of clinical data that could be useful to the entire scientific community [pict66].

Figure 66: Follow up layout: the operational sequence of our clinical follow up scheme.

But let's now move on to the analysis of the data in our possession. Let's do it following a temporal order, and therefore the relative authors, starting logically from the pioneers of the pre-digital period, up to modernity.

1. LITERATURE: the first exceptional work I would like to talk about: Leonard Linkow, 1998 [1]. A report of 12 years of work; the analysis of more than 900 operated cases. Certainly a job that remains unmatched even today. First of all, who are the authors of this eminent work? Leonard Linkow, holder of the chair of Surgery and Implantology at NYU, and holder of the chair of Prosthetics at the Pittsburgh Dental school of Medicine; and Robert Ghalili, professor of periodontology, University of Medicine and Dentistry, New Jersey. Is it a case? An Implantologist, a prosthodontist (the same eminent person) and a periodontist; I do not think. So coincidentally, the three "departments" with which we have structured our "ideal studio". Oh yes, because they are the three disciplines that deal with assembly and follow-up monitoring.

Perhaps Linkow wanted to suggest (and anticipate) it to us between the lines? I really think so. And he himself tells us that he writes his work in a moment of crisis in juxta-periosteal implantology, in a moment of absolute enthusiasm for the versatility of endosteal implants. And he himself tells us that the difficulty lies in the peculiarities of the design related to the morphology of the bone site and the function of the dental arch to be rehabilitated. It limits its use to cases recruited with very narrow and non-negligible indications. The examination carried out on his own impressive case history (and on the failures accused) encourages him to seek the origin of these results in the very design of the implant fixture and the cusp anatomy of the restoration itself. Particular attention is paid to the healing phase and to the prosthesis intended for this.

The reversal of the trend in the numbers is very evident, given the application of the canonized rules, up to a 10-year survival rating of 93% of the operated cases. Same period, same setting. C Bellavia 1998. [2]. An impressive experience too, almost a thousand cases treated and a very low success rating before a careful analysis of the experience gained. Also in his case, surgeon-prosthetist. But not a coincidence. Bellavia introduces us to the fundamental concept of "reading anatomy" and how important it is to understand the concepts of support zones and retention zones; ascribes the failure to mechanical imbalances resulting from incorrect designs of the prosthesis in relation to the anatomy of the bone site. It introduces the concept of dynamic evolution connected to the loss of the dental element.

Like Linkow, he is an author who straddles the transition between analogue and digital techniques. CBCT is used to create stereolithographic models on which to physically draw the frame, models to be passed to the lab for production (again with lost wax techniques). The complications? Always the same; mucositis (as

soon as it began to be called that), peri-implantitis, mobilization associated with discomfort for the patient; removal. As soon as the possibility of fixing the frame with osteosynthesis screws began to be considered. More than 50% "failure rate" in the initial approach, changed to values between 85% and 90% of 10-year survival in the "anatomical-mechanical" approach phase of the project. But what did two authors like these have in common? Simple, the fact that they were able to draw and operate at the same time. To be honest, it must be admitted that this was made easier by the fact that the analogue technique favored this; despite the invasiveness of the double surgical approach, the drawing on a physical model, the identification of the support and retention areas, was decidedly simpler than what happens today.

In fact, CAD work, whether graphic or parametric, is not within everyone's reach, therefore, often, the operator entrusts his technical and architectural concepts to a technician, who, no matter how good he may be, will never be able to have operational foundation of the concept of implant and prosthetic site. Hence a situation in which, with clinical opinion continually required, the project can become really laborious and risk losing fundamental steps such as the synchronization of the dental axes and the related arch with the gingival and/or bone one. Linkow and Bellavia understood this well, and attributed much of the responsibility for the sensational failures they achieved. Another concept to which clinical failure was ascribed, introduced once again by both authors, was that of biological spaces for revascularization. That is, the frame size per unit area. This relationship must be ideal to favor the reform, by "first intention" of the anatomical continuity of the bone-mucus/periosteum interface, under penalty of bacterial invasion, osteolysis and the consequent mobilization of the structure. But let's move on to more contemporary authors, decidedly "projected into the digital age". Maurice Mommaert, 2018, nine patients monitored for two years [3]. He is a surgeon. It opens with data on peri-implantitis affecting the endosseous bones. 56%. Then it gives us the data on the 10-year survival rate of the juxtas. From 79% to 93%. A very respectable rating. Then he presses on with the 15-year estimate on the comparative juxta/endossei survival rate.

Virtually the same. Causes of failure, attributable to imperfect fitting of the frame on the bone surface. He makes no mention of prosthetic and biomechanical congruence applied to the frame. It mentions a pioneering author in the history of the juxtaperiostei. Obgeweser, Swiss maxillofacial surgeon 1959, [4] thirty-five implants inserted in thirty-three patients. Follow-up control at 18 months highlights problems in a third of patients. At three years complications in two thirds of patients. 4 mucositis patients. 5 peri-implantitis patients. 2 patients fractured the prosthetic neck and 4 paresthesia. 19 cases of mucositis at three years and 13 in apparent good health. An implant removed. In short, a world-famous surgeon with a very high failure rating. As a final consideration, he attributes all the failures collected to the prosthetic restoration. A pioneer, but still with too many questions to answer. But let's go back to the present day, an Italian surgeon, M. Cerea [5], 2018. A sample of 70 patients monitored for 24 months. Treated in 5 different clinical settings. Smoking and bruxism exclusion criteria. Fixed prosthetic restoration for everyone. 3 implants removed due to recurrent infections. Pain, bleeding and post-surgical edema in 4 patients (further description is missing regarding the type of operation and duration of symptoms); fracture of the prosthetic restoration in 4 patients; ceramic fracture in 2 patients. There is certainly already a good sample of patients monitored for a period of time considered significant.

