BONE-LEVEL CONICAL DENTAL IMPLANTS: EVALUATION OF THE PREDISPOSING FACTORS RESPONSIBLE FOR THE MARGINAL BONE LOSS.

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Alla mia famiglia, che mi ha sempre supportata,
lasciandomi libera in ogni mia scelta.
A mia Madre intima leale confidente;
A mio Padre forza propulsive della mia grinta;
A mio Fratello esempio di dedizione e costanza.

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è la chiave per raggiungere ogni obiettivo.

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in una terra diventata mia seconda casa.

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per precisione e professionalità.

Alle mie Amiche, Donne dai caratteri forti e diversi,
che riescono a capirmi ed aiutarmi in ogni momento….
…Crescendo insieme.

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To my family, which has always supported me,
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who can understand me and help me all times ...
... growing together.

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... building Our Life together.

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INDEX

MBL CONCEPT AND DEFINITION

Numerous retrospective studies have shown that during the first year of functionalization, implants undergo marginal bone loss ranging from 0.9mm to 1.6mm. Starting from the first, bone reabsorption is considerably reduced, so much so that a loss of about 0.1 mm of bone every year is considered physiological. One of the traditional implantology problems has always been the crestal alveolar bone reabsorption around the implant collar once it has been loaded with abutment and crown. This bone remodeling and resorption can reach up to 2 millimeters after the first year of loading.
The reason for this subsequent reabsorption is not entirely known and various hypotheses have been advanced. One of the most accredited is the occurrence of a mechanical stress following the masticatory load that affects the crestal bone surrounding the implant (mechanical theory). Another advanced hypothesis consists in the presence of microgap in the area of connection between abutment and implant: this would create the beginning of a bacterial colonization that invades the spaces between implant components with the mucosa inflammatory processes onset and crestal bone surrounding the implant itself which force the mucosa and bone to withdraw apically and establish the biological level or width on the implant and no longer on the implant-abutment junction (bacterial theory).

The literature gives us other interesting ideas for the relation between the implant abutment / peri-implant tissue and in particular the influence that the vertical dimension and the abutments shape can have with respect to marginal bone stability. Galindo maintains that the height implant abutment shoulder a relationship with the peri-implant marginal bone loss, since a reduced shoulder height causes an angular reabsorption due to a proximity of the bone tissue with the crown-abutment interface and its inevitable bacterial load.[1] By removing this interface from the hard tissues the inflammation due to bone resorption would be minimized in favor of a marginal bone crest better maintenance. The ideal shoulder height identified by Galindo is 2 mm. Rodriguez has observed how a conical abutment use on a platform switching connection has led to a circular and more coronal orientation of collagen fibers, contributing to the soft tissues stabilization around the rehabilitation, inhibiting the apical migration and consequently protecting also the bone tissue levels.

Curam and Hub, agree that a concave profile directly influences the bone margin remodeling inducing a lesser reabsorption and a better connective tissue attack around implant connection, moreover the greater space offered to the soft tissues increases volume, trophism and stability.

A different tissues response and consequently a much more reduced bone loss is observed when the PLATFORM SWITCHING concept is applied: it consists in using an abutment with a smaller diameter than the implant neck diameter and an extremely precise connection that reduces considerably the gap between the system components. Several hypotheses have been put forward to explain this phenomenon and the protection against crestal bone by platform switching.

1) The mechanical theory indicates a greater stress that is exerted on the neck entire surface in the traditional implant, while in the one with platform switching the stress zone moves to the implant central area and not to the peripheral zone.

2) The bacterial-inflammatory theory foresees that the infiltrate on the abutment-implant junction is moved horizontally towards the implant center, moving away from the adjacent crestal bone.

The maintenance of peri-implant bone tissue is essential for the long-term dental implants success. The most widely used parameters for measuring outcomes in implant dentistry are related to the implant, the peri- implant soft tissue, and the prosthesis, besides the subjective assessment of the patient.[(2)] These parameters are related to the tissue stability, which influences marginal bone loss progression (MBL) around healthy implants. The loss of 2 mm of bone around the implant neck during the first year after functional loading has been assumed as normal by the dental community and has even been considered a successful outcome in some classifications, an example Albrektsson et al. 1986; and Misch et al. 2008.

SUCCESS CRITERIA

Starting from Bränemark, the evolution of clinical protocols and the technological characteristics of the materials has led to an ever increasing number of patients treated with implant-prosthetic rehabilitations, allowing an increase in comfort and chewing performance.
In 1986 Albrektsson established the following implant success criteria:

- a single, non-prosthesis implant is clinically immobile;

- radiographs show no rarefaction around the implant;

- after the first year of loading, vertical bone resorption does not exceed 0.2 mm for year;
- there are no symptoms such as: pain, infections, mandibular canal invasion, paresthesia and neuropathies.

However, the success criteria must be distinguished from the survival criteria. You speak of survival when an implant has a marginal bone loss greater than 2.5 mm, a peri-implant depth > 5 mm (with BOP - / +) or a recession of the peri-implant mucous margin, as consequent an uncovering marginal implant, without inflammatory manifestations clinically evident, without functional and aesthetic problems, with the implant remaining in the oral cavity for an indeterminate number of years[4].

Longevity.
As previously stated, in this guideline the prosthesis survival is not considered but only the implants longevity. It is recommended that in order to respect the implants minimum survival concept, these should be considered in the context of the prosthetic artifact they support, as prosthetic rehabilitation is the most important aspect for the patient.
Misch established clinical criteria for the evaluation health implant, also evaluating the prosthesis survival and not only of the implants, suggesting a minimum prosthetic survival of 90% at 10 years.

Pain

The pain and sensitivity are subjective criteria and dependent on the discomfort degree patient's interpretation.

Unlike the natural tooth, where pain is a pathology indicator of the latter and represents the first cause of dental emergency, an implant is rarely disturbed by subjective pain and sensitivity criteria.

Therefor this criterion contributes less to the implant health determination.

Generally, the pain does not occur if the implant is not still and surrounded by inflamed tissue, or has a rigid fixation but presses on a nerve termination.

In a rigid implant, the implant sensitivity or a slight soreness at palpation, rather than pain, is more abnormal and signals a more significant complication for the implant than a tooth.

Sensitivity during function or percussion usually involves healing near a nerve or, more rarely, bone stress beyond physiological limits.

If sensitivity to a nerve (mandibular canal) occurs immediately after surgery, the implant can be unscrewed for 1 mm and re-evaluated for symptom reduction after 3 weeks. If the sensitivity appears after the first stage of healing and is not due to the surgical invasion of an anatomical reference point, stress could be the cause. First of all, the attention is placed on soft tissues and prosthetic components.

Mobility.

A dental element shows normal physiological movements in the vertical, horizontal and rotational directions. The amount of movement of a tooth is related to its surface area and root shape. Therefore, tooth mobility is influenced above all by the number and length of the roots, by their diameter, shape and periodontal ligament health state. A healthy tooth shows no vertical clinical mobility. The mobility of a tooth is greater horizontal than vertical.

Mulhemann has considered the fact that the tooth movement can be divided into initial mobility and secondary movement.[5] Initial mobility is observed with light force, occurs immediately and is to periodontal ligament attributed.

The secondary movement occurs as a result of an additional force applied to the tooth, and is directly related to the amount of force applied and dependent on the viscoelasticity of the bone.

The term rigid fixation is a clinical expression that indicates an absence of clinically observable mobility.

The term osteointegration instead is a histological term that defines the direct contact of the bone with the implant surface to the enlargement of an optical microscopy.
The two terminologies have been used interchangeably for the evaluation of implant mobility, but the maximum predictability is obtained with the rigid fixation evaluation. Term indicating the absence of implant clinical mobility, assessed with vertical or horizontal forces of less than 500g, similar to the natural teeth evaluation. It should be kept in mind that the lack of clinically observable movements does not mean the real absence of any movement. Furthermore, the lack of implant mobility does not always connect with a direct bone-implant interface. However, when observed clinically, rigid fixation means that at least an implant portion is in direct contact with the bone, although the bone contact percentage cannot be specified.[6]
A mobile implant indicates the presence of connective tissue between implant and bone.
Although imperceptible, implant movements are still present in the lateral direction and hypothesized that most of these may be due to component flexion and lack of cortical bone at the mesial and distal faces level, compared to the thicker cortical laminae present in the vestibular lingual dimension.
Mobility also varies directly in proportion to the applied load and bone density and reflects the bone tissue elastic deformation.
Unlike a tooth, for which mobility is not a primary longevity factor, it constitutes instead a determining factor for implant health.[7]
Rigid fixation is an excellent health status indicator, as it is an easy objective test. Therefore, it is generally the first clinical criterion evaluated for a dental implant. The techniques for establishing rigid fixation are similar to those used for the natural teeth mobility. Two rigid instruments apply a lingual vestibular force of 500g. The tooth mobility amplitude can be measured from 0 to 4, where 0 is a normal mobility for physiological movement, 1 is a distinguished marked mobility, 2 is a visible mobility up to 0.5 mm, 3 is a severe mobility up to 1 mm, and 4 is an extreme mobility that also includes a vertical component.

This same gradient can also be used for oral implants, with slight modifications.

IM 0 corresponds to the absence of clinical mobility;

IM 1 demonstrates a distinguishable increased mobility;

IM 2 visible mobility with displacement up to 0.5 mm;

IM 3 severe horizontal mobility greater than 0.5mm

IM 4 horizontal and vertical visible mobility.

Percussion
In the past, percussion was used to assess the rigid fixation presence. However, it does not represent an indicator of clinical health or rigid fixation.

CRESTAL BONE RESORPTION.

The marginal bone around the implant crestal region is usually a significant implant health indicator. Surgical trauma often causes a small bone resorption, which can sometimes be several millimeters. The operator can assess the bone resorption presence due to surgery before the prosthesis is constructed. Crestal bone resorption after the prosthesis application is a primary indicator of the need for a preventive initial therapy. The early loss of crestal bone 1 mm beyond the abutment micro-gap after the prosthesis application is generally due to excessive stress on the transmucosal site or to the ridge module implant design. The crestal bone level is measured from the crestal implant position to the second discovery surgical stage.

Initial bone resorption after starting up beyond the abutment connection and the collar region is often the result of excessive stress on the crestal bone-implant interface.[7]

It is therefore important to reduce stress factors, such as occlusal forces, the extensions length and, above all, the parafunctions. A secondary bone resorption around an implant is generally a combined condition of bacteria and an increase in stress.[8]

Several studies affirm that marginal bone resorption, after the first year of operation, is at most 0.2 mm. Adell et Al determined that successful implants after the first year of loading had on average a bone resorption around 0.1 mm for each subsequent year[9]. Cox and Zarb. observed a similar amount of average bone loss of 0.1 0.13 mm for year, after the first year of prosthetic functioning[10].

In ideal conditions, the tooth or implant should lose bone in minimal amounts. However, it is not possible to know how much bone resorption indicates success or failure. In general, if more than half implant height has lost contact with the crestal bone, the implant has a significant risk and is considered a failure, regardless of the original amount of bone-implant contact. Furthermore, probing depth should be considered in relation to bone resorption. If an implant has 5mm bone loss and has 10mm probing depth, the situation is much worse than an implant with 6mm bone resorption and 3mm probing depth.

Radiographic evaluation

Radiographic evaluation to establish crestal bone resorption is the most commonly used clinically.
The clear turns display on the radiograph indicates the use of a correct angle. Ideally the abutment - implant connection should appear as a clear line between the two components. When the top of the implant is placed at the bone crest level the area reabsorption amount, at this level is easier to evaluate
A peri-implant radiolucency indicates the surrounding soft tissue presence and is a sign of implant failure. The cause can be infectious, iatrogenic, non-rigid fixation or local bone healing disorders. Apical radiolucency has rarely been observed in a non-mobile implant. This is more likely to represent the one of the side plates perforation, but may be due to cutter contamination, overheating or an infection.[11,12.)]

Probing depth

As far as the teeth are concerned, the probing depth is a very effective means of establishing its past and present health. The increase in the depth of the sulcus around the natural teeth is related to the pathological state and to resorption.
Often, for the same purpose, periodontal indexes are used to evaluate dental implants. However, the correlation of the implant sulcus depth with the health state is controversial.
The probe in a natural tooth measures the sulcus depth and the junctional epithelium attachment depth. In a natural tooth, the connective area has 13 different fiber groups, of which six physically fit into the cement. This area stops further penetration of the probe and acts as a barrier to bacteria entry.
When the measurement is carried out on an implant the connective tissue has only two types of fibers and neither is implant connected. Then at the implant level, the probe passes the gingival sulcus, the junctional epithelium attachment, the connective tissue and comes closer to the bone.
Despite the limitations, periodontal probing and depth assessment, it helps the dentist monitor these regions. When the sulcus depth increases, the oxygen tension decreases. The bacteria in an implant sulcus are similar to those of a natural tooth.
Home oral hygiene procedures cannot clean a sulcus deeper than 2mm.

Pocket depths greater than 5-6mm have a higher anaerobic bacteria incidence. Therefore, as a general rule, to allow the patient to perform an effective home hygiene the ideal implant sulcus must be kept below 5 mm.
Despite the increasing pocket depth uncertain significance, the survey is an appropriate method to evaluate potentially harmful changes in the peri-implant environment. It also reveals tissue texture, bleeding and exudate.

Index of bleeding

For a natural tooth, bleeding during probing is inflammation and plaque index related.
The bleeding index is a sulcus health indicator. The bleeding and gum health use as implant health indicators is controversial.
Regardless fact that gingival health is synonymous with success, all clinicians agree that ideal condition for around implant soft tissue an should be the inflammation absence.
Radiographically evident bone resorption and increased pocket depth have been correlated with sulcular bleeding.[8] Thus the gingival tissues status around an implant should be recorded and used to monitor the patient's daily oral hygiene.
When used for teeth, this index measures gingival inflammation on the vestibular, lingual / palatal and mesial all teeth surfaces with a score from 0 to 3. Bleeding symptoms include a score of at least 2.
These scores can be used for implants.

Maintenance of osseointegration under functional load

It’s complex to predict how forces are transmitted to the bone-implant interface, what happens to the implant and how the bone reacts by reshaping.
First, the masticatory loads transmission to osseointegrated implants is characterized by significant biomechanical differences with respect to natural teeth. Natural tooth is connected to bone by periodontal ligament collagen fibers which foresee its intrusion up to 50-100 μm; the implant is instead a direct contact with the bone and system elasticity depending on the bone elasticity.
A force is therefore deeper for an osseointegrated implant than natural tooth, because it is transmitted directly to bone tissue. Moreover, the presence of

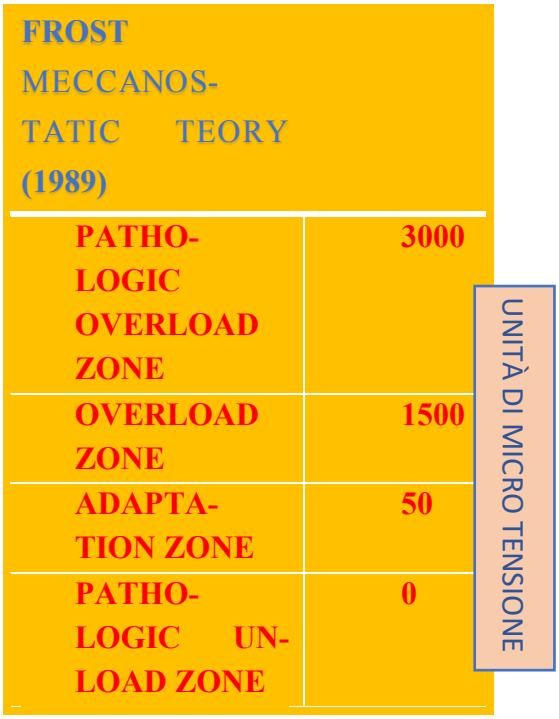
periodontal receptors (PMR) in the ligament, ensures an excellent entity and direction of masticatory loads control. In implants case a simple free non-specialized nerve termination present in the surrounding bone tissue is required; certainly, the control and defense against problems cannot be as sensitive and precise as in natural teeth case.

Secondly, we need to consider the bone tissue biomechanical properties.

Bone tissue is characterized by:

• anisotropy: the properties vary with the stress direction;
• inhomogeneity: the properties vary from point to point within tissue;
• subjective specificity: property values vary from one subject to another;
• viscoelasticity: mechanical properties depend on time; the deformation is increasing over time even at constant load;
• functional adaptation: the biomechanical properties change in response to stresses. The bone functional adaptation is characterized by bone cells ability to produce or reabsorb the bone matrix mineral component.

A model to explain the functional adaptation of the loaded bone is represented by Frost's Mechanostatic Theory (1989).[13]



On the basis of this theory, 4 increasing bone tissue levels are distinguished.

1. Pathologic unload zone: if no force is bone applied, its mineralization is lost gradually and its resistance consequently (ex non usu atrophy).

2. Adaptation zone: if correctly stimulated bone, right physiological remodeling is created which allows the bone itself maintenance;

3. Overload zones: if the applied force exceeds the adaptation area, the bone tissue reacts by opposing the external stimulus with osteoblast activation and bone apposition

4. Pathologic overload zone: if the load exceeds the physiological range the osteoblasts function can be inhibited, and therefore the osteoclastic function prevails. Consequently, the bone becomes weaker and in the dental implants case the osseointegration is lost. Finally, when the tissue elastic limit and resistance are exceeded, there is a bone fracture.