Personally I think it is not very significant regarding two factors. The execution of the interventions in five different clinical units could lead to non-uniformity of the follow-up procedures, as well as a difficulty in recording diagnostic data. Furthermore, a somewhat superficial description of the methods of designing the prosthetic product. Even the use of ceramic materials could be questionable. However, an eminent work which attests to the increasing success rating associated with the modern digital approach. Another interesting work, by a Japanese surgeon. Year 2013, K. Takaoka [6]. It describes in great detail the most feared complication, sinusitis associated with "juxta" rehabilitation of the upper jaw. This is attributable either to a condition of absence of bone structure separating the maxillary sinus and oral cavity, or to excessive pressure on the bone cortex forming the floor of the maxillary sinus. A careful diagnosis, whether anatomical or mechanical, can certainly protect against this type of complication. Now is the time to consider perhaps the most authoritative testimony. Year 1997, American Board of Oral Implantology & Implant Dentistry [7], led by T. Reynolds, collected a sample of almost 1000 cases "spread over a period of almost 70 years of clinical experience of some of the best references in world implant surgery.

They analyze them and draw conclusions which, to this day, still remain a reference: they establish that 1 juxtaperiosteal implants, can be indicated and therefore used properly both to rehabilitate the mandible and the upper jaw. 2 the resistance to the forces transmitted by the masticatory load, manifests itself through the support of the metal structure on the basal component of the two maxillary and mandibular bone structures, and that the resilience of the structures themselves is offered by the interaction with the natural undercuts present and by the possibility of fixing the structure to its seat through the use of osteosynthesis microscrews. In short, the definitive recognition of this surgical technique almost 60 years after its first clinical application. We now come to one of the most complete and exhaustive recent works on the subject of juxta-periosteal implantology. Rancano-Alvarez 2019 Seville - Spain [8]. Consider that Alvarez directs one of the most active centers to date in the field of juxta-periosteal implantology. But let's see his work. He also starts from what is reported by the American Board, recognizing its official nature and scientific value. First consideration: the digital age has completely revolutionized the technical approach to the method. And this is a fact. It also reports works by Loperfido (2014), Fisch (2018) and Misch (2019) where there is even fear of an "osteoinductive push exerted by the mechanical pressure that the implant frame releases onto the bone surface. As regards the secondary pathology, it is equated to that resulting from endosseous implants, i.e. inflammatory and infectious in nature as the primum movens of bone erosive phenomena and the formation of purulent exudates.

Mucogingival dehiscences are also included among the possible surgical and functional sequelae. Generally speaking, it offers complication ratings of 40% in the mandible and 33% in the upper jaw. Partial rehabilitations have a complication rating of 41% compared to 33% for full-arch ones. Let's get to the survival ratings: 90-100% at 5 years; 52-86% at 15. Reports a work by Minchetti with numbers that stand at 91% at 11 years, precisely (on the examined sample of 22 cases) a survival of 100% of upper jaw rehabilitation cases and 80% for the jaw. Minchetti also records a higher success rating in full-arch cases (100%) compared to "partial" cases (87%).

2. OUR EXPERIENCE: We have operated on 13 cases in the last two years. Of these 11 in the clinic where we work on demand. Two c/o colleagues. We lost a case (67-year-old male upper full-arch veteran of implant failure. Unfortunately, we do not have comforting or certain data in this regard as we were not able to check the prosthetic product performed and the patient was not subjected to the normal procedure recommended follow-up. At two years we have not recorded any other adverse events other than the manifestation of a case of gingival dehiscence in a 64 year old woman due to a case of partial posterior in the upper jaw. This case was however asymptomatic and free from inflammatory conditions and /or infectious. For all operated cases, the perioperative period was free from significant painful symptoms, severe edema or bleeding that did not self-extinguish. In one case of partial mandibular extension 34-37 we recorded a period of hypoesthesia referred to the territory of the mental nerve, completely returned two months after surgery. We did not find any fractures of the prosthetic restorations assembled on the day of surgery; Nonetheless, in almost all patients we performed occlusal corrections during the scheduled check-ups, following the protocol we edited. In three cases we followed an anesthetic scheme also including operative pharmacological sedation, because specifically requested by the patient.

We can be satisfied with what we have obtained from this analysis. First of all, the examination of the relevant literature. First: we can recognize "numbers" that are completely comparable to those of endosseous implants. Second: higher complication rating for jaw and for partial rehabilitations. Third: All the authors agree on the type of inflammatory or infectious complications that can be found. Another positive fact is the reversibility of these complications has been found and documented, given however an early recognition of reactions considered prodromal (a mucositis which can become contaminated and lead to a septic event. Fourth: the etiopathogenetic moment of the complications can be ascribed, in order of events, 1 to an erroneous design with constituent parts that are too thick or wide to the point of not promoting the normal healing and reconstitution processes of the physiological bone-periosteum interface. 2 an imperfect correspondence between the metal frame and the underlying "host bed". This would cause the formation of connective tissue which could evolve towards an epithelial cell line and therefore trigger the cascade directed towards the formation of dehiscences. 3 excessive pressure exerted by the delimiting arms and, above all, by the connecting ones or by the prosthetic plates in the case of osteotomy sites. Such condition would cause bone resorption underlying the compression zone, triggering reactions similar to those described

in the previous point, up to the formation of dehiscences. 4 incongruous design of the prosthesis which could cause ischemic compressive syndromes in the healing phase of the surgical suture, local overload situations, or even dislocating events until the fixture is mobilised. 5 lack of an adequate follow-up program which could cause late recognition of pathological conditions (perhaps otherwise solvable).