DETERMINANTS

The parameters that influence implant stability (both primary and secondary) can be divided as follows:

Surgical parameters

The surgical technique plays an important role in determining implant stability and, consequently, in the treatment result. The most obvious influencing factor is the drills diameter used in relation to implant diameter, that's, the extent osteotomy performed to any sub-preparation. Other factors are the preparation depth and the possible site tapping. The risk factors mainly concern the traumatic surgical technique cases that can cause bone damage through "compression bone necrosis".

Patient related parameters

The most significant patient-related parameter is bone in quality and quantity terms. Among the risk factors associated with bone quality is the implanted bone, irradiated bone and cancellous bone presence. All these considerations are becoming increasingly common as more and more patients can undergo implant treatment. The insertion torque also depends on the local bone quality: a dense and compact bone will offer greater resistance to shear forces.

Parameters related to the implant

In general, an implant body can be divided into a crestal module (cervical geometry), a body and an apex. Each of these parts has characteristics that are favorable for obtaining good implant stability. The implant-related parameters that affect implant stability include the crestal module, implant design (conical or cylindrical shape), length, diameter, surface type, auto threading, spire geometry. An implant's crestal module receives most of the implant loading and appears to play an important role in implant stability. It should be slightly larger than the outside diameter of the threaded implant body.

This is because the seal created by a wider crestal module determines the implant greater primary stability, especially in more unprepared softer bone, because it compresses the crestal bone region. The design of the implant not only governs the primary stability but, more importantly, determines the percentage of BIC (Bone Implant Contact) and the available contact location for the effective force transfer to the bone after occlusal loading.

Parameters related to the treatment protocol

Implantology mainly involves two surgical techniques:
The "two stage" which provides a first "submerged" phase, when which the implants must remain submerged under the gum for 2-4 months, without being subjected to any type of contact or prosthetic load and a second phase, when foresees the mucosa reopening and the implant connection to the prosthetic abutment.
The "one stage" in which the implant is inserted and left transmucosal, so as not to have to re-intervene to discover it with a second surgical phase. The original two-stage surgical protocol ensured an initial healing period before load, during which stability was improved by new bone formation and osseointegration. Today, one-phase protocol is becoming increasingly common. In many cases the initial mechanical stability is sufficient to justify immediate loading. However, the lack of a pre-load healing period may increase the risk of insufficient stability at the time of loading.

SURGICAL PARAMETERS.

Milling.

The implant rehabilitation success depends largely on the alveolar bone primary healing capacity which determines the implant osseointegration. The implant site correct preparation and the healthy bone presence are of fundamental importance for primary healing. Osteotomy using cutters causes not only a mechanical trauma but also a bone temperature increase that must repair around the implant. Thermal trauma caused during implant preparation is an important factor that influences osseointegration and therefore implant survival.

Bone necrosis occurs when the temperature exceeds 47 ° C for more than 1 minute[14,16]. Therefore, the bone thermal and mechanical insult must be minimized during the implant osteotomy. This is why cutters must be used with irrigation to prevent bone tissue overheating[15]. It has been observed that higher temperatures are reached in the external cortex than at the osteotomy bottom and therefore it is preferable to use a cutter external irrigation. It is necessary to carry out a continuous movement "inside and outside" to avoid exerting excessive pressure.

Primary Stability.

The implant primary stability is obtained during the first surgical phase and is necessary to avoid micro-movements that could lead to the peri-implant fibrous tissue formation and consequent fibrointegration. It is guaranteed by the bone that surrounds and delimits the implant site.

Primary stability depends both on the implant macroscopic design and on the way in which the implant site is made: the result is a mechanical joint with the bone. It is therefore necessary to insert the system according to the manufacturer's protocol in order to obtain an optimal insertion torque.

The primary stability is therefore a mechanical phenomenon, mainly related to 4 factors:

• Bone quality (relationship between cortical bone and trabecular bone).

• Bone quantity.

• Implant geometry.

• Surgical insertion technique.

After implant placement, the bone tissue initiates the healing process which will lead to the replacement of the bone damaged by the surgical trauma with newly formed bone that contracts direct contact with the implant surface.

Following the osteotomy, a peri-implant bone portion goes into necrosis due to vascular interruption in the Havers and Volkmann canals, which vascularize the osteons, providing nourishment and oxygen by diffusion to the osteocytes. The vascular interruption, caused by the burs cutting in the bone, leads to osteocytes necrosis and, to the bone devitalization.

The greater the tightening force (torque) fixture impressed, the greater is mechanical retention of the same inside the bone; the latter then continues to mechanically support the implant in the healing initial phase until it is replaced by new vital bone that will provide the bone support necessary for the implant long-term survival. During this process, the initial bone is progressively reabsorbed to make room for the new. Inevitably, this leads to a certain loss of primary stability which lasts until osteoinhementation is achieved, with the new stability appearance linked to bone formation, called "secondary stability". The gradual change from primary to secondary stability is critical between the second and third week.

In summary we report below the temporal phases described by Albrektsson[17]:

• During surgical trauma the blood vessels are damaged, causing hemorrhage and the formation of a clot. At this stage platelets play a fundamental role.

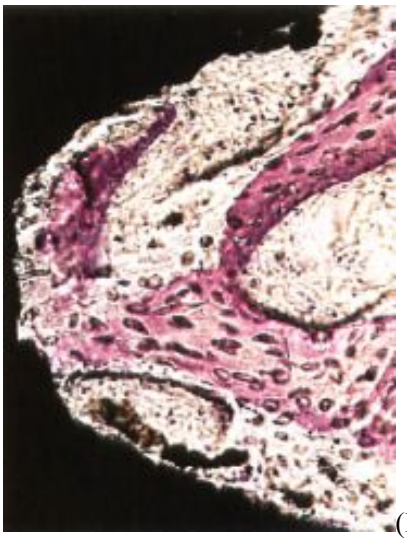
• The circulation cessation causes in the first hours after surgery, local ischaemia at the fractured margins due to the oxygen to osteocytes supply lack.

• Necrosis includes feedback mechanisms between signal factors, mitogenic and chemotactic, and is the prelude clot demolition by leukocytes, but it’s necessary to underline the importance of angiogenesis as the only way to supply nutrients to the perimplan compartment.

• After about 4 days, thanks to the vessels increased permeability, migration and colonization occurs by the undifferentiated mesenchymal cells produced by the marrow and released into the circulation to fill the post-extraction socket.

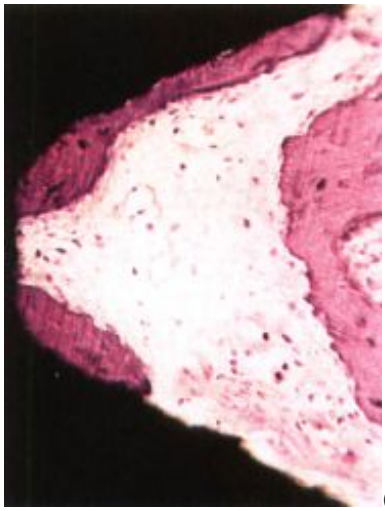
• In the following days there is cellular differentiation (granulocytes and macrophages rush to eliminate cellular and bone debris in necrosis) and organization of the periprosthetic tissue.

• A month after implant insertion, you will notice a very small amount of newly formed bone around the fixture. (fig A)



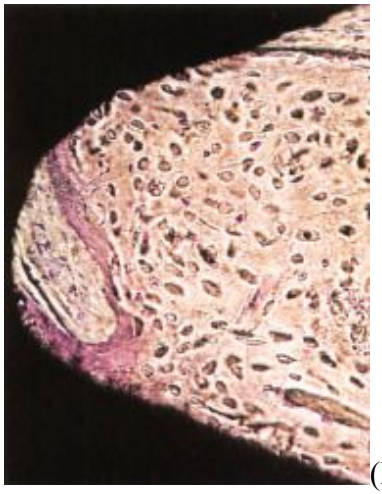
(Fig.A “Image by oral surgery manual SICOI”)

• Three months after surgery there is an increase in bone present at the implant interface; in some cases the thread is filled with cortical bone, in other cases mostly soft tissues have been found. (FIG.B)



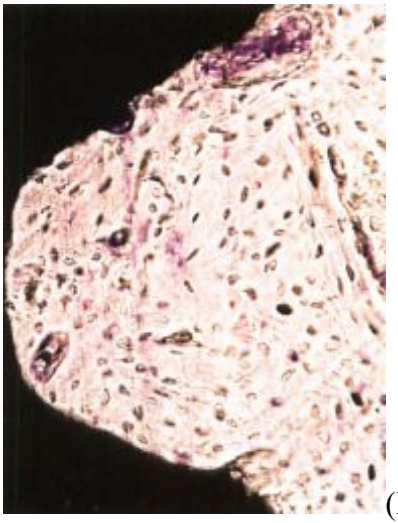
(Fig.B"Image by oral surgery manual SICOI")

• Six months after the operation, we can observe, with a slight individual variability, a good cortical bone within the thread. (Fig. C)



(Fig.C"Image by oral surgery manual SICOI")

• One year later, a cortical bone contact surface of 90-95% was found. (Fig. D)


(Fig.D "Image by oral surgery manual SICOI")

Only later (after the 3-6 months established by Branemark) can implant stability be guaranteed by remodeling and bone formation at the bone-implant interface, that is from osseointegration.

Implant distance:

The optimal anatomical position choice of the implant is based on the bone available amount
there is a minimum distance both to insert an implant near a tooth and to insert an implant near another implant; there is also a minimum thickness of bone that must remain both vestibular and lingual. The respective measurements are approximately 1.5 mm between tooth and implant, 2.5 - 3 mm between implant and implant and 1 mm at the buccal and lingual level.

To avoid soft tissues loss (papilla) due to adjacent tooth bone resorption and to allow the soft tissue to reshape around the implant
Not respecting these parameters leads to a probable aesthetic failure, integrated implants but not satisfactory dental crowns final aesthetic and to a very probable functional failure, bone loss and consequently implant loss.

The implant head different positions in the space three dimensions directly influence the final result and, better is the surgeon's control over the implant head optimal position, the greater possibility of obtaining an optimal aesthetic and functional result.

The choice of which will be the optimal implants position is determined and guided by the final restoration and must be decided during the diagnostic process must be decided. For this reason, in the case of large restorations or complex cases, it is recommended to perform a diagnostic wax-up in articulated models. The surgical guide for the surgeon can be made from this wax-up. The greater the case difficulty, the more precision will be required: in these cases, it is recommended the use of fixed profile splints described by Sicilia et al.[18] is recommended. In simple cases or single units restorations (premolars, lateral incisors), both adjacent and antagonistic teeth can be used as a surgical reference.

Subsequently, a description is given of the implant head ideal position that refers to each of the space three planes.

Mesio-distal relationship

Aesthetic restoration if the implant head in mesio-distal plane occupies the pocket area is not possible.

Bucco-lingual relationship

In this plan, the most suitable position for different authors is the one located between the incisal edge and the final restoration cingulum.

This position allows a restoration with an optimal emergence profile regardless of the implant axial inclination: there are cases in which the buccal wall resorption or just the anatomy of a jaw with hypoplastic features, force a non-axial fixture insertion. Faced with this delicate situation there are two possibilities: or identify the fixing device head in the optimal position (between the incisal arch and the cingulum arch) even if it does not have an axial direction or look for a possible more axial position that allows to the fixture to receive functional loads along the implant axis. The first possibility will allow the construction of an optimal dimensions restoration and similar to natural crowns. The second possibility leads us to two different scenarios:

* The the implant head vestibular position is likely to show part of the restoration metal component due to the peri-implant mucosa thin layer. Furthermore, the restoration dimensions will necessarily be longer than those that should correspond to the adjacent teeth size.

* implant head Lingualized position: the restoration size will be adequate and in harmony with the adjacent teeth. But the emergency profile will hinder the patient's hygienic maintenance as well as introducing unwanted loading moments.

Apico-coronal relationship

The apico-coronal plane position will be related to the restoration emergence profile. This is due to the necessary transition between the implant head width and the width of the restoration gingival portion. The ideal position in the apico-coronal plane will be dictated by the prosthetic restoration width and by the position of the adjacent teeth gingival margin. As a rule, a distance between 2 and 4 mm apical to the adjacent gingival margin is considered adequate and not to the amelo-cement junction that may not even coincide with the gingival margin (eg multiple gingival recessions or presence of periodontitis).

If the fixture head is too coronal, the restoration profile will need a transition so pronounced as to be unpleasant; it is also very possible that the screw metal is exposed to the slightest recession.

It is important to remember that during the first year of prosthesis insertion the buccal mucosa margin tends to undergo an apical migration of 0.6 mm on average

If, on the contrary, the implant head is buried more than 3-4 mm with respect to the adjacent gingival margins, the emergence profile will be adequate but the manipulation from the prosthetic point of view, in the case of cemented prostheses, will be complex due to the difficulty to remove overflowing cement. The mucosal health maintenance will be even more difficult the more the prosthetic implant seal is buried.

Relationship between implant and tooth

The interdental papillae presence in a prosthesis supported by implants adjacent to a tooth, depends directly on the distance of the tooth interproximal bone crest with respect to the restoration contact point. In this way, if the distance is less than or equal to 5 mm, probability of having a complete papilla is 100%; if that distance is 6 mm, probability is 67%; if that distance is 7 mm, probability of having a papilla is 27%. Although in the literature it has been shown that there is less bone loss between narrow implant-tooth spaces[19]. However, the interdental papillae size undergoes an annual increase of about 0.375 millimeters on average compared to the initial position, unlike the buccal gingival margin which suffers from recession.

Implant-implant relationship

A minimum distance of 3 mm is required for the interdental papilla to be predicted between two implant restorations.[19] This is explained by the biological thickness formation that occurs not only in the vertical direction but also horizontally, the latter of about 1.5 mm in each installation. This mechanism could also explain the fact that vestibularly located implants have a tendency to show or make the head metal appear, giving a gray appearance to the marginal mucosa.

PARAMETERS RELATED TO THE PATIENT

The patient selection and the drafting of a treatment plan that takes into consideration all those aspects that are fundamental for the correct osseointegration realization and its maintenance is fundamental.
The main indications, common to all implant-prosthetic rehabilitative interventions can be schematically listed in:

1. Monoedentulie (alternatively and fixed prosthetic artefacts).

2. Partial edentulous, both intercalary and distal, adopting the bridge on implants technique or distal implant support technique (as an alternative to removable prostheses).

3. Total edentulos for the total fixed prosthesis execution on implants or a mobile implant anchor prosthesis.

4. Anchoring for orthodontic movements.

Contraindications to implant surgery can be divided into general (systemic) and local.

The generals, in turn, can be distinguished in absolute, which forbid in any case the implant insertion, and relative, for which it is possible to insert the implant, but only with particular precautions, or after having obtained the perfect disease control.

• ABSOLUTE GENERAL CONTRA-INDICATIONS:

- Absence of a sufficient amount of alveolar bone.

- Age less than 16 years.

- Heavy cancer diseases; patients undergoing high-dose radiation therapy or bisphosphonate therapy are much more exposed to the risk of osteonecrosis.

- Serious dental diseases.

• RELATIVE GENERAL CONTRAINDICATIONS:

- Insulin-dependent diabetes; patients with reduced tissue healing capacity.

- Osteoporosi; poor quality bone, does not guarantee the implant stability.

- Heart disease.

- Pregnancy and breastfeeding.

- Acute articular rheumatism.

- Trigeminal neuralgia.

-Bruxismo.

• LOCAL CONTRAINDICATIONS:

- Periodontal disease not controlled and active.

- Smoke: increases the implant failure risk as it affects the healing capacity of post-operative wounds and has a negative effect on peripheral circulation, hindering the osseointegration process.

- Inadequate oral hygiene: the bacterial load can cause gum tissue and bone inflammation, reabsorption of the same and, consequently, implant loss.

Dependent patient parameters that can cause marginal bone resorption and lead to possible implant loss are characterized by the various cofactors influence, which we can thus subdivide:

LOCAL FACTORS:

• bone,
• mucosal
• patient's microbiota environment

GENERAL FACTORS:

• Habits: oral hygiene, alcohol and tobacco consumption
• Inflammatory profile: systemic diseases (osteoporosis, diabetes, rheumatoid diseases etc.)

We therefore proceed with the deepening of the general contraindications, after anatomo-physiological descriptive alveolar bone introduction.

ALVEOLAR BONE

The alveolar bone is that part of the mandible and maxilla that forms and supports the dental elements alveoli. It is one of the four structures that make up the periodontium together with gingiva, cement and periodontal ligament and has the function of distributing and reabsorbing the forces generated by intersupidation and mastication. The alveolar bone develops in conjunction with the teeth formation and eruption and consists of bone formed either by cells originating from the dental follicle (own alveolar bone) or from cells independent of tooth development.
The alveolar walls are covered with compact bone while the area between the alveoli and between the compact bone walls is occupied by spongy bone which occupies most of the interdental spaces but only a relatively small portion of the buccal and palatal bone surfaces.

The spongy bone contains bone trabeculae whose architecture and size largely determined by genetic conditions, while only in part are the forces result to which the teeth are subjected during their function.[20]

It should also be borne in mind that the buccal and palatal surfaces bone thicknesses of the alveolar process vary from one region to another. The bone plate is thick at the molar teeth palatal and vestibular surfaces, but thin in the mouth anterior region. The right alveolar bone that covers the alveolar wall often continues with the compact, or cortical, bone of surface
Remodeling begins with the retrieval of osteoclast progenitors from the circulatory stream and their differentiation into osteoclasts in the sites where bone resorption must occur. In turn, new osteoblasts adhere to the gap walls formed by resorption and lay down layers successive bone forming the new osteon concentric lamellae. In the young individual these processes of remodeling and remodeling are much greater than in the elderly; for this reason, mature osteons prevail in the adult and the bone appears very compact due to the scarcity of resorption cavities lingual and buccal. In the incisors and premolars regions the compact bone placed at the teeth buccal surface level is much thinner than that placed at the dental elements lingual surface level. In the molar region, however, compact bone is more often at the buccal surface level than the lingual one.[21]

Post-extraction alveolar bone healing

When a tooth is lost during life, following an extraction or a traumatic event, a process of alveolus healing is established which leads to a deposition of bone tissue in the space previously occupied by the dental element root.
Bone is produced by osteoblasts, in fact they cover all the bone surfaces that show active bone formation. However, these cells are unable to migrate or move, so they are unable to proliferate within a bone defect; for this reason bone defect healing depends exclusively on the presence of osteogenic precursor cells in the surrounding bone or in the surrounding tissues and by their ability to invade the defect and to differentiate into osteoblasts.