The examination of our case study, albeit small, led us to make some considerations. First of all, we did not find any irreversible inconsistencies (such as to recommend the interruption of the surgical procedure) between the frame we engineered and the patient's clinical bone site. This speaks for a correct design sequence that we have developed. Even the prosthetic reconstructive standards seem to be adequate for the method. The follow-up demonstrated operational validity and, above all, profitability. The lost case confirms that schooling in the clinical unit where one works is of vital importance. For this reason we will take great care of this aspect before handing over this method to the clinical team which, despite its apparent simplicity, presents an averagely high level of difficulty and therefore the need for operational skill and malice.

DISCUSSION

1. TECHNICAL EVOLUTION AND DIGITAL ERA: what does the History of Surgery teach us it? always talks to us about courses and appeals. And it? also talks to us about optimization. A surgical procedure serves to solve a medical problem on a patient meeting technical parameters corresponding to those for which that technique is subject. We are in 1940 J Dahl, a Swedish surgeon, a problem: highly atrophic maxillary bone bases; a necessity: rehabilitating an edentulous person with a fixed prosthetic device.

Always a deep attention to the needs and expectations of the individual, understood as psycho-physical well-being. A typically Northern European attitude. A truly innovative solution for that period, which could only come from that mentality and those surgical skills. Create a structure that "fits" onto a hard bone surface (only basal bone remained, all the alveolar bone having been reabsorbed), resistant and, above all, under-squared [1].

Then it opens, prepares the field, studies the local conformation, imprints it and closes again. Then it is placed on a plaster model. And he begins to draw... internal and external oblique line, retro-molar trigone, depressions and apophysis of the symphyseal region. He highlights the undercuts while holding the model in his hand; he explains to us that today, we would have had to invent meshlab+meshmixer draping or fully automatic Exocad draping.

Turn the model over and over in your hands, anticipating 3D rendering and graphic couplings. Draw as we do today at the Rhinoceros semi-parametric Cad…. Or to a graphic designer like Meshmixer... then, once the design is finished, he passes the model to a technician who didn't even imagine that it would become a very effective graphic software like Exocad... he, with wax and wisdom, draws delimiting arms, connecting arms and posts prosthetics foreseeing the functional miracle that a conometric system would perform once the surgery was completed... as soon as the screwed solutions were glimpsed... But what had Dahl really found Semplice? had directed us, and forced us, in practice to refer to the concept of Implant Site and Functional Rehabilitation... despite the fact that digital hadn't yet been talked about.... this blessed implant site, we still talk about it today, and perhaps we still haven't fully understood... Today, I ask my students, my designer partners, what difference they could "see" between the implant site of endosseous implants and that of one juxta"; an architectural abyss, a conceptual abyss... today they say: iuxtas fail, they don't hold up, they don't work... perhaps due to false legends spread by those who used them without taking absolutely into account the engineering importance that "that implant site" has in the "iuxta" implant biomechanics, once assembled and loaded with a fixed prosthesis? I would say yes... Then it was the turn of "Illuminati" of the caliber of Chercheve, Linkow Bellavia, who, having experienced sensational failures, wanted to fully understand the reason for this malfunction... and, fortunately, they started from two fundamental points... the "Implant site" and the wonderful concept of "biological healing spaces".

Look for the right points of Resistance and Resilience (pay attention to two biomechanical modules diametrically opposed to each other and therefore characterizing the load resistance function), use them, leaving plenty of space for the elevated soft tissues to reunite with their "natural host bed", i.e. the

corresponding bone site. Result? Bellavia, but above all Linkow begin to collect a series of successes that overturn the first rudimentary and analogue statistical analyzes carried out... they had given us the right answer!!! Yes, it's a shame that they also prescribed juxta and included less "ethical" colleagues, let's say, and perhaps even less scholars... or rather, certainly less scholars.

In short, Linkow really told us everything necessary to make them go well. I was lucky enough to meet him, as, together with Raphael Chercheve, he was a dear friend of my father, also an oral surgeon, who passed me the book they wrote. So I found these teachings beautiful and ready to "assimilate". And then? Then came digital. It became confusing to us that, as soon as we had learned to discern the indicated cases, at times to draw even well, always on plaster models, always with two surgical interventions. ……. I saw the three "cheerful surgeons" operate on a French patient and insert the implant on the same day. First surgery 9:00am. Patient locked up and put to bed. Second intervention at 4:00pm. Patient with juxta inserted (and hammered - back then this was done to make him reach and double the undercuts -).

Obviously no prosthetics. Then came digital. Did he help us? It certainly helped us surgeons, equalizing the skills of the very good and the very poor, allowing everyone to plan. Perhaps the juxta epidemiological statistics didn't help, as many jumped into it headlong; more and less competent. The failures decreased only in appearance because, at this point, we are in the midst of a boom in endosteal surgery + reconstructive surgery + short implants. There's almost no need for juxta anymore... but really? Absolutely not, it's just that the scientific community tried to convince us that the "reconstructive" way was the most correct one... here too a problem, as usual, of inclusion criteria.

It is useless to think about reconstructive surgical procedures on classes 4 or 5 according to Cawood or horizontal "CW" recessions according to Misch..., just as it is useless to "add" iuxta to classes 2/3, where implants can easily be performed. But let's go back to digital. What was the real digital revolution? (and let's not talk about surgical technique yet). Certainly Matching, the spatial orientation of bone and intraoral renderings; not least the rendering of the dicom files coming from the 3D scans of the bone site. The first allowed us to contextualize all the diagnostic data available and orient them spatially as in the biological reality of the patient.

The second (but in procedural order they are reversed) to have three-dimensional bone renderings. Result? The bone rendering burned the first intervention in which it opened to take impressions of the site. The matching allowed us, Truly, to previsualize the implant site in its entirety and to go further, up to the previsualization of the prosthetic VTOs.

So? The rules were explained to us by those who were unable to apply them due to lack of technology; we had established the inclusion criteria precisely; the parametric CADs also put us in a position to choose the desired prosthetic connection, in short, the future and the real "Iuxta revolution" had begun.

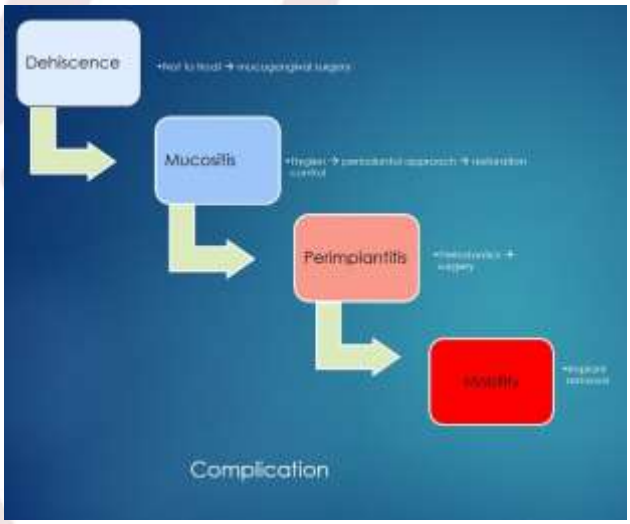
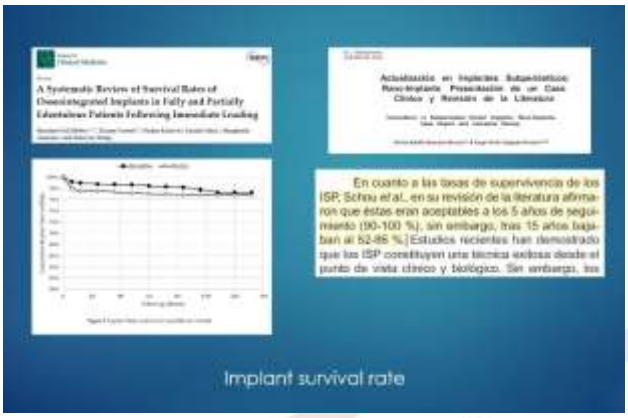


Figure 67: Drawback and complications: the complications associated with this method vary in severity and prognosis over time.

2. EFFECTIVENESS AND APPLICABILITY: in surgery these are two almost diametrically opposed concepts; the first expresses the percentage of successes referring to an operated sample; the second is the versatility of the system used. That is, the more it adapts to the patient's conditions at check-in, and how much, once the indications have been found, it can be carried out by the average surgeon.

Therefore two parameters that are very different from each other because the more the first increases, the more the second



must decrease. That is, rehabilitation is safe, if well applied rigorously in the existence of ALL the inclusive criteria, in the hands of expert professionals or organized in a very complex professional system in terms of group skills. In the previous modules we have seen how the "bone atrophy class" criterion is one of many that must be considered. In practice it is a set of very precise and homogenized morpho-functional characteristics that make a case an indicated and therefore safe case. First big difficulty. Apply the strict rules of inclusion. “morpho-functional characteristics” means that it will be the supervision of those who know dento-maxillofacial orthopaedics, which will make it possible to recognize cases indicated or not. Angles and intermaxillary divergence, growth in ante or post-rotation, occlusal fulcrum, compensations of the occlusal planes; all apparently very distant concepts, but so immeasurably fundamental to building correct implant-prosthetic mechanics and dynamics.

Furthermore, the dynamics are completely different from those of endosseous implants. However, application procedures that are not impossible and which we have talked about extensively up to now. The characteristics of the prosthetic restoration will depend, as explained in detail, on the orthopedic-skeletal characteristics of the bone bases and occlusal planes, therefore the morphology of the implant support frame and therefore the choice of the most suitable site, be it bone or gingival mucus. It starts from the bone site and always ends there. But let's call it an implant site.

Because the soft tissues also play a key role in establishing the morphologies and positions of implants and teeth. The skills of the medical team are also a "keystone" in the determinism of clinical applicability. Multidisciplinary procedures with very high functional and architectural interdependence of the biological and artificial components of the site.

Therefore the team, even dividing roles, must be able to do and do everything well. And, strangely, from what has been said, all this is easily teachable. And our reality is proof of this. Even more the effectiveness of this type of morpho-functional rehabilitation increases, the more its applicability decreases. And from this it will derive, but we will talk about it later, the concept of the reference clinical center.

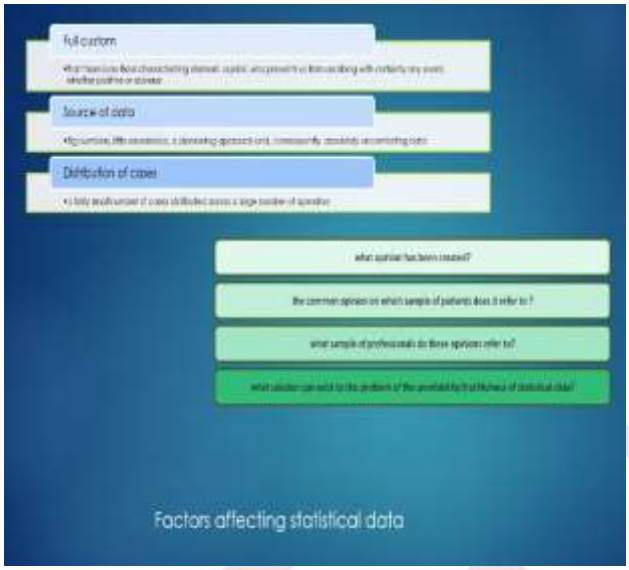
Figure 68: Comparison between e-osseus and iuxta implants: the rating of complications over time of juxta-periosteal implantology is comparable to that of traditional endosseous implants.