After the tooth extraction, processes that lead to the alveolar bone regeneration are triggered in the alveolus:

At first the site is filled with blood, serum and saliva, which, after a few minutes, will be organized into a clot. The stable clot formation is essential for the intraosseous defect correctly filling: in fact, it will act as a "scaffold" on which the osteogenic cells can migrate.

After tooth extraction day we will find fibroblasts and fibrin in the clot most peripheral portion; the osteoblasts begin to cover the bone margins and the osteoclasts determine a minimal reabsorption of the alveolus edge, necessary to induce the osteoblasts to produce their bone matrix. Finally, lymphocytes and leukocytes appear.

After two days from the extraction we see the real granulation tissue formation, characterized by the blood vessels, fibroblasts and leukocytes presence.
With a hemolysis process, the inflammatory cells begin to dissolve the clot in its central part.

At one week the granulation tissue is predominant: fibroblasts, collagen fibers and blood vessels that are organized in a new vascular network (neoangiogenesis) are present. Bone deposition begins in the alveolus most apical portion, with osteoid formation. In this phase, the epithelial cells migration onto the granulation tissue also begins: the wound epithelial covering begins; because of this process, if a stable clot had not previously been created, there is the risk that the epithelial cells fill a part of the bone defect, causing an alveolar process height low.

At around day 14, the alveolus marginal portion appears to be covered with immature connective tissue, rich in inflammatory cells and vessels and the appearance of osteoid tissue along the walls is observed.

After 4-6 weeks the alveolus is filled with connective tissue and bone tissue; meanwhile the epithelium completely closes the surface and progressively keratinizes.

In the first month it is mainly formed lamellar bone that accompanies the resorption of the alveolus hard lamina.

After 2 months, the alveolus shows a bone neostructure, but its complete recovery can take up to 4 months. Usually the cured post-extraction socket never reaches the alveoli vertical height of the neighboring dental elements.

Usually the extraction socket recovers without complications; but, even in healing without complications, the alveolar defect that results as a tooth removal result will only be partially repaired. In fact, in conjunction with the bone growth inside the alveolus, there is also a reabsorption of the alveolar ridge. The largest amount of bone loss occurs in the horizontal dimension, and this happens mainly on the ridge vestibular side. There is also a loss in the ridge vertical dimension, which, however, is more pronounced on the buccal side.[22] This resorption process takes the form of a narrower and shorter ridge[23] and relocated to a more lingual / palatal position.

The alveolar defect resulting from a tooth loss can also be complicated by previous bone loss due to periodontal disease, endodontic lesions or traumatic episodes. Most of the alveolar bone loss occurs in the first 6 months, but bone resorption activity continues throughout life, at a mini-speed, eventually leading to the large amount removal of mandibular structure.[24]

Classification of bone atrophies

The physiological process of resorption which the jaws and jaws undergo due to the dental elements loss, if continued over time, can lead to inadequate bone support for an implant insertion, altered skeletal relationships between the jaws and an keratinized mucosa reduction.

Cawood and Howell[25] made a randomized study in 1988 by analyzing the jaws reabsorption after tooth loss and noted that resorption processes follow quite repeatable patterns despite individual variability.

In this regard we can remember that bone loss is affected in speed and entity by different cofactors: age (the elderly are more susceptible), sex (the female is more affected), skeletal morphology (the patient with a vertical dimension reduced to because of a deep bite it is more sensitive) [26]. The Cawood and Howell study[25] conclusions were as follows:

• The basal bone is not reabsorbed, unless it is subjected to local irritative stimuli such as incongruous prostheses or prostheses that have excessive loads.

• The alveolar process undergoes significant changes after the dental element loss. Bone resorption changes according to location:

• In the interforaminal mandibular region and throughout the maxilla, resorption is mainly horizontal and is more pronounced on the buccal side;

• In the posterior mandibular areas resorption is mostly vertical.

• Following the alveolar process reabsorption, the relationship between maxillary bone and mandible also undergo changes: The arches become shorter in the antero-posterior direction.

In a transversal sense the upper jaw becomes narrower, while the mandible widens. Some studies show that, between the two arches, the mandible undergoes a more rapid reabsorption (four times higher in height), due to the palatal vault lack, a protective factor instead for the maxilla [26]; furthermore, as a consequence of the loss in the vertical dimension, the inter-arc distance increases, even if it is compensated by a mandibular rotation. Ultimately the apparent maxilla contraction is in a centripetal sense, while for the mandible it is in a centrifugal sense. [26]

Perioral muscle and floor insertions become progressively more superficial.

The attached gingiva decreases.

We are witnessing a progressive change in facial morphology that reflects the change degree in the maxillary bones and soft tissues.

To describe post-extractive bone resorption, 5 classes for the maxilla and 6 classes for the mandible were proposed by Cawood and Howell [25]: (fig 1-2)

1. MAXILLA:

• I class: tooth present.

• II class: The post-extraction Alveolus.

• III class: Edentulous Cresta post-extractive late but with adequate thickness and vertical dimension.

• IV class: Adequate height, but insufficient thickness.

• V class: Crest unsuitable both in terms of thickness and vertical dimension (molar process loss).

2.MANDIBLE:

• I, II, III, IV and V class: Equal to the maxillary classes.

• VI class: Resorbed ridge, associated with basal bone reabsorption.

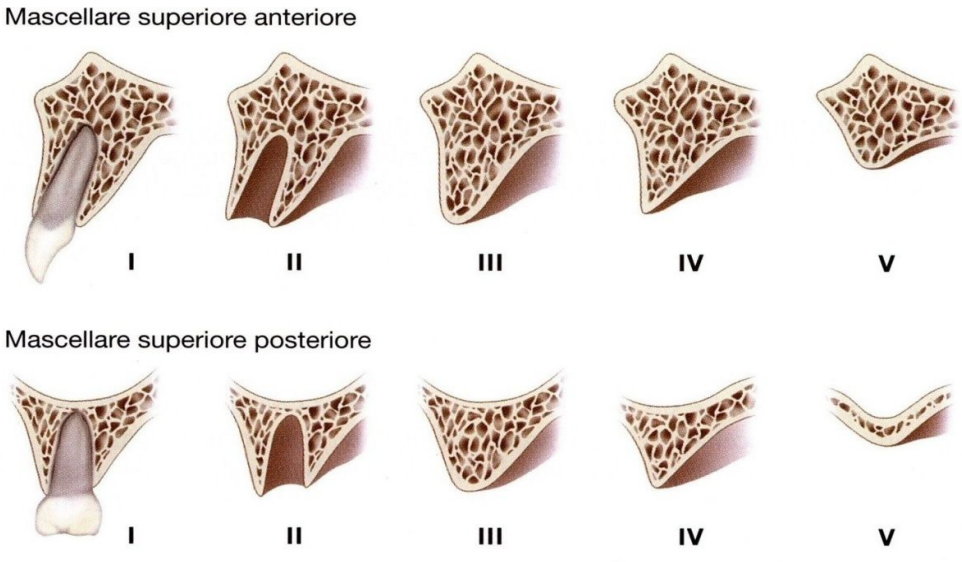


Fig.1 (Image by "Clinical periodontology and oral implantology")

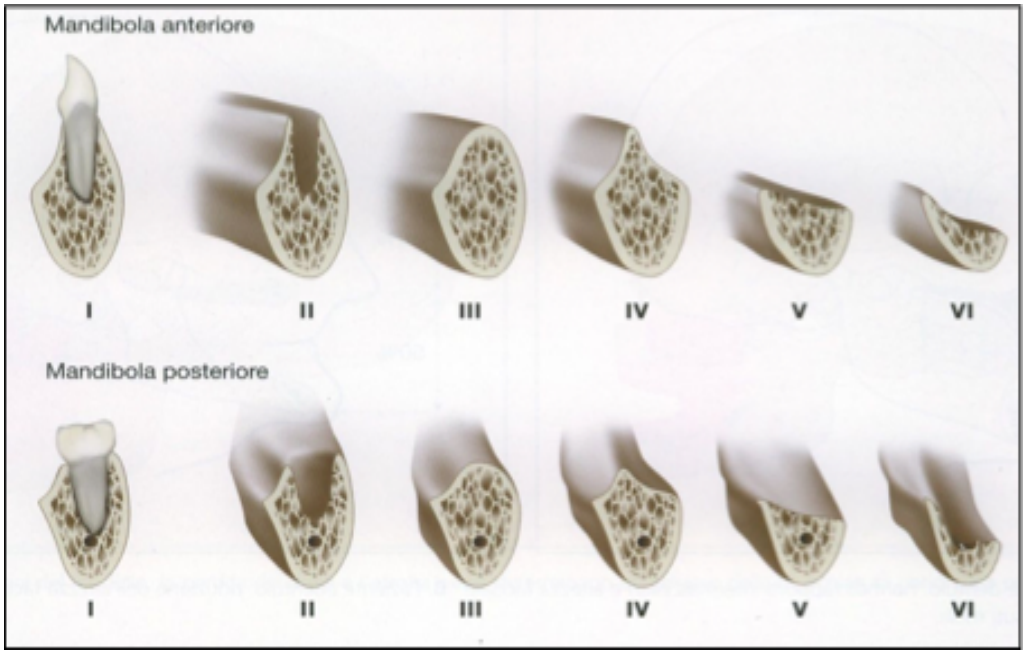


Fig.2 (Image by "Clinical periodontology and oral implantology")

In classes I, II and III there is an adequate amount of bone, which makes it possible to insert an implant, so no surgical techniques are needed to increase the volume; classes IV, V and VI, on the other hand, need a bone volume correction, due to the considerable defect they present.

In specific:

class IV maxillar atrophy: mostly a vertical bone resorption. It is necessary to make a distinction between anterior and posterior maxilla:

In the posterior sector in some cases we can insert the implant, but only if the horizontal dimension is maintained (≥ 10 mm); however, more frequently, we must give up insertion because the vertical bone thickness is insufficient, due to a maxillary sinus pneumatization (the breast widens and consequently its floor migrates to a more coronal position).

In the anterior sector it is easier to have a sufficient bone height (≥ 8 mm), between the alveolar margin and nasal cavity the floor.

IV class atrophy in the jaw: usually the bone height is normal, but a reduction in the horizontal dimension can be noticed such as to make impossible the implant insertion. Also in this case there is a distinction between front and rear sector:

In the posterior part, even if there is sufficient space between the alveolar margin and the lower alveolar canal (≥ 8 mm), there is often a reduction in the horizontal dimension which prevents the implant insertion (like Branemark).

In the front, however, even if there is an alveolar process reabsorption, the anatomy of the basal bone allows the implants insertion; for this reason the region between the two mental foramina is considered privileged: it shows a sufficient bone quantity, which does not require reconstructive interventions to increase it, and a remarkable bone compactness that guarantees stability.

V-class atrophy in the upper jaw: clinical profile that occurs mainly in total edentulous patients, with severe atrophy and consequent alveolar process disappearance; the nasal cavity floor and the maxillary sinus are separated from the oral mucosa by a bone very thin layer. In addition to being impossible to place implants, due to the extent of resorption it is not possible to guarantee sufficient retention even with total mobile prostheses.

V-class mandible atrophy: situation characterized by a decrease in the alveolar ridge vertical dimension and a consequent reduction both inter-arched space anterior and posterior.

In the posterior region it is impossible to place an implant, due to the proximity of the alveolar margin with the inferior alveolar canal.

In the anterior region, however, even if reabsorption occurs, it is possible to place an implant, which will be inserted using the residual basal bone.

Jaw-class VI atrophy: situation characterized by severe atrophy, in which not only all the alveolar bone is reabsorbed, but also a part of the basal bone.

All this will lead to a decrease in the buccal and lingual fornix, which may highlight the need for a vestibuloplasty operation. This situation often involves total edentulous patients.

In the posterior region following this process we will notice a inferior alveolar nerve superficialization, which prevents the implants placement in this area.

In the anterior region, on the other hand, unlike the upper jaw, the jaw basal bone does not undergo changes in the horizontal dimension and therefore the implants placement may be possible.

Bone density

The bone available is particularly important, as was seen previously in implantology and describes the external architecture or edentulous area volume taken into consideration for the implants.

Very important in the implant-prosthetic treatment plan preparation is the evaluation of bone internal structure, described in terms of quality or density, which reflects a certain number of biomechanical properties, such as resistance and elasticity modulus.

The bone density available in an edentulous site is a determining factor for treatment planning, implant shape, surgical approach, healing time and initial progressive load during prosthetic reconstruction.[27]

Bone is an organ that can change based on a number of factors, such as hormones, vitamins and mechanical influences.

However the biomechanical parameters, such as the edentulous state duration are predominant.

The maxilla and mandible have different biomechanical functions.

The jaw, as an independent structure, is designed as a force absorption unit. When teeth are present, the outer cortical layer is denser and thicker, and even trabecular bone is thicker and thicker.

The jaw, on the other hand, is a force distribution unit. Every tension on the jaw is transferred from the zygomatic arch and from the palate. As a result, the jaw has a thin cortical lamina and a fine trabecular bone that supports the teeth. They also observed that bone density is highest in the teeth (lamina cribrosa) and thicker at the ridge level compared to the regions around the apices.

While the Cawood and Howell classification takes bone availability into account, in 1970 Linkow classified bone density in three categories[28]:

Class I bone structure: this ideal bone type consists of homogeneously spaced trabeculae with small spongy spaces.

Class II bone structure: the bone has slightly larger reticulated spaces, with bone pattern less uniformity.

Class III bone structure: between the bone trabeculae there are large spaces filled with marrow.

Lekholm and Zarb45 in 1985 [29], to identify sites suitable for implant placement, proposed a different classification, which concerns the quality of bone:

Type 1 bone: Almost the entire maxillary or mandibular bone is composed by compact bone.

Type 2 bone: A compact bone thick layer covers an dense trabecular bone internal part.

Type 3 bone: A compact bone thin layer covers an dense trabecular bone internal part.

Type 4 bone: A compact bone thin layer covers an low-density trabecular bone inner part.

In 1987 Misch[30] expanded this classification based on the bone tissue macroscopic characteristics and on the cortical and medullary quantitative ratio, identifying 5 bone densities:

Class D1 Bone characterized by thick cortical and poorly represented medullary. Location: mandibular symphyseal and parasymphyseal region.

Class D2 Cortical bone and dense trabecular structure inside.

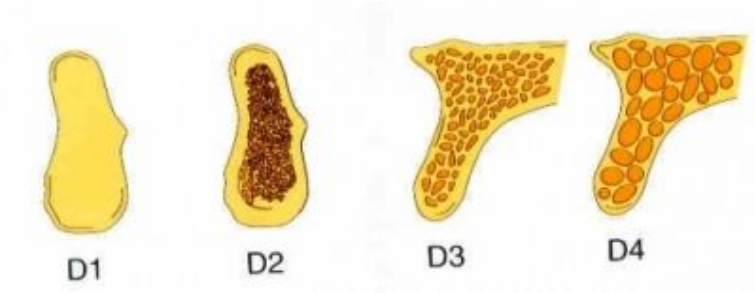
Location: mandibular region anterior and posterior, maxillary anterior region.

Class D3 Bone with thin cortex and trabecular structure with large cavernous spaces inside it Seat: mandibular posterior region, maxillary anterior and posterior region.

Class D4 Cortical bone almost absent and predominantly spongy structure.

Location: maxillary posterior region.

Class D5 Immature bone.



(Image by "Clinical periodontology and oral implantology")

Bone density localization

A literature review and a partially and completely edentulous patients survey after surgery indicated that, in the oral cavity different regions, the different bone densities location may be overlapping.

Based on the Misch classification, D1 bone is almost never observed in the maxilla and is rarely seen in most jaws. In the lower arch, D1 bone is found in about 6% of the time at the jaw front and 3% in the back.

Bone with D2 density is most often observed in the mandible. The jaw anterior part consists of D2 bone in about two thirds of the cases. Almost half of the patients have D2 bone in the jaw back. The jaw has D2 bone more rarely than the mandible.

About a quarter of patients have D2 bone, and this is more likely in the anterior and premolar region of partially edentulous patients.

D3 bone density is very common in the jaw. The anterior edentulous maxilla presents D3 bone in 75% of cases, while almost half of patients have D3 bone in the jaw posterior part (more often in the premolar region). Also almost half of the mandible posterior parts have D3 bone, while it is found anteriorly in about 25% of the edentulous mandibles.

D4 density bone is found more often in the jaw posterior part, particularly in the molar areas.

THE ORAL MUCOSA.

Among the local factors belonging to the patient dependent parameters for long-term implant success we find the oral mucosa.

The mucous membrane that covers the alveolar processes up to the teeth root can be divided into two distinctly distinct areas. The peripheral zone, adjacent to the fornix, which is represented by the vestibule alveolar mucosa; and the area near the margin, which is free and is represented by the gum. The alveolar mucosa is characterized by a more delicate organization, greater mobility and a darker red color. The gum, on the other hand, is tightly adherent to the bone and teeth and, in normal conditions, shows a paler color. The gingival masticatory mucosa covers the alveolar process and ends in a free margin at the level of the dental elements collar. It consists of a superficial epithelial layer and below this there is a connective layer called the “lamina propria”.