Here it is enough to anticipate, but I think it is quite "logical" as a concept, that this type of rehabilitation, multidisciplinary, and the phases of which they are composed are closely interrelated, require a high degree of "familiarity, malice and experience. It is clear that the more you do them, the more you can count on a safe and replicable result. Here is the concept of the reference clinical center that we will talk about at the end.

3. RECONSTRUCTIVE SURGERY: ALTERNATIVE? I would say that, if we take what was stated above as valid, they are not two competing rehabilitation strategies. It is a simple question of indications and efficiency limits.

To what degree of horizontal or vertical atrophy, will the reconstructive approach be effective and stable over time? And, above all, in whose hands? And let's look at it from the opposite point of view, what technical problems are encountered in the juxta approach on atrophies that are not yet perfectly evolved?

Certainly very many, since as we have learned the residual alveolar bone tissue that interacts with the metal frame runs the great risk of resorption and therefore can confer instability and periodontal problems of the frame-soft tissue interface.



Clearly, "social" dynamics connected with this choice are also created; reconstructive surgery requires medium-long waiting times of between 4 and 9 months depending on the type and extent of the procedure applied.

This triggers mechanisms of non-compliance of the method with the "social" expectations of the patient and, sometimes, with the commercial expectations of the practice. The fact that the "iuxta" scheme involves the assembly of the implant and restoration in one-shot mode, while in the reconstructive schemes, two surgical phases are often foreseen, bone and implant, followed by a prosthetic, could certainly influence a choice clinic which should be the exclusive prerogative of the inclusive criteria.

Figure 69: Factors affecting statistical data:

4. TECHNICAL LIMITS AND ADVANTAGES: another criterion discriminating the quality of a surgical or therapeutic approach in the broad sense: the risk/benefit ratio. that is, we will try to consider the technical difficulties and the related morbidity/morbidity relating it to the therapeutic objectives in terms of medium/long-term survival. Let's start with therapeutic goals. It could be simplistic to classify them as functional rehabilitation of an impairment affecting the masticatory system. Consider “that impairment.”

In fact we are talking about edentulism, whether partial or total, in the case of an extreme degree of bone atrophy. There is a complication, i.e. a “para physiological” condition associated with these “simple edentulisms. That is, if we consider the process of aging of the jaws, we understand how bone resorption or atrophy is always accompanied by a change in the relative spatial relationships of the two bone bases, changes on the three reference planes, vertical, sagittal and transversal; in return, a functional alteration of the entire masticatory dynamics can be noted; in practical terms, reconstructing a function in such an architecturally and mechanically modified environment is truly difficult; and indeed it is.

Mechanically, the forces acting on bone bases shaped and oriented in this way manifest themselves with both axial and tangential components that are different from what happens during the function of normal bone bases both in terms of architecture and relative position. So, a priori, a condition frankly contraindicating rehabilitation in this, let's say, evolutionary biodynamic situation connected to aging? Only theoretically because there have been three people who have proven the opposite: Andre Leroi Gourand (living biomechanics) / D:H Enlow (craniofacial growth) /C Bellavia (atlas text of juxtaperiosteal implantology).

They basically taught us how the skeleton and function adapt to aging and edentulism, and therefore how to imitate this aging; essentially our rehabilitation must be suitable for all the other components of the site, i.e. bone atrophy, spatial relationship of the bone bases, soft tissues etc. So we know how to make juxta-periosteal implants work. And we have learned to apply it [2;3;4]. This does not mean that it is simple, but when there are rules, scientifically validated, which demonstrate the particularity and functional characteristics of a rehabilitation, then it will be enough to 1 know these rules 2 apply them, to obtain a functional restoration dependent on the degree of pre-existing impairment. existing, or, as the three authors suggested, a functional rehabilitation developmentally centered on the starting condition, i.e. on an apparatus that has undergone an aging process. Now let's talk about numbers [5;6;7].

There is general agreement in saying that the average survival of these rehabilitations is comparable to that found for traditional endosseous implants. The clearest study on the matter reports a 10-year value of 75% for iuxta versus 91% for endostei.

At 15 years the data on implant loss are comparable. So the juxtas would fail a little more. Let's now contextualise this data with the patient's age. Here too, the literature reports an average age of patients undergoing juxta rehabilitation that is slightly higher than that of patients treated with endosseous. So what? Simple, a question of aging. That is, iuxta implants, precisely because they are indicated for an older patient population, are, a priori, destined to last a little less than traditional ones.

Therefore the statistical data should be reread from this point of view to be truly comparable and therefore reliable. Which is to say that our maxillary bone bases have a non-infinite functional life as "maintainers of dental apparatus". Leroi Gourand himself taught us how dental morphology must change with age. Therefore, comparing the average survival data of these two rehabilitation modalities could have little statistical significance. A provocation, in short. So encouraging epidemiological data for a technique whose binding biomechanical foundations we have learned. Now is the time to evaluate its limits and benefits. Let's start with the limits. Only one basically which we have already mentioned. Multidisciplinary treatment with high technical inter-correlation. It means that all aspects connected to the type of rehabilitation, from the acquisition of digital data, to the design, to production and final assembly must be conducted in such a way as to be absolutely centered and balanced on the result to be obtained. So a laborious process. But not impossible. According to the follow-up. Equally structured between peri-operative healing checks and occlusal balance to be constantly monitored. This phase also requires well-structured and consolidated technical logistics. A periodontium department and a functional and organized prosthesis department. We could talk about technical difficulties related to the design phase, but this goes beyond this work as design can hardly be "handed down" or taught, if you prefer. Design is part of a professional background that everyone must "sew" onto their own person or structure, whatever you want. And the benefits? Certainly well highlighted and conveyed in this work; executive speed, adequate functional recovery, low impact of post-surgical complications, all data that characterize surgery, a rehabilitation technique called "modern" not to forget the commercial advantage that the practice gets from a truly "one shot" rehabilitation [pict70].