We distinguish a free gingival masticatory mucosa and an attached gingiva. The free gingiva is the most coronal portion of the gingival structure, which surrounds the dental elements collar in addition to the interdental area. The attached gingiva represents all the remaining gingiva.

A dividing line may be present between the two structures, a sulcus deepening inside the tissue and following the free gingival margin festooned course, thus defined as a free gingival sulcus. The free gingival margin, in its most coronal portion, has a rounded appearance and tends to be reflected inside in the enamel direction, forming a small invagination (gingival sulcus). This sulcus is detached from the tooth surface, even if very close, and apically continues in the junctional epithelium, a structure with a few cellular layers, which presents a mild adhesion to the dental enamel.

The epithelium adhesion to the extra cellular matrix is crucial for the systemic and oral health maintenance.[31] In the oral cavity the teeth, or artificial teeth on the implants, penetrate the gum soft tissue. In this interface the soft gingival tissue must be well bonded by means of the epithelial seal to the teeth or to the implant surface to maintain health over time. After an insult or a wound the epithelium migrates quickly to form the initial epithelial covering, thus restoring the barrier against infections. Therefore, this seal is certainly one of the keys to the our implant therapy success. If we can preserve it over time it can guarantee the our implant health level. It is evident that this integrity state is directly proportional to the amount of potential periodontal pathogens present on this site. The patient active collaboration who must carry out the correct home oral hygiene maneuvers and attend the professional hygiene sessions, for the maintenance phase, according to the professional's indication, is therefore fundamental.

Around the natural teeth we can distinguish a biological amplitude, in physiological conditions, defined by sulcular epithelium, junctional and connective epithelium. While, in the all peri-implant tissues health situation we can identify a biological space that will be defined as the distance between the crestal bone most coronal level and the epithelium level must coronal. According to Bragger U (1997) the biological space average height is variable from 3 to 3.7 mm and will depend on the epithelium vertical dimensions, the epithelial sulcus and the connective.[32,33]

If in a first superficial evaluation we can think that these two anatomical conditions, amplitude and biological space, could be the same thing, the table below shows how in reality there are fundamental differences (table 1).

	NATURAL TOOTH	IMPLANT
	Ranging from root canal cement to bone	they are arranged circularly and parallel along the axis of the implant
LIGAMENT CELLS	Fibroblast-like	absent
GUM VASCULARIZATION AND OVERCREST CONNECTIVE	from the lateral overperiosteal vessels to the alveolar process from the periodontal ligament vessels	from the intraosseous vessels
EPITELIAL CELLS	they form the seal supported by the periodontal fibers	they combine with titanium with hemidesmosomes

Table 1

These differences translate into precise clinical implications. We know that periodontal disease has a bacterial etiology, but its progression deep into the tooth supporting tissues is mainly linked to an inflammation produced by inflammatory substances released by the bacteria themselves. Thanks to the periodontal ligament presence the disease progression is slowed down (excluded the rapidly destructive forms), and is manifested by the periodontal tissue apicalization with consequent increase in the pocket. In peri-implantitis there are no deep periodontal structures able to slow down the process progression.[34] The disease evolution is much faster. The peri-implantitis prevention appears to be the only real weapon. The immediate identification of a mucositis onset, and its treatment with non-surgical mechanical therapy, has been shown to be a valid approach to avoid the onset of plaque-induced peri-implantitis which unfortunately turns out to be very frequent.

Tissue Biotype

An great importance element, especially in the aesthetic sectors, concerns the patient's tissue biotype evaluation. From the clinical point of view it is usual to distinguish patients in two large groups, represented by the thin and thick biotype. It is important to remember that this distinction does not follow rigid classification schemes, as a wide range of intermediate conditions can exist, even within the same patient, between different sites, for example between upper and lower arch.

- The thin biotype is usually accompanied by teeth of narrow and elongated shape, the amelite-cementitious junction progression (which is genetically determined) appears very accentuated in an interproximal sense and, consequently, the gingival margin that follows the such junction course (except in cases of recessions) takes on a very festooned pattern, with narrow and elongated papillae, associated with a very delicate gum tissue and a very thin bone vestibular cortex.

- The thick biotype, on the contrary, is often associated with short and wide teeth, the amelite-cementitious junction course is less pronounced and, consequently, also the gingival margin will have a less festooned pattern; the gum tissue is more robust and rich in collagen and the vestibular cortical bone is characterized by a greater thickness.

Implant therapy in a patient with a thin biotype requires greater caution, especially when a timing of type 1 or 2 is required. In fact, if the vestibular cortical bone is not complete after extraction, type one timing is not recommended, a due to the vestibular recession high risk, and one of type 3 or 4 is associated with regenerative techniques. The thick biotype is less demanding for achieving a valid aesthetic result and requires less need for regenerative therapies, especially when the vestibular cortex remains intact.

PATIENT MICROBIOTA ENVIRONMENT

Finally, among the local factors belonging to the patient parameters dependent for a long-term implant stability success, the individual microbiota environment plays an important role. The oral cavity accommodates more than 700 different microorganisms that are part of both the resident and transient flora [34,35.] developed during childhood up to culminating at puberty which serves as a defensive barrier against pathogenic species. The normal or resident flora lives in a balance state with the host, but the oral cavity is continuously exposed to the entry of new microorganisms. Our oral flora knowledge is based mainly on the predominant species crops identified.

The resident oral flora can be divided into indigenous and supplementary flora. The indigenous oral flora is characterized by bacterial species that have been found in every adult human being of all populations, without considering the environmental conditions.

The human indigenous oral flora contains species of streptococci (S. salivarius, S. sanguinis, S. oralis, S.mitis), actinomyces (A. naeslundii, A. odontolyticus), Haemophylus (H. paraunfluenzae, H. aphrophilus), Neisseria (N. subflava, N. mucosa, N. oris), Fusobatterium (F. nucleatum), and Prevotella (P. intermedia, P. melanino genica, P. buccae, P. oaralis). Resident flora also contains genera and bacterial species in relation to the specific individual and therefore designates the additional oral flora. The additional flora bacteria have specific requirements related to adhesion, nutrition and pH level, which may be favorable in some individuals but not in others. An example is Streptococcus mutans, which is favored by the sugars deposition that facilitate the bacterial cells adhesion to the tooth surface and contribute to creating an acid environment. Lactobacillus species proliferate especially in individuals with reduced salivary flow and / or low salivary pH. Numerous species (P.gingivalis, T.forsythia and Treponema) are members of the inflamed periodontal pocket flora, but not of the healthy periodontal site flora.

Organisms enter the mouth more or less accidentally through food, drinks, kisses, contact with animals, etc. A greater number of pathogens is often present in the transient flora and therefore colonizes the host without permanently damaging it.[36] These potentially pathogenic organisms exist in a transient state and include some opportunists, such as S. aureus, group A Streptococci, pneumococci, enterococcus, gram-negative aerobic basins, pseudomonas and H. influenzae. If the host is damaged, systematically or locally, opportunistic bacteria can cause oral infection.

The association of bacteria present in the biofilm is not random, but is actually determined by specific relationships between the various bacterial species.

Six closely associated groups of bacterial species were identified (Fig. 3); these included:

- Specific species of Actinomyces;
- A yellow complex consisting of the genus Streptococcus members;
- A green complex formed by Capnocytophaga species, the serotype a of A. actinomycetemcomitans, Eikenella corrodens and Campylobacter concisus;
- A purple complex formed by Veillonella parvula and Actinomyces odontolyticus;
- An orange complex formed by Campylobacter gracilis, C. rectus, C. showae, Eubacterium nodatum, the subspecies of F. nucleatum, F. periodonticum, Pe. micros, Pr. intermedia, Pr. nigrescens and S. constellatus;
- A red complex consisting of T. fosythia, P. gingivalis and Tr. denticola.

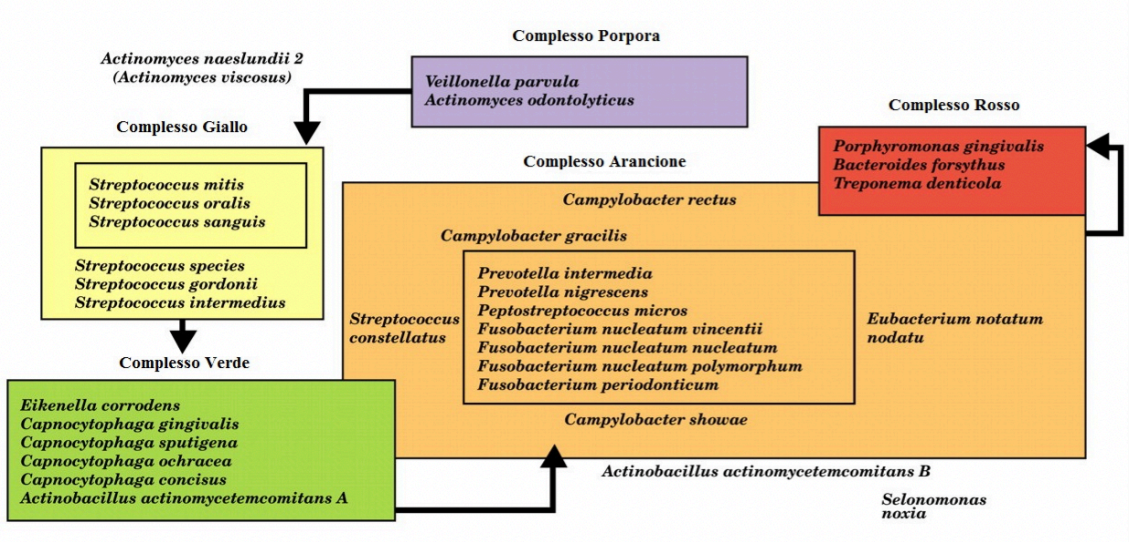


Fig. 3 Microbial complexes detectable within the dental plaque. (da Thomas, J. G., Nakaishi, L. A. (2006). Managing the complexity of a dynamic biofilm. *Journal of American Dental Association.* **137**, suppl: 10s-15s; con modifiche).

The first four groups of species represent the first colonizers of teeth surface, whose growth usually precedes the orange and red complexes multiplication, consisting mainly of Gram-negative bacteria. The last two groups of species are considered the periodontal diseases main etiological agents.

Bacterial plaque is not only formed on the natural teeth surface, but also on artificial surfaces exposed to the oral environment, including implant surfaces.

To date it is possible to state that the structure of peri-implant plaque deposits may resemble that encountered in the subgingival environment.

The bacteria, once organized in colonies, give rise to bacterial plaque and if they are not promptly removed they cause, with their metabolites production, a state of gum inflammation next to the implant called peri-implant mucositis.

If the etiological factors are removed promptly, the tissues can therefore heal without any consequences. However, if the inflammatory state persists over time, the situation will gradually worsen with the evolution from mucositis to peri-implantitis.

MUCOSITIS AND PERIMPLANTITIS

Peri-implantitis is also an inflammatory process that affects the peri-implant tissues characterized by a progressive bone tissue loss; if left untreated in its initial stages it irremediably leads to the implant loss.

The peri-implant pathogenic plaque is the primary extrinsic etiological factor of the peri-implantitis onset. In the presence of plaque accumulation on implant surface, the subepithelial connective tissue undergoes the infiltration of a phlogistic cells large number and the epithelium appears ulcerated and poorly adherent: mucositis, in the long term, can lead to tissues progressive destruction and therefore to the inflammatory process called peri-implantitis.

When the plaque extends apically, the tissue destruction signs clinical and radiographic begin to appear around the implant and to the teeth with a inflammatory soft tissue and bone loss around the implants greater size.

Fusobacterium, Spirochetes and microorganisms with black pigments, like Prevotella intermedia, often found in high proportions.(4)

The microbes found at implant failure sites mainly belong to the Fusobacterium and Bacteroides species. The lack of comparison, with the teeth loss, of the two periodontal bacterial species Actinobacillus actinomycetemcomitans and Porphyromonas gingivalis is linked to the subgingival micro-environment suitable absence for their growth. Moreover, a remarkable difference was observed between the bacterial morphotypes of totally edentulous and partially edentulous patients[4.] and this would indicate a greater predisposition to peri-implantitis in partially edentulous patients. The so-called periodontal pathogens would decrease in the totally edentulous patients implant sulcus of, although (5) they continue for a long time to be present also in these subjects.

So surely the previous periodontitis experience has a great influence on the peri-implant flora, just as the presence of dental elements conditions its composition.

The bacteria that cause peri-implantitis are mainly Gram-negative anaerobes such as: Prevotella intermedia, Porfiromans gengivalis, Actinobacillus actinomicetemcomitans, Prevotella nigrescens, Treponema denticola, Bacteriodes forsythus.

The mucositis characteristic clinical signs:

- phlogosis, with erythematous and sometimes ulcerated mucosa;
- edema due to the recall in the site of elements responsible for the non-specific immune response (PMN);
- bleeding on probing, which confirms bacterial infection. This determines the implant mucosal seal compromise, but is not associated with a bone implant anchoring loss or signs of hard tissues osteolysis.

Perimplatitis is detectable through:

- radiographic evidence of bone crest vertical resorption;
- a peri-implant pocket formation associated with radiographic bone loss (Fig. 3);
- bleeding on probing (BOP);
- swelling and redness mucosa;
- no typical pain.

From all this it must be concluded that for the implants maintenance particular attention must be paid to the bacterial plaque control that forms around the implants titanium collar. Balshi (1986) [39] pointed out how peri-implant oral hygiene procedures should be directed mainly towards two areas:

1) implant portion that mucosa comes out and tand is rapidly colonized by bacteria

2) all the prosthetic superstructure various components.

The osseointegrated implants maintenance involves a hygienic measures series performed by the patient at home and by specialized personnel during periodic calls to maintain the peri-implant tissues in a healthy state.

Peri-implant health involves the absence of any visible inflammation signs and a peri-implant sulcus presence no more than 3 mm deep, without bleeding on probing.

According to a chronological criterion, the Perimplantitis is classified into:

- EARLY: when it develops before the osteo-inclusive healing process is completed

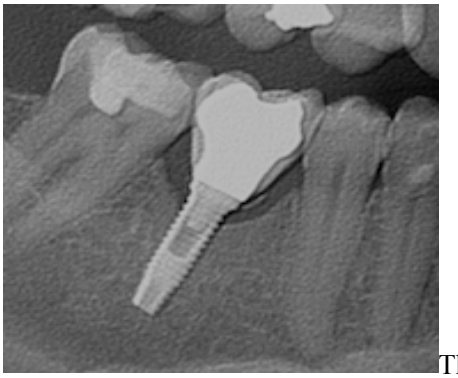
- LATE: when it appears to be concluded osteoinclusion-osseointegration process, often manifesting itself after the prosthetic load.

From a clinical point of view it also differs in:

- MUCOSITIC: inflammation affects only the mucous membranes that cover the implants, with hyperemia and poor bleeding; the clinic is often subtle; the implant supports the masticatory load; any pockets are contained; the intraoral Rx is substantially silent; if intercepted and treated it is frequently reversible; a differential diagnosis should be made with incongruous prosthesis injuries.

- OSTEITICS: the inflammatory process involves both the gingival mucosa and the peri-implant bone; the lesion is visible radiographically and appears as diaphanous by eccentric resorption; clinically, bleeding and sometimes suppuration are ascertained; pathological probing depth; spontaneous and percussive pain.

The mucositic phase often precedes the osteitic phase.

 The X-ray shows implants surrounded by peri-implant tissue. (Fig.4)

The implants affected by peri-implantitis therapy has the purpose of decontaminating the peri-implant tissues from bacteria and is performed by removing them through professional oral hygiene interventions, surgical curettage and / or topical antibiotic applications: Laser use is also proposed -therapy.

The peri-implant oral hygiene maintenance must be divided into two distinct moments:

- home oral hygiene

- supportive therapy

GENERAL FACTORS

Habits

Home oral hygiene

Home oral hygiene includes the toothbrush use, the proxa-brush use for interdental spaces and the super-floss use around the implants collar. These instruments are used by the patient according to the classical techniques and with a bi-daily frequency (morning-evening) to prevent the bacterial plaque from starting the colonization of the peri-implant sulcus.

Brush

The brushing performed by the patient should be intrasulcare, vibratory and rotary. The bristles hardness and the toothbrush size should be related to the present gingival keratinization and the patient's mouth size. The toothpaste should contain pyrophosphates to delay the bacterial plaque calcification. The use of dentifrices containing chlorhexidine is not recommended. This substance should only be used with a specific indication and for short periods. (Consensus- Ittingen 1993)

Proxa-brush

The proxa-brushes should always be used by patients with prosthesis on implants in association with normal brushing and the super-floss use. There are various shapes and sizes on the market: the choice must be made in relation to the interdental spaces width present.

Super-floss

The super-floss can be used by the patient as a valid alternative to proxa-brushes to remove the plaque both in the fixed prosthesis and in the prosthesis resting on implants. This super-floss is very useful to remove bacterial plaque from the implant collar and from the interdental spaces.

Supportive therapy

Supportive therapy includes the operations set that are performed during the periodic recalls. This therapy has as its purpose:

- maintenance of peri-implant soft tissue health.

- The osseointegration maintenance.

- Injury to soft and hard tissues prevention.

- The biological failures diagnosis.

- The mechanical failures diagnosis.

- Provide drug therapy if indicated.

The importance of establishing a recalls adequate scanning for patients with implants has been underlined (Weber and Lang 1991) [(40)]. An ideal maintenance program involves the patient recall one month after the restoration and then every three months during the first year. From the second year the patients will be included in a recall scheme studied in relation to the individual ability to maintain an adequate plaque control.

Evaluation peri-implant health criteria

At each recall the patient must undergo a diagnostic tests series to assess the peri-implant health state:

1) probing depth

2) bleeding on probing

3) exudation / suppuration presence

4) hyperplasia presence

5) clinical mobility presence

6) bone resorption and / or bone level detectable radiographically.

As for the survey, this should not exceed 3 mm; the possible appearance of bleeding on probing should immediately trigger therapeutic measures. X-ray examinations should be done every year and possibly more often if other pathological symptoms appear.

A loss of 1.5 mm of bone height is considered normal in the first year immediately after implant placement. From the second year onwards a reabsorption of 0.1 - 0.2 mm per year is considered normal.

Professional hygienic prophylaxis

Prophylaxis sessions, performed during periodic recalls, should always be preceded by "Oral Hygiene Instructions" to verify that the patient correctly performs the various maneuvers, to re-motivate the patient and improve his Compliance.

Compliance

Patient behavioral response towards his health and the means at his disposal to maintain it.

Professional hygienic prophylaxis is performed with manual instruments (manual scaling) and with mechanical instruments (mechanical scaling). The instruments used for the hygienic profile have been specifically designed to avoid damaging the implants surface. They are:

- plastic curettes.

- instruments with plastic coated tip

- rubber cups + non-abrasive fluorine paste - Air-Flow.

Polishing

Polishing is the operation that serves to complete the hygienic profile, making the surfaces perfectly smooth and clean. It is executed either with rubber cups mounted on a handpiece or with special air-jet + water (Air-Flow) devices.

Rubber cups

The rubber cups are effectively used for the bacterial plaque and / or various pigmentations removal. They must be used without the use of abrasive pastes so as not to alter the titanium surface of implants collar, nor of the prosthetic superstructure.

Mechanical scaling

The supragingival scaling, or just subgingival, peri-implantar scaling can be effectively performed with a mechanical vibration instrument which has a metal tip coated with a single-piece plastic insert. This instrument is very effective in removing plaque and calculus without altering the titanium implants surface and prosthetic superstructures.

Pharmacological therapy

Topical and systemic chemotherapy and / or antibiotics should not replace mechanical therapy but should instead be completely applied if the situation requires it. If, despite a proper home and professional maintenance therapy, an increase in the peri-implant probing depth (<4 mm), an bleeding onset on probing and / or a suppuration is noted, then additional topical pharmacological therapies should be established and systematic. The chemotherapy drugs used in these situations used topically or sub-gum topically include 0.2% chlorhexidine and H2O2: the first for its powerful antibacterial action, the second because it activates the white myeloperoxidase system in addition to be active against anareobes.

The antibiotics indicated in these same situations include tetracyclines, in the form of pasta or contained in impregnated fibers and Metronidazole in the form of gel.

As for the antibiotics systematic administration, this should be reserved for the most serious disease forms. In the literature we find numerous data that justify the use of some antibiotics (Tetracycline, Amoxicillin, Metronidazole, Ornidazole, Clavulonic acid) according to a well established protocol.

Alcohol and tobacco consumption

Tobacco smoke in all its forms (cigarettes, pipe, cigars) and the use of chewing tobacco are associated with various oral cavity pathologies, having different nature and interesting various tissues and oral functions. Tobacco is also capable of producing oral ecosystem marked alterations that, by conditioning the commensal flora balance, can predispose to infections

Numerous epidemiological studies controlled for variables such as age, plaque and tartar levels, sex and socioeconomic status have shown, over the past two decades, that smoking is, after plaque, the most important preventable risk factor for the chronic periodontitis onset and progression, even in young subjects, at low risk for periodontitis (41). Numerous studies have also shown that smoking is a risk factor for peri-implantitis. Smoking has various inhibitory effects on the inflammatory and immune response that justify the greater prevalence and periodontitis severity in smokers: phagocyte inhibition and neutrophil chemotaxis, antibody production inhibition, immunoglobulin G2 species, increased interleukin 1 release by macrophages (IL-1) and tumor necrosis factor alpha (TNF-α) in the presence of bacterial antigens, vasoconstrictor action on gingival microcirculation and inhibition of vascularization during healing or inflammation, activity synthetic fibroblasts and osteoblasts inhibition[41]. Furthermore, in smokers, the partial oxygen tension in periodontal pockets is lower than in non-smokers, and this leads to a periodontopathogenic bacteria greater prevalence such as A. actinomycetemcomitans, T. forsythia and P. gingivalis in the smokers subgingival plaque compared to that of non-smokers, even in shallow pockets (41.)

A failures doubled percentage in implant therapy was observed in smokers(41). In smoking patients the peri-implantitis prevalence is higher than in non-smokers and, based on data available in the literature, smoking is currently considered a peri-implantitis risk indicator.(43,44.)

If the damage caused by smoking at a periodontal level is irreversible, the smoking cessation has beneficial effects on the response to periodontal therapy, as well as on the periodontitis progression: for this reason the habit at the smoking cessation should be considered an essential periodontal therapy component, as is the domiciliar plaque control

Cross-sectional studies have shown a relationship between consumption / frequency of alcohol consumption and periodontitis prevalence.[44,45.] It has also been highlighted, as already demonstrated for smokers, that in the subgingival flora of patients alcohol consumers there is a periodontopathogens percentage greater than in the asymmetric subjects

alcohol intake increases the phlogistic markers expression and the polymorphonuclear leukocytes presence in gingival tissue, contributing to a more pronounced inflammatory response. Alcohol consumption could negatively influence the implant therapy success,

Also known is the synergistic effect, in terms of developing oral cancer increased risk, between alcohol abuse and tobacco use.[46] Overall, 7-19% of oral carcinoma cases are attributable to high alcohol consumption,[47,48.] which can act both as an independent factor and as a co-carcinogen facilitating the initiation produced by other factors and / or acting as a promoter.

Chronic exposure to ethanol results in oral and esophageal mucosa atrophy. This morphological alteration is associated with increased activity mitotic of the basal layer, whose pathogenetic mechanisms although not known, but probably ascribable to the ethanol cytotoxic effects, end up increasing the oral epithelium susceptibility to chemical carcinogens, especially those of tobacco. This latter effect is also enhanced by the alcohol solvent action, which increases mucous permeability[49] through direct damage to membrane phospholipids or a molecular rearrangement at the mucous barrier level.

PATIENT INFLAMMATORY PROFILE

Systemic disorders

PATIENTS AT RISK OF ONJ AND IMPLANT TREATMENT

Cancer patients undergoing radiation therapy or on bisphosphonate therapy are at greater risk of developing osteonecrosis. Careful anamnesis and careful physical examination are fundamental in this patients diagnostic evaluation.

Maxilla / mandible osteonecrosis is a progressive infectious and necrotizing disease with little tendency to cure, described only recently in association with bisphosphonate therapy.

Currently, the exact mechanism that leads to ONJ induction is not known and the complete picture of the risk factors that can determine this injury is not yet defined.

Regarding bisphosphonates use, the international literature reports, as primary pathogenetic factors for ONJ onset, the altered bone remodeling capacity and repair induced by these drugs as well as the associated hypovascularization.

Furthermore, concomitant dento-alveolar surgery and oral cavity pathologies are important risk factors.

Not all ONJ episodes are diagnosed at the same severity stage. The ONJ can remain asymptomatic for weeks or even months and is generally identified clinically following the exposed bone appearance in oral cavity. Lesions can become symptomatic with paresthesia, pain, dysphagia and halitosis in secondary lesions presence, infection or in adjacent or opposite soft tissue trauma case caused by exposed bone irregular surface or incongruous dental prostheses.

The overt phase is manifested as a oral mucosa chronic erythematous ulceration, with an underlying necrotic bone surfacing, often with purulent exudate presence, with possible spontaneous or provoked bleeding and with a tendency towards extension towards the contiguous regions.

The clinical characteristics of ONJ

Patients with osteoporosis seem different to neoplastic patients, with less severe-pictures, clinically less demanding and with a high healing rate reported in more recent literature.

The ONJ diagnosis is based primarily on the medical history, the patient clinical history and the clinical examination. The typical aspect, on physical examination, is that of an exposed bone area of non-vital yellowish-white color, with dimensions varying from a few millimeters to several centimeters, surrounded by an inflamed and edematous mucosa. these lesions hygiene is often difficult for patients. (50,51,52.)

Before arriving at bone necrosis, signs and symptoms can be identified that may direct the clinician towards a disease early diagnosis such as pain, tooth mobility, erythema, mucosal edema and ulceration. In 40% of the cases, however, the lesions are completely asymptomatic and these can remain even for long periods with consequent picture worsening that does not reach the doctors observation at an early stage. It is pointed out that the signs and symptoms are typical of any odontogenic infection. Particular attention must therefore be paid to the patient with history of bone or tumor metabolism and his pharmacological history.(53)

The mandible is struck twice more frequently than the maxilla, more commonly in the areas with thinner mucosa (bulls, exostoses and mylohyoid crest) and in areas subjected to dento-alveolar surgery.[53]

The lesions are almost always complicated by an over-bacterial infection picture with oral micro-organisms. The resulting osteomyelitis can lead to suppurative, painful palpation and mucous or cutaneous fistulas. (54,55.)

The ONJ advanced stage leads to mandibular or maxillary bone fractures.[55]

The characteristics and extent of the injuries allow us to divide the ONJ into three main classes:

1. Type I: limited area that presents exposed necrotic and avascular bone, painless.
2. Type II: area presenting exposed necrotic bone associated with pain and infection.
3. Type III: wide area presenting exposed necrotic bone associated with pain, infection, possible pathological fracture, extraoral fistula or osteolysis extended to the lower margin.[56]

The signs and symptoms that are mainly found in this pathology are:

Signs

- Alveolar bone loss
- Bone resorption
- Changes in the medullary trabecular aspect
- Dense alveolar bone tissue
- Thickening of the periodontal ligament space
- Lower alveolar canal narrowing

Symptoms

- Bone pain
- Mental nerve paresthesia
- Neuropathic pain

- Dental elements loss
- Odontogenic pain
- Not re-epithelialised post-extraction cavity[57]

After the first scientific papers that documented this disease onset and the overcoming of uncertainties about its relationship with bisphosphonate intake, one wondered how to treat affected people and how to prevent ONJ developing in the population at risk.[57] It is of primary importance that patients, before starting treatment with these drugs, go to the dentist to undergo a oral cavity thorough examination.[58] The guidelines for the patients taking bisphosphonates management include the patients division into those who have yet to start bisphosphonate therapy and those who are already suffering from the disease, and describe the interventions to be performed for each of the two situations.

In the first case for prevention: the patient will have to undergo a complete oral and extraoral examination including radiographic examinations, the compromised dental elements extraction and conservative care for carious lesions. During the same session, the classification of the subject's oral and periodontal hygiene status must be carried out.

In the second case, patients suffering from ONJ will have to undergo oral hygiene sessions, elements with third-degree mobility extraction, and conservative / endodontic treatment of carious teeth more or less severely. The prosthesis will have to be re-evaluated if it is incongruous and the odontogenic infections will have to be treated with aggressive systemic antibiotic therapy. As far as the necrotic lesion is concerned, it must only be locally medicated, regularized in the margins if sharp and, for the masticatory traumas prevention, protected by obturators or vinyl material applications.

For patients in the second group who need dental avulsions and who are taking or have taken bisphosphonates, the surgical management protocol varies according to the type of drug. A risk of incurring osteonecrosis is defined for them:

1. Low risk: subjects who take or have taken bisphosphonates orally for less than a year or who have received less than five bisphosphonates IV administrations and who have to undergo non-complex surgical procedures.

2. Medium risk: subjects who take or have taken bisphosphonates IV for non-malignant diseases or per os for more than 1 year and who must undergo non-complex surgery.

3. High risk: subjects who take or have taken bisphosphonates IV for the malignant bone diseases treatment or oral bisphosphonates for more than 3 years.

The procedure / protocol for the prevention of osteonecrosis of the jaw in the oncology setting, provides three different methods of intervention.

Patients who have not yet started treatment with bisphosphonates

Before starting treatment with bisphosphonates, patients who are adequately informed must carry out a dental examination to evaluate their oral health, set up an adequate prevention program and possibly treat local diseases; for this purpose, the specialist doctor (for example, the oncologist, endocrinologist, orthopedist) and / or the general practitioner, direct all the patients who must begin drug therapy to a dental examination. The dentist takes charge of the patient and, in agreement with the specialist doctor, identifies the therapeutic treatment needed: if the patient must undergo intraoral surgery, it is advisable that bisphosphonate therapy be postponed for at least a month and, in any case, until the gingival mucosa complete restoration that overlying the surgical injury; however, oral implant operations are not recommended; it is also necessary to make removable prosthetic products less traumatic.

The dentist informs and sensitizes the patient about the problem, also through illustrative material and instructions for early warning of any clinical sign or symptom (pain, swelling); the professional also provides a periodic clinical and radiographic follow-up program.

Patients who have already started bisphosphonate therapy but have no symptoms

In asymptomatic patients taking bisphosphonates, the specialist doctor or general practitioner should not suspend such therapy, but refer the patient to the dentist, who will make a careful clinical evaluation highlighting and treating oral health problems and diagnosing development promptly of any bone or mucous lesions. He may resort to non-invasive methods, providing for monitoring with frequent checks. In the case of oral surgery essential for the treatment of infection and pain, the dentist (I) evaluates, in agreement with the specialist, the possible risk of osteonecrosis, (II) adopts specific treatment protocols, (III) uses techniques that minimize local tissue trauma, (IV) performs frequent postoperative monitoring.

Symptomatic patients during treatment with bisphosphonates

The specialist doctor and the general practitioner must send the patient, who presents clinical signs or symptoms attributable to the onset of ONJ, to the dentist, also considering the possible insidious and unspecific establishment of the pathology. The dentist will carry out a detailed assessment of the situation, will alleviate the pain symptomatology with targeted and non-invasive therapies, set up a possible antibiotic therapy and a program of frequent checks to follow the evolution of the lesion as well as to reach and maintain an adequate level of oral health and will provide any necessary surgical procedures.

The suspension of therapy should be decided in collaboration between the specialist doctor and the dentist, carefully evaluating, for each individual patient, the risks and the possible advantages deriving from a possible suspension of bisphosphonate therapy.

In malignant bone diseases surgical and therefore implant therapy is not recommended due to the addition of risk factors such as the use of chemotherapy and chronic corticosteroids, radiotherapy cycles and intravenous administration of bisphosphonates. These conditions do not recommend elective treatments such as implantology because the risk of incurring ONJ seems to be very high. From a pharmacological point of view, today the fact that the latest trends lead to the prescription of IV drugs even to people with osteoporosis must be taken into account. these patients do not have sufficient data to dictate safe treatment guidelines.[59]

DIABETIC PATIENTS AND IMPLANTOLOGY

Diabetes mellitus, independent of the type, results in a clinical condition that leads to a chronic increase in the concentration of glucose in the blood, causing a state of hyperglycemia.

Diabetic patients thus find themselves having to live with a whole series of disorders, which can take on more intense or more blurred characters depending on the severity of the form considered.

These include particularly long times for wound healing and increased sensitivity to infections. These conditions are linked to the alterations that the greater concentration of sugars produces in the blood and at the level of the capillary walls: through various molecular mechanisms both the action of the cells of the immune system and that of the corpuscles responsible for coagulation and tissue repair is slowed down or inhibited; consequently the healing of cuts and wounds becomes less efficient, as does the immune response against viruses and bacteria.

However, in recent years, the reorganization of health facilities and the cutting of national funds have led to a weakening of the infrastructure network for the diabetic patients treatment, which becomes particularly evident when dental pathologies are taken into consideration.

Individuals with diabetes mellitus, not infrequently, have recurrent pathologies in the oral cavity and, in particular, of the teeth: gingivitis and periodontitis are frequent, especially in the absence of careful oral hygiene.

This is because the lower capacity to resist infection is associated with a greater availability of sugars in salivary secretions, which helps to create a perfect environment for the proliferation of microorganisms.

Surgical operations at the level of teeth and gums inevitably require special attention and those of dental implantology are no exception: even if modern methods are considered minimally invasive, in diabetic patients the possibility of complications is particularly high and, for this reason, in absence of the necessary safety conditions the intervention is generally not recommended.

The potential risks

The dangers associated with dental implant surgery in a diabetic patient range from a simple increase in healing and recovery times, to severe peri-implantitis (infections of the tissues surrounding the implant) with consequent slowing of the osseointegration process of the implant and failure of the same.

In subjects suffering from the most severe forms of diabetes, bleeding may occur due to coagulation problems, up to hyperglycemic shock, which may also be affected by the emotional stress experienced during the operation.

Implantology for diabetic subjects

For those who suffer from diabetes, are dental implants therefore always precluded?

In reality, dental implantology can be practiced safely in patients with compensated diabetes, or in which the level of glycaemia is constantly maintained below the limit values thanks to drugs and the adoption of a diet and an appropriate lifestyle.

In the absence of other clinical conditions that could make the intervention contraindicated, such as previous episodes of ketoacidosis, the precautions generally recommended by the specialists are:

- even more scrupulous oral hygiene than usual both in the days preceding and in those following the operation;
- taking antibiotics as a cover against the danger of infections;
- careful monitoring of the closure of surgical wounds through subsequent follow-up visits;
- a careful check of blood sugar levels in the pre- and post-operative stages;
- carrying out the intervention mid-morning, after several hours from breakfast and strictly after taking insulin medications.