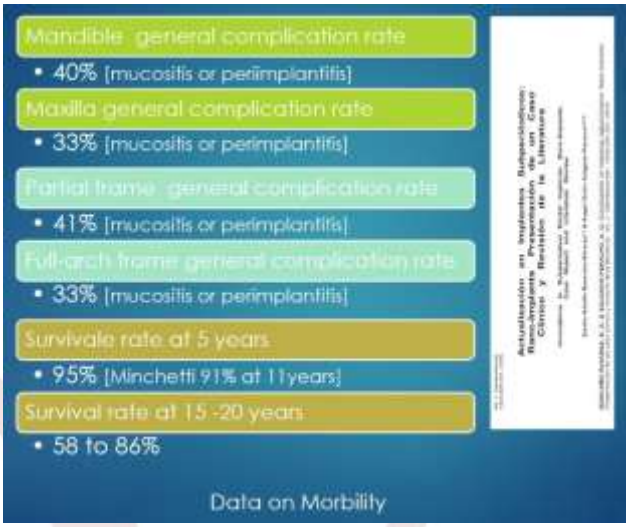


Figure 70: Literature data: the official data reported by the various authors.

5. COMPLICATIONS: delicate but fundamental topic. And enlightening. It is important to start with literature. The "predigital" authors brought us several references regarding this aspect [8;9]. Basically, the failure was commensurate with the need to remove the implanted surgical device following the loss of its stability. Little clinical importance was attributed, as indeed nowadays, to the problem of dehiscences.

Loss of stability: was attributed, and is still valid today, to three important factors: 1 incorrect occlusal load 2 imperfect adaptation of the metal frame to the bone site, 3 excessive pressure on the bone site due to incorrect design of the subperiosteal structure. Today we recognize the veracity of these three etiopathogenetic mechanisms in the determinism of the loss of stability while finding the mitigating factor in the occurrence of such situations today mainly due to the fact that the frames are fixed in their place thanks to the use of self-tapping microscrews.

The incorrect management of prosthetic loads, today in the digital age, could be considered the most important cause of failure. Let's move on to the other important topic. The dehiscences. Although, biologically speaking, dehiscences could be interpreted as an attempt by the organism to expel a foreign body, we can clinically distinguish at least two types. Step back; Dehiscence is understood as the gingival retraction in

correspondence with a part of the implant frame which, as a result, becomes uncovered. As mentioned, clinically we distinguish at least two types, associated or not with local septic conditions, therefore with mucositis or peri-implantitis.

Yes, even juxtaperiosteal implants can suffer from retrograde septic contamination and therefore mucositis or peri-implantitis exactly like endosseous implants. In principle, "cold" dehiscences not associated with local septic phenomena are not treated and are stable over time. They are generally caused by local situations compromising the mucogingival site, such as frenulum, lacinia or retractions generally related to periodontal events neglected or not taken into consideration in the diagnostic phase. If physical causes due to anatomical gingival anomalies are recognised, local plastic corrections can be made which interrupt the progression.

For septic cases, however, the contaminated site must be treated locally, even with open procedures. The treatment may require removal of part of the frame or even the entire device in more serious cases. Fortunately, this is a very rare event, never observed in the cases we have treated [10;11;12]. I personally believe that an imperfect correspondence between the implant structure and the corresponding bone site can trigger a healing process such as to cause the connective tissue interposed between metal and bone to proliferate, tissue which could differentiate into epithelial tissue and therefore cause the externalization of the implant metal. The pulling action of the masticatory muscles on the oral mucosa can also cause ischemic compression and therefore necrosis of the gingival tissues in correspondence with particularly emerging implant structures. This theory, however, conflicts with what we have clinically found. Mobilisation, a very rare clinical event since the implant frames are fixed to their seat with osteosynthesis screws, always requires the removal of the entire structure without the possibility of recovery.

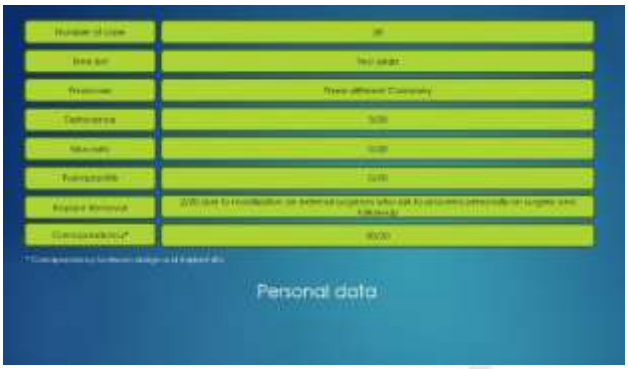


Figure 71: Personal data

6. HUMAN SKILLS TRAINING: the position reached by our team of clinical tutors of a program that deals with the distribution of a custom product such as the juxtaperiosteal one, as well as starting from the concept of personal skills. of technical managers of the design department, forced us to make some considerations. The team that will take care of assembling a "iuxta" rehabilitation must necessarily be prepared to manage a surgery with a medium-high level of difficulty. Especially for flap design and site preparation; for the safe and passive positioning of the frames and, finally, for the suture which must be absolutely flawless. The person who will take care of the prosthesis must be able to obtain and maintain a truly impeccable level of occlusal-functional balance. And as we know, human occlusion is not to be considered static and stable, but rather constantly evolving; therefore, the control action must be constant. The same applies to the peri-implant periodontal tissues both during the perioperative healing phase and in the first 7-9 months of rehabilitation, a period we consider necessary and sufficient to define stable healing and therefore a static and stable muco-gingival balance. So departments of Surgery, Prosthetics and Periodontology are really well organized and interconnected with each other. We do not dare to say that a surgeon of medium capacity, at his first "juxta", can carry out the assembly of the rehabilitation components in total autonomy, especially if not supported by a good team including a prosthetist and periodontist. This is certain. However, it is certain that a team can be easily trained on all technical-operational needs and also in a relatively short time. A theoretical-practical training course with a hands-on approach extended to all medical and non- medical office staff will give satisfactory results in terms of operational autonomy achieved, with a course completed on 6-7 cases treated. Also in this we see the character of modern efficiency and effectiveness

as well as reproducibility of the operational technology that we are here to (re)propose [13].