On the other hand, dental implantology is not recommended in patients in whom the disease is not kept under control with due care or in which the blood sugar level is often above the limit value of 200 mg / dl.

PREGNANT WOMEN AND IMPLANTOLOGY

Hormonal, vascular and immunological changes associated with pregnancy can generate a different inflammatory response at the level of the gingival tissues compared to that of a patient who is in a regular situation.

During the months of waiting everything changes and in the body of the woman a series of systemic adaptations occur; the hormonal changes increase the presence of bacteria and could trigger an altered immune response. Elevated estrogen levels in pregnancy cause some changes in the oral mucosa; the gingival response, therefore, could be altered compared to the norm.

Dental implantology allows, thanks to the use of suitable and increasingly updated techniques, to improve one's smile in a safe way. However, there are some cases where more attention needs to be paid, one of these is certainly the gestation period.

First of all, it must be emphasized that every situation must be evaluated together with your doctor, the dentist will assess both the nature of the problem and its seriousness, but above all if it is really necessary to intervene. It is possible to treat pregnant patients in complete safety, only minor precautions are necessary. It is generally recommended to perform dental implantology only when the clinical picture is complex or if it could lead to infection risks; if there are not particular problems it is advisable to wait until the end of the pregnancy to avoid undergoing interventions that may require x-rays or the use of harmful drugs such as anti-inflammatories and some antibiotics.

THE RHEUMATIC PATIENT IN IMPLANTOLOGY

For the odontostomatologist, the rheumatic disease takes on particular interest due to the possibility with which, in the patient with previous endocarditic episodes, a re-ignition may occur following interventions mainly of oral surgery. These interventions range from simple probing of periodontal pockets, periodontal surgical procedures, simple and complicated dental avulsions, endodontic therapy, etc. Therefore, if the patient's general anamnesis turns out to be positive for the rheumatic disease, these patients should be considered as "patients at risk".

The presence of rheumatic disease must direct odontostomatological therapy towards particular precautions that avoid unwanted complications. In particular, the devices that must always be kept in mind can be summarized as follows:

- any dental treatment, from simple scaling to actual oral surgery, should not be carried out in the acute phases of rheumatic disease and, if a sudden toothache occurs in such a patient, the eclectic dentist must stall, limiting himself to remove the softened and decayed dentin and perform a temporary sedative dressing, delaying the optimal time for a reclamation of the oral cavity with a clinically and biologically extinguished attack;

- avoid causing bacteremia (minimizing tissue trauma; not over instrumenting; restoring periodontal health; etc.);

- in the heart patient, exposed to the risk of endocarditis, when possible, endodontic therapy should be preferable to the avulsion of the tooth not only because it is more conservative, but also because it is safer for the patient's health. In patients exposed to the risk of endocarditis, any type of dental operation must be carried out under broad antibiotic coverage, which must be started one hour before treatment by administering 2g of Amoxicillin per os and in the case of Penicillin allergy It is advisable to prescribe erythromycin (Clindamycin, 600 mg, or Azithromycin 500 mg, or Clarithromycin 500 mg).

In summary, from the considerations presented, it can be concluded that:

• subacute bacterial endocarditis (E.B.S.) represents a serious complication in patients with rheumatic cardiac lesions;

• the cause of this condition is due to episodes of transient bacteremia;

• since almost all dental procedures, from simple prophylaxis to tooth extraction, cause a certain bacteraemia, this fearsome and serious complication, while representing an infrequent occurrence, must be well known by the dentist who must pay particular attention in treating these "patients at risk";

• in the case of a patient who even vaguely hints that he has had some symptoms (rheumatic fevers, recurrent tonsillitis, pain in the large joints, small fibrous nodules on the surfaces of the extensor muscles, erythema multiforme, etc.), it is necessary to study the history and in case of doubt it is advisable to request laboratory tests (ESR, PCR, SLT, increase in neutrophil leukocytes, extension of the PQ tract to the ECG, etc.) and possibly consult the attending physician and / or cardiologist;

• dental prophylaxis of bacterial endocarditis must first be aimed at maintaining a healthy periodontium;

• on the basis of experimental research and statistical surveys, the committee of the "American Heart Association" recommends that dentists perform a prophylaxis in patients with organic heart disease in all dental maneuvers that are capable of causing gingival bleeding;

• in patients at risk, antibiotic prophylaxis must be done at the beginning of any dental treatment and at each subsequent appointment according to a well-defined protocol.

THE NEURALGIC INSANE IN IMPLANTOLOGY

Trigeminal neuralgia "true", more correctly called essential neuralgia, is typically idiopathic based, while secondary forms are recognized as vascular malformations, focal demilienization or compression exerted on the nerve by tumor masses.

The occurrence of the painful event derives from the involuntary stimulation of precise trigger points: daily acts such as speaking, chewing, brushing teeth, shaving or putting on makeup can all induce painful manifestation.

The symptom is an extremely acute pain, distributed along the trigeminal dermatomers, in particular of the maxillary and mandibular branches. The patient often describes it as "a stab" or "an electric shock". Clinically, a sign may be visible, specifically a spasm of the facial musculature (painful tic). The duration is usually a few seconds, in exceptional cases greater than a minute; the event is followed by a period of refractoriness.

Obviously the nerve center patient cannot undergo implant therapy as it would risk aggravating the symptoms

BRUXISM IN IMPLANTOLOGY

Parafunctions

The main factors are parafunctions like bruxism, clenching and thrust of the tongue.

Bruxism mainly concerns the horizontal rather than functional wear of the teeth because it consists of a rubbing of the incisal and occlusal surfaces of the lower arch with those of the upper arch. It is the most common oral parafunction, reported in about 10% even though many of those concerned are not aware of it.

The involved forces are of higher intensity, from 4 to 7 times more than normal, of much longer duration, of lateral direction rather than vertical and of cutting rather than of compression. These forces can develop while the patient is awake or more commonly as he is asleep, generating an increase in load in the system for several hours a day.

In patients with implants with severe bruxism, complications such as prosthetic fractures, screw loosening, abutment fractures and crestal bone loss that can lead to implant failure are very frequent.

The frame, often including the term bruxism according to dental literature, is a parafunction that generates a constant force exerted by an occlusal surface on the other, without any lateral movement. Mandible can be positioned in any position before the static load. The direction of the load can be horizontal or vertical, the forces involved are much greater than the physiological loads . Bruxism is one of the main risk factors even in prosthetic rehabilitations and remains associated with a greater risk of mechanical complications but does not seem to affect the duration of implants. However, in a patient with this disorder, every precaution must be taken to maintain the integrity of the prosthesis. Bruxism has always been thought to be able to overload prostheses, putting implant abutments at risk, but even today there are no scientifically based guidelines and we must limit ourselves to following the indications available in the literature. These include first and foremost the use of junction plates, suitably discharged at the implant sites, and the use of metal rather than ceramic restorations, especially in the molar areas.

The parafunctional thrust of the tongue is an unnatural force exerted against the teeth during swallowing. Although the thrust force of the tongue is of lesser intensity than other parafunctional forces, it is of a horizontal nature and can increase stress in the transgingival implant site.

In addition to the parafunctions, the force exerted can be influenced by the patient's teeth, age, sex and skeletal position-

In a patient with long-standing edentulism the maximum force of closure decreases as muscle atrophy progresses.

After implant placement this force can increase by 300% in three years.

IMPLANTS PARAMETERS

Despite the fact that implantology is, contrary to what one might think, one of the oldest dental disciplines, in the last half century, this branch has made great strides.

From experimental studies conducted on animals before, and on men later, in 1952 Branemark defined the concept of osseointegration, and for this reason considered, the father of modern implantology.

From this date, we have witnessed a rapid evolution of this branch up to the present day; the use of dental implants in the treatment of partial and total edentulism has become an integral treatment modality of restorative dentistry.(60)

An endosseous implant is an alloplastic material inserted into a residual bone crest, mainly as a prosthetic support .(61)

Implant-supported prostheses have very great advantages over adhesive or muco-supported prostheses. In fact, as already explained above, the implant stimulates the bone and maintains its dimensions in a similar way to natural teeth.

CLASSIFICATION OF IMPLANTS.

Based on their morphological and structural characteristics, the implants can be classified as follows:

1. endosseous implants.
2. subperiosteal implants.
3. transosseous implants.

The endosseous implants can be inserted both in the mandibular bone and in the maxillary bone through the incision of the periosteum.

These implants are the most commonly used. Most of these implants are designed and manufactured in accordance with the concept of osseointegration, which is fundamental for the success of implant therapy. According to their design, endosseous implants can be classified into:

a) blade implants;

b) root-shaped implants (cylindrical, hollow, truncated, and screwed).

Subperiosteal implants are used in a clinical setting when the width and depth of the bone are not such as to allow the insertion of endosseous implants. The implant, inserted below the periosteum, consists of a metal frame shaped like the bone surface on which it will be placed. The clinical procedures for the construction, placement and removal of these implants are more complex than those of root-shaped implants. Thus, due to the high probability of rupture and clinical complications, these types of implants are rarely performed today.

The clinical use of transosseous implants, instead, occurs exclusively if the patient presents a severe bone atrophy. Due to the extremely invasive nature of the intervention, today this type of implant is rarely used used and bone atrophy is resolved by performing autologous bone grafts (taking bone tissue from the patient's iliac crest) in the mandibular bone.

As previously mentioned, the most used implants today are the endosseous ones, designed to be positioned in the thickness of the bone so as to simulate the root of a natural tooth.

The osseointegrated implants used today can be schematically divided into two different types:

1. two-component systems.

2. One-component or transmucosal implants.

Two-component implants include an endocavial part of anchorage and a trans mucosal component that allows the adaptation of prosthetic rehabilitation: the connection between the two components is usually positioned at the level of the bone crest where a micro gap is present.

One-component implants consist of a single unit comprising the endo-osseous and trans-mucous part without the presence of microgap.

This type of implant is inserted in only one surgical time so that the trans mucosa component is not submerged but appears in the oral cavity.

In this case, the healing period allows both the osseointegration of the implant and the formation of an interface between the implant and the soft tissues.

Although one and two-component implants differ in some aspects of the peri-implant tissue interface, numerous clinical studies have demonstrated the reliability from both the clinical and prognostic point of view.[62]

As previously mentioned, there are three types of root-shaped endosseous implant bodies based on the shape: cylindrical with screw or combined.

IMPLANT MORPHOLOGY

(Image by ”digital implantology book”)

Root form implants

The screw implant is certainly the most used among endosseous implants. It lends itself to solving the most different anatomical situations, both in terms of the bone tissue conformation and in terms of density.

There are screw implants of extremely variable shape. There are screws that are better suited to compact bone and others to spongy tissue. The industry produces two or three component screws for the submerged insertion technique (two-phase implantology) and monolithic screws for the emerging technique (monophasic implantology).

Screws have been produced for implantology in steel, ceramic alumina and, recently, also in zirconia, but the most widespread and universally used are titanium.

The titanium gradation they are made of influences the elasticity and strength of the implant, with variable advantages and disadvantages depending on the different anatomical sites. Further distinctions concern adaptability to be used as post-extraction implants and as immediate loading implants.

Morphological types

The screw implant shapes that were originally proposed followed the wood screw concepts. Many of these emerging screw, adequately updated, are still used by numerous operators and commercially re-launched. In very early times, "basket" implants were also presented. In these forms we find many details that characterize the implants present on the market today.

Among the screw various forms there are differences in pitch, conicity and procedure.

Some authors propose a surgical technique that involves an undersized milling in respect to the volutes, that are larger than the core, while others argue that it is necessary to force the implant into the bone in a small hole to increase stability.

Over the years, numerous new forms of emerging screw systems have been developed, innovative above all with regard to surface treatment, the emerging profile and the stump that has been made more performing and suitable for use even in aesthetic areas.

An example of an extremely specific implant shape for a given anatomical site was brought at the end of the 1970s by the Swedish school[63], which turned towards a design of a fine-pitched type of iron screw with little pronounced volutes, aiming mainly to treat the chin anatomical site in edentulous patients selected for bone availability and general health conditions. Some axioms proposed at the beginning, such as the mandatory indication not to take x-rays during and after the operation and the need for a two-stroke technique to achieve osteo- integration, were later abandoned, due to a clinical confirmation deficit, by the same authors who had supported them[64].

The diameter variability and of the prosthetic solutions that can be proposed make it possible to adapt the product choice to one's professional abilities, ranging from the simplest to the most complex methods.

Screw systems potential

- Rapidity of surgical execution

- Availability of submerged and non-submerged forms useful for solving the most different anatomical conformations.

- Adaptability to post-extraction sockets

- Suitability for regenerative procedures

- Suitability for immediate loading

- Mesio-distal dimension similar to that of the dental elements, which allows to avoid the adjacent space invasion.

- The root-crown relationship improvement with that of the pre-existing tooth due to the implant depth development.

- Prosthetic result.

Clinical limits: Poor adaptability to thin crests, especially in submerged versions

Surface

The variety in surfaces that have been proposed is remarkable. They range from the smooth surface obtained with extremely advanced honing procedures, to the rough surface obtained by adhering titanium particles to the implant surface, passing through roughness obtained by sandblasting, etching, etc.

At the knowledge present state, it is still controversial whether the implant surface roughness is decisive for osseointegration and whether it affects more when using the two-stroke procedure or when loading the implant immediately.

Anatomical locations

Screw implants are adaptable to almost all anatomical sites. The limit on its use is imposed by the bone crest thickness and the obtainable root-crown ratio. Using the 2-stroke procedure, which involves waiting a few months to wait for the bone to be implanted, bone regeneration protocols, tissue grafting and enlargement of the ridge can be applied contextually.

Anatomical fixity.

The bone tissue in the jaws is variable, affecting the screw implant choice and the insertion procedure. The differences in density also have a decisive effect on the surgical technique.

Cylindrical system

The cylindrical and / or cylindrical-conical endosseal implantology implant, smooth and / or threaded with macro or micro coils, is the most widely used today.

In this section we analyze the typically cylindrical implant with a non-threaded or minimally threaded surface, deriving from the Branemark school experimentation.

The Swedish school, in basing its theory on the intimate bone-to-implant connection between the bone and the implant surface, did not consider primary fixity and only proposed cylinders with a non-spiral surface, variously treated (wrinkled) or only minimally threaded. An insertion even minimally forced into the bone, was considered as a harmful factor (anti-reparative bone insult).

Then the clinical trials pushed towards thread the cylinders more and more and more, transforming "iron screws" into "wood screws", with sustained grip, self-tapping, independently of the ostoinducting surface treatment.

Nowadays the methodological evolution and the reunification of the various implant schools have supplanted the dogmas and the frankly cylindrical-smooth implant used singularly and separately, is finding more and more rare application, limiting its use to lower molar edentulous areas or in implant constructs through multiple-oblique-inclined insertions, where the " abutment " function is prevalent.

(Image by ”digital implantology book”)

SURFACE

Microarchitecture and implant macroarchitecture.

Many aspects of the biocompatibility profiles established for dental implants depend on factors such as: biomaterial, tissue and host.

Titanium is a metal that has a low weight, a high strength / weight ratio, a low modulus of elasticity, excellent corrosion resistance, excellent biocompatibility and easy workability and polishability. For these characteristics it is the most widely used material in dental implants construction, commercially pure titanium or alloy; the currently most used alloy (titanium-6-aluminum-4-vanadium) is composed of 90% titanium, 6% aluminum and 4% vanadium.

The biomaterials characteristicscan be divided into categories associated with surface or mass properties. The biomaterial surface chemistry, the topography (roughness) and the tissue integration type, can be correlated with the host responses in vivo, both short and long term. Furthermore, the host environment directly influences the interface area between the biomaterial and the specific tissue due to the local biochemical and mechanical circumstances of healing and the longterm clinical aspects of the function under load. Interaction at the interface between receiving tissues and implanted material is limited to the implant surface layer and a few nanometers in vital tissues. The integration details with the hard and soft tissues and the forces transfer, which result in static and dynamic conditions, are able to significantly alter the clinical longevity of the devices placed. The scientific community has always focused its attention on interactions in the biomaterial-tissue interface and strongly supports the value of the analysis of the dental implants surface characteristics.
The biomaterials used for the manufactoring of dental implants manufacture and the associated abutments that contact the oral tissue subepithelial areas es can be classified as:
metallic, ceramic and modified surfaces (coated, treated or with ionic fixation).
The structural atomic characteristics of the coatings are fundamental with regard to the surface composition, resistance to corrosion, cleaning, surface energy, bending and the tendency to interact, as well as the ability to denature proteins.
When studying a surface, the aspects to be considered are essentially morphological and chemical.

The morphological aspects to be studied are macrotopographic (in the order of millimeters, such as implant design and its threading), microtopographic (in the order of micrometres, such as topography and surface geometry of the implant) and ultrastructural (in the order of nanometers, hence the surface nanostructural aspects)[65]

The surface preparation processes are numerous and the parameters that define each process can be extremely modifiable. So the different surfaces number is almost unlimited and these are hardly categorized, except for the fireworking process that characterizes them.[66]

Tab 2. Implant surfaces classification.