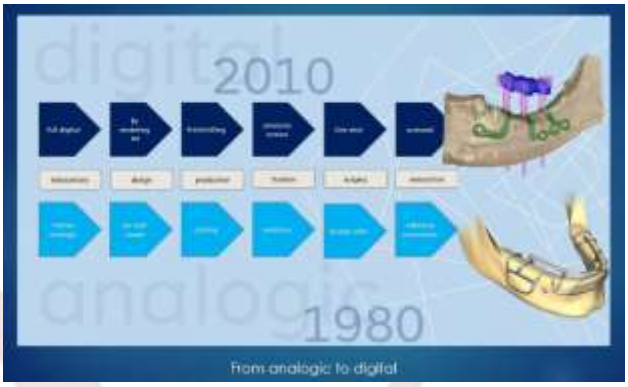
Figure 72: From analogical to digital era: advantages and difficulties associated with the transition from the analogue to the digital era.

CONCLUSIONS

1. CLINICAL INDICATIONS: the well-established fact that this rehabilitation technique is very complex and, moreover, has multifactorial procedural compartments, requires, first of all, a precise placement of the candidate within very specific inclusive criteria. By doing so, a high executive and prognostic safety is achieved, completely comparable to that obtained in the case of endosseous implants. The issue of very "narrow" inclusive criteria can absolutely be correlated to the fact that the implant site is made up of many parts, whether biological (alveolar bone, gingival tissues, antagonistic arch, architecture of the maxillary bone bases and occlusal plane), or " artificial" (the implant frame in its components, the extra-gingival connection bar, the prosthetic connection system and the prosthetic restoration itself). Here, we will say that we are in the area of full clinical indication when all these components are perfectly integrated and harmonized with each other in a perfectly balanced system. An ambitious but not impossible objective to achieve, also because, in the digital age, the proponents of this anatomical-functional harmonization are precisely us who work on the CAD. another controversial point; given the characteristics of the project, who is most suitable for its execution? Without a doubt a team made up of surgeons and technicians. Another peculiarity of this work.

2. TECHNICAL SKILLS: not to mention the technical skills required. Certainly very high in all areas that interact in the work flow, from the collection of diagnostic data to the execution of the project, surgery, prosthetic assembly and, above all, follow up. In practice, it is a question of perfect logistical organisation.

3. A MATTER OF NUMBERS: numbers, in medicine, and especially in surgery, are synonymous with safety. Numbers that provide epidemiological and statistical data. And medical statistics are used to evaluate many parameters; by centering the treatment on the intended patient by referring to the epidemiological curve to know, for example, whether the patient we are about to operate on is aligned or not with the average age found. Given that in case of discrepancy it could make us suspect an error of evaluation made in the choice of treatment. Numbers that can help predict, given a correct analysis, the onset of



problems in the peri-operative healing phase; numbers that can also help in the economic optimization phase of the product which, let's not forget, is highly customized and therefore difficult to "industrialize". And precisely the "customization of technical processes could be the peculiarity that will always make their technical-scientific development difficult.

In fact, each case is different from the others. This places designers and operators in a position of extreme difficulty in creating, first, rules whose application can simplify and make the result predictable, second to acquire sufficient experience, such as to allow, bad to say, that "clinical glance" necessary to identify critical issues and comforting data for each new patient. In this context, the concept of a clinical reference center would fit well, where perfectly trained and specialized clinical operators on the procedures are gathered at the same time, as well as a minimum and sufficient number of cases to create the technical awareness necessary for the optimization of any procedure. However, we

remain fundamentally very optimistic about the future of this

technique which over the years has shown increasing levels of credibility in the scientific environment, effectiveness, predictability and safety.

Figure 73: Effectiveness and applicability

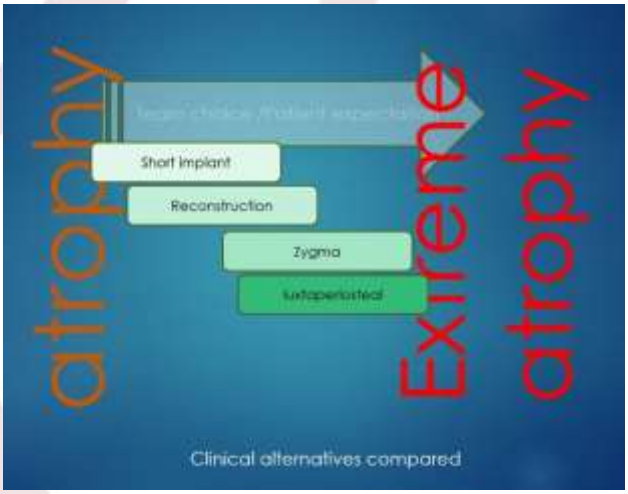
Figure 74: From reconstructive surgery to iuxta periosteal implants: the decision-making criteria for choosing one method over another, while remaining within the scope of the full applicability of each, also focus on the technical predisposition of the operator.