SURFACES		PRODUCTION TECNIQUE
Surface smooth.		TURNED
		MACHINED
		Electropolisched
Surfaces Micro-rough combined	ADDITIVE	Titanium Plasma Spray (TPS)
		Plasma spray calcium-phosphated (HA)
	SUBTRACTIVE Sandblasted and Acidification.	Sandblasting with aluminum oxide
		Sandblasting with titanium dioxide
		Acidification with Acidi

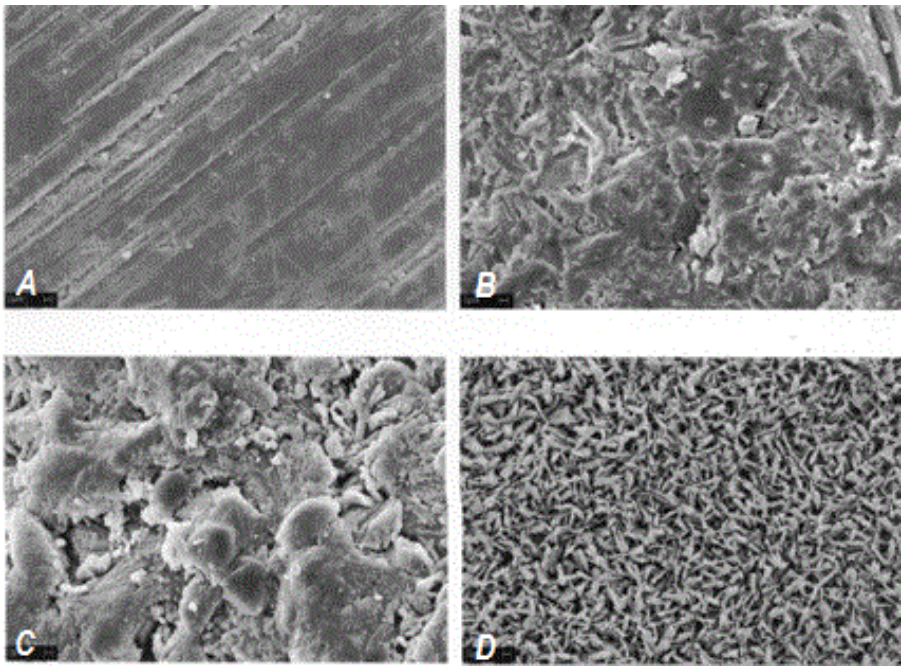
As far as microtopography is concerned, traditional implant surfaces can be classified as: smooth and micro-rough.

Smooth surface implants, now almost abandoned, are machined (machined) or turned (turned) or electro-cleaned (electropolisched).

In the case of mechanical turning, the surface appears to be macroscopically shiny, but actually has streaks and irregularities related to the lathe action.
For this reason the "smooth" term should be avoided.[67]
In the case of the electropolished surface, the raw surface is subjected to electrochemical treatment by immersion in an electrolytic solution, through which a current passes, until a glossy surface is obtained.
Implants with a smooth or machined surface were the first to be used in the clinic for a long time.
In order to obtain better clinical results in terms of a greater and more rapid apposition of new bone on the implant surface, implants with micro-rough surfaces were introduced more than thirty years ago.
Nowadays it is unequivocally demonstrated how implants with micro-rough surfaces stimulate a greater and more rapid new bone apposition compared to implants with a smooth surface.
Histological and histomorphometric studies in vivo on animal models and on humans have indeed demonstrated incontrovertibly how implants with a rough surface allow for greater osseointegration, with more BIC and higher bone quality on the surface.[68]
Indeed, superficial microtopography influences adhesion, proliferation, cellular differentiation and the production of local factors.
This large type of implant can be obtained through various techniques: additive, subtractive or combined.
Micro-rough implants for material removal are obtained by sandblasting, acidification or combination of these two methods.
The sandblasted surfaces are created by sandblasting the metal core with abrasive grains, a process influenced by the number and speed of the rotations that are sent to the implant, as well as by the pressure of the bottles used.[69]
The sandblasting procedure is performed in order to increase the irregularities of the implant surface, using agents such as aluminum oxide (Al2O3 also called alumina) or Titanium Dioxide (TiO2). Surfaces thus treated are those that present the maximum variability of the surface appearance.

The acidification procedure, proposed to modify the titanium surface without leaving residues that remain after sandblasting, instead foresees the implant's immersion in acid solutions resulting in the erosion on the surface, leaving a formation of peaks and depressions of various dimensions. This process' outcome is dependent on solution concentration, immersion time and temperature.
(HCl) with sulfuric acid (H2SO4) or with hydrofluoric acid (HF).
As an alternative to acidification with strong acids, implant surfaces can also be obtained by treatment with weak acids.
Acidification with organic acids, such as oxalic acid and maleic acid, results in a surface characterized by a peculiar geometry, with a sequence of repeated concavities, of homogeneous and controlled dimensions.
Regarding micro-rough implants obtained through additive techniques, an example is represented by plasma spray implants coated with Titanium particles (Titanium Plasma Spray), or for the application of a coating in calcium-phosphate or hydroxyapatite (HA). In the first case the surface is first sandblasted and then treated with thermo-spray with pure titanium particles at high temperature. A coating layer of about 10-40μm thick, extremely rough and solidified on the surface is obtained.
In the second case, the HA coating has a thickness between 50-70 μm and a highly rough surface. The characteristics of these surfaces, such as degree of roughness and its thickness, obviously depend on a series of parameters such as particle size, speed and impact, temperature and surface distance.[70]
Finally there are the micro- rough implant surfaces obtained by combining sandblasting and acidification.
Combined approaches aim to modify both from a macroscopic (sandblasting) and microscopic (acidification) point of view. Numerous clinical works are underway to assess the implant behavior with a sanded and acidified surface.

Implant surfaces in comparison: A, surface obtained by machination; B, sand-blasted surface with Al2O3; C, calcium-phosphated plasma spray; D, Titanium sandblasting.



Surface Analysis of Titanium Dental Implants with Different Topographies

M.H. Prado da Silva[a], G.A. Soares[a], C.N. Elias[b], J.H.C. Lima[c], H. Schechtman[d], I.R. Gibson[e], S.M. Best[e]*

There are also surfaces treated with electrochemical anodization. The anodization takes place in an electrolytic solution with strong acids (H2SO4, H3PO4, HNO3, HF), at a temperature of 20-25 ° C and applying a voltage of about 80V: a growth of the starting layer is obtained (at 180-200 nm, compared to 5 nm of electrosanding), with the presence of Ti and O and any contaminants (carbon), which can be removed with washes. The anodized implants currently on the market have a porous morphology (1-2 microns) and a surface layer thickness that can range from 2 to 7 microns. When the imposed voltage increases there is a growth of bone-implant contact. In addition to high voltages, the process can also occur at high currents (200 A / m2), with the result of thickening the oxide layer to more than 1000 nm: since the latter ends up dissolving along the conventional current path and to thicken instead on other regions, micro or nanopores are created (diameter varying from tens to a few hundred nm on the surface. The dependence of the result on many factors (the current density, the concentration of acids, the composition is evident) and the temperature of the electrolyte): the effects are modifications of the microstructure and of the crystallinity of the oxide layer, which are translated
in both biomechanical and biochemical changes.

there are also combined treatments like SLA (sanding and acid etching). Following the good results provided by the two techniques of subtraction of sandblasting and acid etching, it was decided to combine the advantages in a single treatment, in order to obtain an SLA surface (sandblasted with long grain corundum followed by acid etching with sulfuric acid and hydrochloric). It is produced using a coarse grain (250-500 microns) using a sandblasting technique with corundum particles that generates a macruvidity on the titanium surface. This phase is followed by a strong acid etching bath with a mixture of HCl / H2SO4 at elevated temperature for several minutes. This creates micro-cavities of the order of 2-4μm superimposed on the sandblasted surface so as to further increase the micro roughness. The topography obtained is
an ideal structure for fixing
cells and helps promote protein adhesion in particular, which is considered essential in the early stages of bone healing.
From research in implantology is in
subsequently derived the SLActive surface, which shares the same macro and microtopography with the SLA surface. the SLAactive plant is characterized by a film of hydroxylated and hydrated titanium dioxide, produced in concentrations of N2 (atmospheric nitrogen) that prevents atmospheric contamination, and finally, it is stored and sealed in plastic vials containing an isotonic solution of NaCl to pH of 4-6 to preserve the chemically active phase of the surface.
The SLActive surface is characterized by a high surface free energy (surface tension), is subject to reduced atmospheric contamination and is strongly hydrophilic with a high wettability.

With SLActive, there is a water contact angle of 0 ° which must be compared with the 139 ° of the conventional SLA surface. These characteristics lead to a more rapid osseointegration of the implant, due to the increased stability of the implant given by the onset of a rapid and stable blood clot. SLActive increases cellular activity early, with increased osteoblast differentiation, increased production of osteocalcin, type I collagen, alkaline phosphatase and local growth factors, such as VEGF, PGE2 and TGF-ß1, reducing the risk of failed osseointegration especially in the early phase of posionamento, which represents the phase of greatest risk.

IMPLANT MACROARCHITECTURE

From the macroscopic point of view, for the implant shape and the turns arrangement, it is useful to make a distinction between implants with cylindrical shape and implants with conical shape. The cylindrical were the first to be tested, to be subsequently replaced by conics: clinical results have shown that the cone shape is better suited to the grafting site and that it determines a better anchoring bone-implant at the interface level. The osseointegration is better both from the point of view of biological processes and cell adhesion, and as regards load distribution.

There are on the market types of screws that approximate a cone in the overall shape, but which in detail are formed by progressively smaller cylindrical sections; it is not unusual use implants that combine both types, equipped with a cylindrical upper portion and a conical lower portion.

The single or double thread is a factor of lesser importance than the shape, although it must be recognized that a greater thread increases the surface area and therefore affects the implant micro-texture, ie the roughness. The thread profiles are rounded to prevent stress concentration in unwanted points.[71]

It is necessary to point out that many companies are progressively adopting the Switching Platform concept: the platform (or collar), which is the junction between the implant and capsule, appears to be the point of maximum concentration of the bacterial charge. To resolve this problem and prevent tissue loss (resorption), the abutment conformation was changed in order to raise the attack point of bacteria, to bring it as far as possible from the junction and to allow a better cohesion between the two connected parts, therefore better stability. By creating the connective tissue support base (the platform not occupied by the abutment),

there is a stabilization of the collagen fibers, minimizing bone resorption and helping to reduce mechanical stress on marginal bone.
With platform switching, the prosthetic connection diameter is reduced by concentrating the inflammatory infiltrate over the implant platform and not laterally.
In practice, the biological width of about 3 mm takes into account, in the case of platform switching, also the implant platform portion not covered by the abutment and therefore is reduced in height.

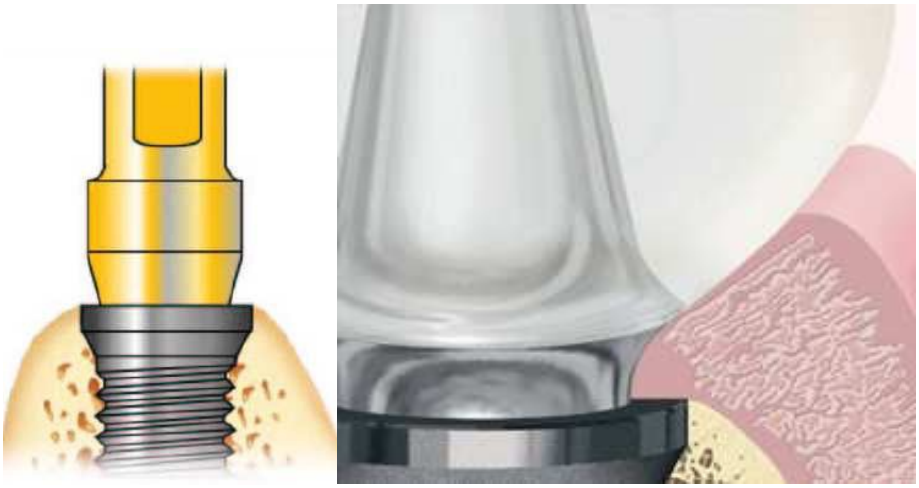
The reduced transmucous volume of the abutment allows an increase in the volume of peri-implant soft tissues, constituting an effective barrier effect against bacterial penetration and apical migration of sulcus epithelium, which lead to bone resorption.
Several hypotheses have been put forward to explain this phenomenon and the protection towards the crestal bone by the platform switching:

1) The mechanical theory indicates a greater stress that is exerted on the entire surface of the implant's neck in the traditional implant, while in the one with platform switching the stress zone moves to the implant central area and not to the peripheral zone.

2) The bacterial-inflammatory theory foresees that the infiltrate on the abutment-implant junction is moved horizontally towards the implant center, thus moving away from the adjacent crestal bone.

The system can raise doubts about the mechanical strength of an undersized abutment, that is, with a diameter smaller than that of the implant.
However, the research shows that the abutment under-sizing does not compromise its strength, which does not deform due to loads below 900 N. and the system can be considered reliable from a mechanical and also biological point of view.

Implant with platform switching.
The gingiva occupies the space of the platform switching.



Images by " Platform Switching: New Concept of Dental Implant "

Implant body

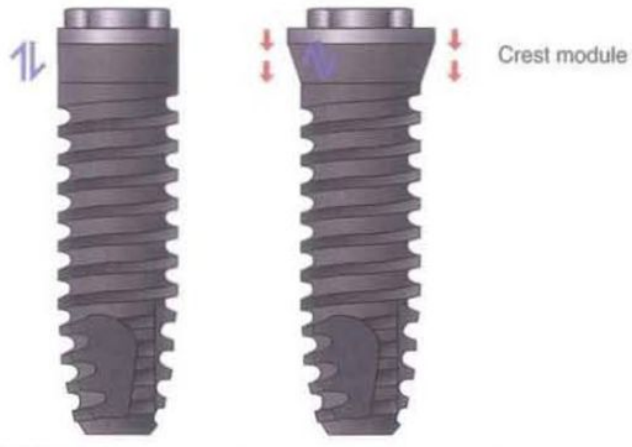
The implant body can be divided into a crestal module, a body and an apex. Each implant section has favorable features for surgical or prosthetic application.

An implant body is designed primarily to make surgery or prosthetic loading of the implant bone connection easier.
The design of the full screw implant body is the one most commonly found in the literature. It is described as a implant with a circular section, not penetrated by holes or any opening. The threading may have a V-shaped, spur-like, spur inverse or square; the V-threaded screws were the first in clinical practice [99;100]
The crestal module of an implant receives most of the implant loading and appears to play an important role for implant stability. It should be slightly larger than the outside diameter of the threaded implant body. This is because the seal created by a wider crestal module determines greater implant primary stability, especially in unprepared softer bone, because it compresses the crestal bone region.
The implant design not only governs the primary stability but, more importantly, determines the BIC percentage and the location of the contact available for the effective transfer of force to the bone after occlusal loading.

A threaded implant body is basically designed to increase the bone-implant interface area and to reduce stress on the contact surface during occlusal loading. The functional surface area of a screw implant is greater than that of a cylindrical implant, from a minimum of 30% to over 500%, depending on the geometry of the thread.

Crestal Module

The implant body crestal module, in both a single-component and two-part system, is the portion that must fix the prosthetic part. It also represents the the implant body transition area to the implant transosteal region on the ridge. The abutment connection area usually has a platform on which the abutment is placed; the platform offers physical resistance to occlusal axial loads. An anti-rotational configuration (external hexagon) is also inserted on the platform, or it is extended within the implant body (internal hexagon). The implant body has a shape that serves to transfer stress and tension to the bone during occlusal loads, while the crestal module is often designed to reduce bacterial invasion.
The dimensions of the most polished part vary enormously from one system to another. When the crestae module is made of liss, polished metal, it is often called a cervical collar.



Img.by:" Scientific Rationale for Dental Implant Design."

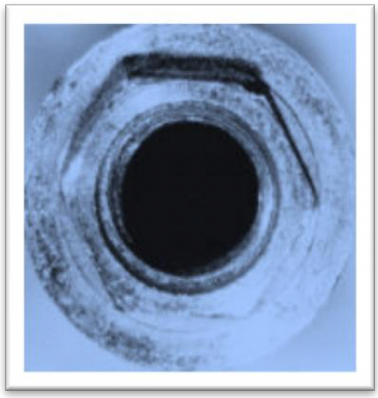
Apice

The apical of each implant should be flat, rather than pointed. This allows the incorporation of the shape characteristics, which maximize the resistance desired profiles, for the entire length of the implant; most of the implants have a circular cross section. This allows to prepare a cavity with a circular section with a cylindrical cutter, for the note corresponding to the implant body.

ABUTMENT-IMPLANT CONNECTION

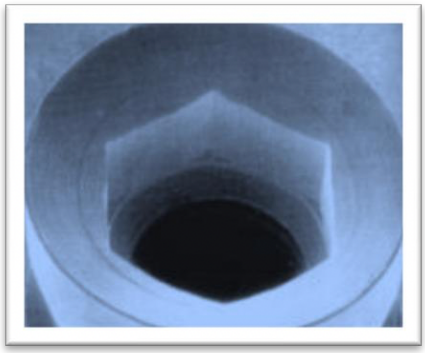
The abutment-implant connection represents an important variable in the masticatory loads distribution from the prosthesis to the bone-implant interface.
The main types of connection are shown below.

External hexagon: at the implant neck level there is an external hexagon with an anti-rotational function. The abutment base, cylindrical in shape, rests on the implant edge.

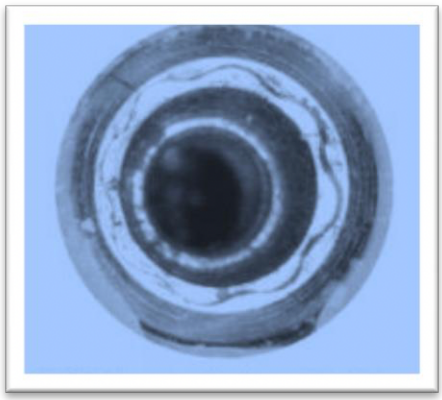


Images By: ”Clinical Biomechanics Vol.65”

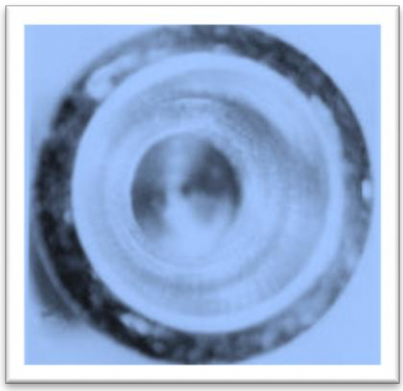
Internal hexagon: the walls of the implant neck are flared towards the inside and end with a hexagon for an anti-rotational purpose.