Figure 75: Pros and cons: the evaluation of the factors in favour and against a technique must be conducted in a conscientious manner and respectful of the patient's expectations.

Figure 76: Complication

References

1. Dahl GSA. Subperiosteal implants and superplants. Dent Abstracts.1957;2:685.
2. C Bellavia: Atlante di implantologia combinata Iuxtaperiostea ed Endossea Masson ed 1989
3. Goldberg NI, Gershkoff A. Six year progress report on full denture implants. Implant Dent. 1954; 1:13–16.
4. F. C. Nichols. Semiburied Dentures implant. 5 Review literature and experimental study. J Oral Surg 12:3,7, 1954
5. L. Barbera et al. Iuxtaperiosteal Implant. Current Concept and Clinical Revue. Clin Oral Science and Dentistry (2023) 6:1
6. D H Enlow Craniofacial Growth. Ed Int Cides Odonto
7. Linkow LI, Chercheve R. Theoriesand Techniques of Oral Implantology. Vol.I. St. Louis: CV Mosby; 1970:171–183.
8. Judy KW, Weiss LM. Modern surgical and design considerations and clinical indications for subperiosteal implants. Part III, Partial subperiosteal implants. Quintesence Int. 1977; 8:37–48.
9. Linkow LI. Implant Dentistry Today—A Multidisciplinary Approach. Vol.II. Padua, Italy: Piccin Nuova Libaria Publishing; 1990:876–878, 900, 902–905
10. N C Gellrich et all A new concept for implant-



borne dental Rehabilitation, how to overcome the biological weak-spot of conventional dental implants? Head and face med (2017) 13:17

11. K. Kulksar Modernization of cortically supported individual Implants Műszaki Tudományos Közlemények vol. 8. (2018) 51–60
12. M.Mommaert Evolutionary step in the design and biofuctionalisation of AMSLI for the maxilla O&MSurg 2019; 48:108-114
13. S.D. Jones et al Load Transfer Characteristic of Mandiboular Subperiosteal Implants Journ of Prosth dentistry Aug1979 vol42 n 2
14. Cawood JI, Howell RA. A classification of the edentulous jaws Int J Oral Maxillofac Surg 1988;
20. Cardiovascular assessment and management of patient undergoing non cardiac surgery European Heart J Vol43;39;10-22:3826-3924
21. A B Bohmer Preoperative risk assessment – from routine test to individualized investigation Dtsch Artzebl Int 2014jun 111(25)437-446
22. H K Shah Gingival BiotypeClassification assessment and clinical importance: a review J Nepal Soc Perio Oral Implantol. 2020;4(8):83-88
23. G Matarese Periodontal Biotype: Characteristic, prevalence and dimension related to dental malocclusion Minerva Stomatologica 2016 August;65(4):231-8
24. V Ratheesh Factors governing alveolar bone remodeling Int Jour of recent SDcientific Research 2019. 1003.3213
25. S V Peran Alveolar bone PERIODONTICS & ORAL IMPLANTOLOGY ch5
26. A S Roy Jaw Morphologyand vertical facial Types: a cephalometric Appraisal 10.5005/jp-journals-10026-1029
27. H Salgado the use of graphene for dental PMMA reinforcement – a systematic study Rev Port Estomatol Med Dent Cir Maxilofac 2022;63(4):179-188
28. X Li Graphene-based nanomaterial for Dental Application: Principles, Dental advance and Future Outlook Frontiers in Bioengineering 17(4):232: 36.
15. F Gatti Patologie sistemiche che aumentano il rischio d'infezione Dentista Moderno 07;2023
16. M Chiapasco et al Prevention and management of complication in oral surgery Dental cadmos 2017;85(1);21-35
17. B Howart review of the ASA Physical Status Classification:Reply. Anesthesiology 05/22 Vol136866-867
18. M Pizzuti Linee guida sulla gestione del paziente emorragico o con emorragia in atto U Op Ematol H SCarlo 02/2008
19. S Halvorsen 2022ESC Guidlines on

andBioTechnology 3,2022
29. MPunset Mechanical Characterization of Dental prostheses manifactured with PMMA-Graphene Composites Materials aug2022
30. M S Zafar Prosthodontic application of Polymethyl Methacrilate: An Update Polymers10:2020
31. E Hoque Titanium and Titanium Alloys in Dentistry: current trends, recent development,and future prospect Helion 8:2022 e11300
32. P Pesode Additive manufacturing of metallic biomaterials and its biocompatibility Materials today proceding
33. J Schweiger 3D Printing in Digital Prostethic dentistry: An Overview of recent developments in additive manufacturing J Clin Medicine 2021May;10(9):201
34. G S Schultz principles of wound healing Fridge & Thomson 06/2006 8;24
35. G Sganga infezioni della ferita chirurgica Urologia 2014;81(4)191-195
36. P H Wang Wound Healing J Chin Med Association 81 (2018) 94-101
37. M Mommaerts Additively manufactured sub-periosteal jaw implants Or MaxFac Surg 02/2017
38. H L Obgeweser Experiences with subperiosteal implants O Surg O med O Pathol 12-7-1959777-786

39. M Cerea Custom-made Direct Metal Laser Sintering titanium sub-periosteal Implants A retrospective study on 70 patients BioMed Res int 2018

40. K Takaoka Maxillary subperiosteal perimplantitis that cause severe resorption of the maxilla with perforation of the maxillary sinus and sinusitis a case report Open J of Stom 2013,3226-229

41. C M Weiss A collective conference on the utilisation of subperiosteal implants in dentistry j Oral Impl 127

42. E A Rancano-Alvarez Innovation in subperiosteal dental implants: Ranc implants case report and literature review Int J Odontostom 13(3); 325-331, 2019