Daisy: the abutment base has a multilobed type design for anti-rotational purposes.



Conic: the abutment, whose profile is tapered, is inserted in the special housing inside the implant creating, through a conical coupling, a whole with the implant itself. It has no anti-rotational function.



The connection represents a discontinuity point and weakness of system. Ideally, a connection should be:

- precise, to guarantee the maximum possible seal between abutment and implant in order to minimize the possibility of bacterial adhesion and proliferation;
- stable, to guarantee adequate resistance to masticatory stress; the two connected components must not undergo relative movements with respect to one another, be they torsional or flexional rotational movements.
- simple, to guarantee maximum practicality of use for the clinician both in the surgical phase and in the prosthetic phase.

Connection accuracy

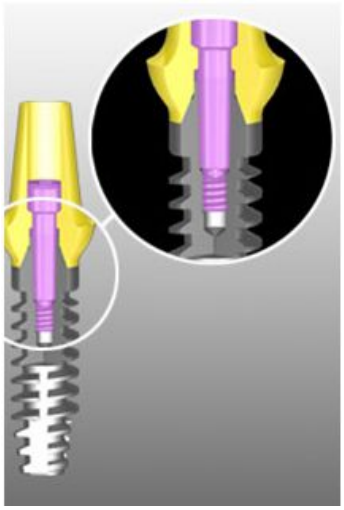
The connection precision conditions the possibility of sealing the site where the abutment is housed inside the implant. If this seal is not created, a bacteria reservoir is formed which, although not pathogenic, is capable of moving from the housing of the abutment to the peri-implant tissues. As a consequence we can verify the ICT formation (Inflammatory Connective Tissue), that is a peri-implant tissue area in which cells continuously activated to oppose microbial insults coming from the oral cavity reside. However, connection accuracy cannot be absolute. It must always be considered that in the industrial production of two mechanical components that must be coupled, a margin of dimensional error (± 10 μm) must be tolerated.

If we add the possibility that the two mechanical components, during the masticatory function, undergo elastic deformations, it is easy to understand how the system cannot be perfectly sealed. Given therefore for granted an excellent patient oral hygiene, the possibility that the bacterial plaque accumulates depends on the precision in the abutment-implant connection and on the superficial abutment roughness.

At the clinical level the plaque accumulation can determine the onset of periimplantitis, an infectious inflammatory process that tends to deepen, putting the resistance of the bone / implant interface at risk.

The connection between the implant interface and that of the pillar can be defined as a "sliding joint" when there is a small space between the two parts, or a "passive connection" or frictional coupling when there is no space between the parts and they are stuck among them.

The surfaces that face each other can constitute a butt joint if the two surfaces are flat and perpendicular in mutual contact, or a bevel joint if the surfaces are inclined inside or outside.



Img.by:" Scientific Rationale for Dental Implant Design."

In prosthetic restorations concerning a single element, in particular, it is necessary to avoid creating a rotation axis around which the prosthetic artifact could rotate; in this regard there are antirotational devices which constitute the fundamental element of the fixture-abutment interface, and on which all the connection geometry depends.
In fact, depending on how the antirotational geometric element is positioned, a distinction can be made between external connection, in which the geometric element protrudes beyond the implant surface, or internal connection.
The anti-rotational element geometry can take the most disparate forms, and almost all of them include a sliding joint: external hexagon; internal hexagon; external octagon; internal octagon; conical screw; locking taper.

Even today the most used interface design is the external hexagon, introduced by Branmark, the 0.7mm high hexagon. This hexagon was study to allow the device grafting for the torque transfer during the implant insertion after having performed the implant site tapping and to subsequently fix a mucous abutment which, together with the others inserted simultaneously, allowed the restoration of an edentulous arch.
All the variants were made with the aim of improving the external hexagon mechanical characteristics or to improve the rehabilitations aesthetic result as in the case of internal connections.

Img.by:" Scientific Rationale for Dental Implant Design."

The objectives of these new projects are to improve the connection stability and simplify the instrumentation necessary for the clinician to complete the restoration. There are at least twenty distinct implant-abutment interface variants available on the market.30

External connections

According to Branemark the external hexagon height had to be 1.2 mm to give guarantees, even if still today most of the external hexagons has a height of 0.7 mm, as it was originally conceived.
From a clinical point of view, one of the problems that remained unresolved is that of the difficulty of inserting the abutment hexagon components into the implant platform, especially in the lateral sectors.
A small incongruity that can manifest itself when an abutment is adapted on the laboratory analogue and then in the oral cavity can compromise all the restoration, especially if these is composed of several elements.

The interfaces designs used today have all been designed with the aim of increasing the resistance to rotation, thus preventing the preload loss and the screw loosening, as well as the permanence of the implant itself in the bone. All this is supported by the data present in the literature, leading to the conclusion that the rotational incongruity significantly influences the abutment life.
If in fact there is a discrepancy, a screw even if tightened to 20Ncm is not able to guarantee an optimal abutment stability. It is also deduced that the greater the rotational incongruity, the greater the torque for screwing the abutment and the preload necessary for maintaining the joint intact and stable.
Among the various alternatives to the hexagon, the octagonal design was proposed, today almost disappeared from commerce. The octagon in fact presented itself with an insufficient height, with very thin walls and with a conformation too similar to the circle; this led to the impossibility of sensing the abutment's correct positioning in the implant and did not guarantee an appropriate anti-rotation and adequate protection of the side loads.
An interesting alternative to the external hexagon has been proposed using an interface called "spline" already widely tested in specialized industrial applications. The most striking thing is its particular design, consisting of six parallel keys, alternating with six grooves; the abutment interface is mirrored to that of fixture. Both the fixture splines and those of the abutment are parallel and self-centering, allowing abutment easier insertion in clinical practice.

Internal connections.

The geometries with internal interface have a platform with a reduced height for the prosthetic components; external loads are transmitted deep inside the implant body and consequently a more protected connection screw.
Furthermore, the geometric connection element is quite extensive, creating a more rigid and more resistant set-off against counterparts, an excellent antimicrobial seal and a better aesthetic result, given the remarkable approach of the restoration to the implant level.
Among the most commonly used internal connections there are internal hexagon connections with internal octagon, screw and Morse cone.

A connection interesting type is represented by an interface with the taper "Morse". The cone is a connection device. Its application in the biomedical field dates back to the sixties with the hip prosthesis; later in the seventies, it was introduced in the dental field.
The abutment consists of a conical pin without threading that is inserted into the respective housing turned into the implant body.
Several manufacturers nowadays offer conical screw connections, based on the concept of Morse taper, although each with different values of the taper angle.
Among the internal geometries, the most widespread is the hexagon, adopted by a rather high number of manufactures; compared to the equivalent external geometry it guarantees the best qualities from the mechanical point of view. The internal hexagon was born as a sliding joint with the geometric element that protrudes from the abutment and is inserted into the respective housing made in the system. We tried to improve the design by creating a longer hexagon with a one degree taper.
Among the internal connections, the pure conometry connection deserves special mention, as it does not require the screws use and where the interface provides a direct joint between the abutment and implant surfaces. The system stability therefore depends on the friction between the two surfaces, and the effectiveness of the system itself is, consequently, closely linked to the material used, the surfaces nature and the geometric shape.
In essence, the conometric connection provides a series of advantages with respect to the other types of internal connection, among which are:
A better loads distribution to the whole implant system, without concentrating them in the screw (which is absent).
Less bacterial penetration in the abutment-implant gap: considering that the bacterium size can range from 1 to 6 microns and that the interfacial gap of this system ranges from 1 to 3 microns, the bacteria penetration through the implant components coupling it becomes very difficult.

PROSTHETIC PARAMETERS

Types of implant-prosthetic rehabilitation.

The edentulous (whitout tooth) sites rehabilitation, whether they concern single lost dental elements, or contiguous elements or the entire arch; they are easily rehabilitated with the endosseous implants grafting with prosthetic support. We can distinguish:

- Crowns on single implants
- Bridges with implant or mixed support
- solidarized fixed rehabilitation supported by 4-6 anterior implants (placed between the mental foramens or the maxillary sinuses) and bilaretal lateral extensions
- solidarized fixed rehabilitation supported by 6-8 antero-posterior implants distributed along the arch without bilateral extensions
- fixed segmental total rehabilitation supported by 6-8 anterior-posterior implants.

The crown on implant is a possible solution for those patients who have teeth that are adjacent to the missing (or to be extracted) that are perfectly healthy or that are still in good condition.
At the visit time, the bone tissue quality and quantity on which the implant is to be built are determined. Based on the diagnosis, the implant operation is decided, or any corrections by which, in cases of bone loss, ensure implant insertion. Three months after implant insertion, the other prosthetic components are placed on it, including the crown. All the implant-supported crowns have an anti-rotational system. As in prosthetics on natural teeth, the ideal crown / implant ratio is 1 to 2 index. In the case instead of patients in whom a high bone resorption is observed, the ratio turns out to be reversed at the expense of the system resistance.
The implantology major advantage is that one or more lost teeth can be replaced with a prosthesis, without going to touch the remaining healthy teeth. The implant bridge is a prosthetic solution that satisfies both functional and aesthetic requirements.

Even when the bone tissue on which it is necessary to insert the implant does not have the necessary volume or resistance, it is possible to increase it with the artificial bone tissue addition. The procedure is part of standard oral surgery and does not constitute any risk to the patient. After a 6 months total from the moment in which the artificial bone tissue was added, this becomes a natural bone integral part, thus creating the necessary conditions for inserting the implant. Once inserted, the implant must remain in the bone for at least 3 months so that it can be loaded with the final crowns (bridge). The crowns can be made up of various materials, which of them will then be used depends on the concrete situation as well as on the desires and financial possibilities of patient.
Although for the implant intervention success it is preferable not to load the implants, in more than 90% of cases it is possible to position the temporary teeth on them immediately after the operation. In this way the patient is allowed to continue with his normal activity during the osseointegration period. The patient can return to his daily activities after just half an hour after surgery.
To guarantee the osseointegration long-lasting duration, the union (splinting) of two or more implants requires the prostheses realization that must respect two fundamental requirements:

- Fit precision and Passivity

Ideally, a prosthesis should guarantee a correct marginal closure on the abutment (fit precision) to limit marginal bacterial infiltration. At the same time, it should guarantee passive absorption without exerting traction on the implants and therefore on the bone tissue. In the absence, therefore, of stomatognathic apparatus function (mandible in rest position) no force should be applied to dental implants. However, passivity and precision of fit are two features that are difficult to achieve simultaneously. The number of clinical and laboratory steps and the different materials used in making implant prostheses are responsible for deformations and therefore errors that are difficult to predict and control. The more the prosthetic truss tends to passivity the more the marginal precision decreases and reverse, the more precise the prosthetic truss is, the less it is passive and the clinician feels high friction on the abutments during insertion. This friction results in a constant force that is applied to the bone-implant interface and that is added to the masticatory loads: this force is called preload.

It is therefore necessary to adopt a method that is able to guarantee a good balance between passivity and precision of fit, limiting the possibility of generating a potentially harmful preload.

The implant is an intraosseous root prosthesis, suitable for supporting an extraosseous coronal prosthesis.
The coronal dental prosthesis is defined by European legislation: "custom-made individual medical device", while the radicular prosthesis is "a surgical type medical device", a standardized product of medical industry.

The coronal prosthesis, of one or more dental elements, can be:
- Unmovable, therefore cemented
- Removable for screwing / unscrewing
- Removable

The above, obviously, refers to the possibility of actual self-removal by patient.

In clinical practice, regardless of the endosseous implant types, the prosthesis must be applied by means of a mesostructure, which acts as a support for a superstructure which is the artificial dental element copy.

The mesostructure can be of different types:
- Prefabricated screwed abutment
- Abutment screwed adapted or fused in the lab
- Emerging abutment
- Electro-welded structure
- Straight content structure
- Individual structure

Currently, in implantoprosthetic clinical practice, methods are also proposed protected by "registration" of the denomination:
- All on Four ®
- All on Six ®

Img. By “Total Prosthesis and Overdenture on Implants. Step by Step procedures.”

"All-on-Four" and "All-on-six" implant prosthetics

The implantology techniques named in this way are implant-prosthetic proposals for the total edentulism (anybody tooth) treatment.
The upper or lower prosthesis is supported on four implants, inserted spatially according to a project suitable for the retentive balancing of the prostheses themselves.

This procedure stabilizes entire prosthetic arches, mostly in resin, by screwing them to the abutments, which are also screwed onto implants.
The upper prostheses may therefore be devoid of the resinous palatal flange, thus giving greater comfort than the traditional mobile prosthesis.
The surgery, which can also be performed guided by a surgical guide, can be standardized and simplified.

Image by ”Digital Implantology Book”

Abutment

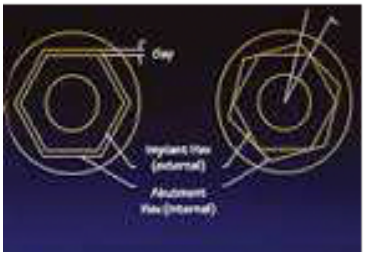
Abutment indicates the support structure interposed between a substructure and a superstructure.
In implant-screw prosthesis, it indicates the supporting MALE to the dental technician that imitates the element or the replaced dental elements.
The abutment is therefore a "sub-crown" prosthesis, a standardized industrial medical device which then supports an individual medical device






Images By: ”Clinical Biomechanics”

This structure differs according to the many systematic systems available on the market.
The choice material is Titanium and today also Zirconia.
Morphologically it is produced with different inclinations to make it suitable for adaptation to the Fixture insertion axis.
The coupling with the Fixtrure can take place directly by screwing in the case of "two piece" implants, but more frequently for the interposition of a small caliber passing screw "," three piece ". This coupling creates a micro-gap that is currently the subject of in-depth studies, both mechanical and microbiological, given that it is precisely the structural failures or unscrewing of these microstructures, in addition to the peri-implantitis, that constitute a frequent source of implant-prosthetic failure. To avoid this, multiple configurations have been produced for the union: internal hexagon, external hexagon, octagon, cone-morse.

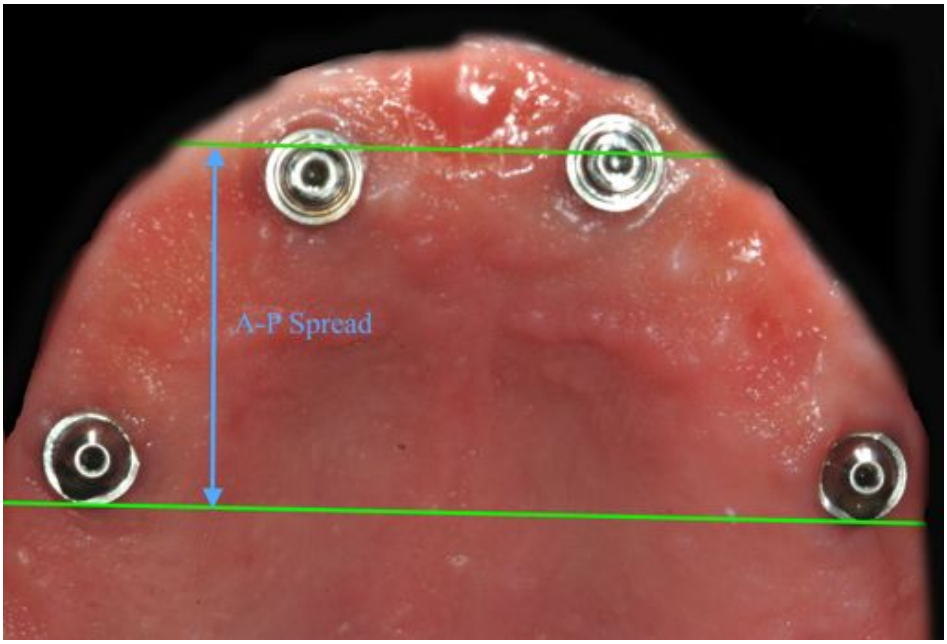


Images by “Bio Engineering Implant Components”

The various prosthetic structures above the implant can sometimes present unsupported extensions called cantilevers.

THE PROSTHETIC CANTILEVER

In prosthetic situations designed with cantilevers, prosthetic extensions without implant support, force large moments can develop on the bone-implant interface and on the implant components based on the extension length and the number and location of the implants in the system.
The extensions intensify the force on the implants, on the abutments screws, on the screwed or cemented prostheses and on the implant-bone interface.
An implant that has a bar with extensions applying a force shows an increase in intensity proportional to the distance between the implant and the application point with a torque moment significant range.
A restoration on several implants with extensions to which a load is applied can be considered as a class I lever in which the prosthesis extension from the last abutment represents the power arm, the last abutment acts as a fulcrum and the distance from the abutment farther from the extension end represents the resistance arm, or AP anterior posterior distance. In general, the length of the power arm divided by that of the resistance arm represents the "mechanical advantage", that is, of how much the applied force is amplified.
To design the cantilever size it is important to evaluate the relationships with the level of antero-posterior distribution of A-P SPREAD implants. AP spread is defined as the distance between the anterior implant center and a line joining the distal margins of the two most posterior implants.

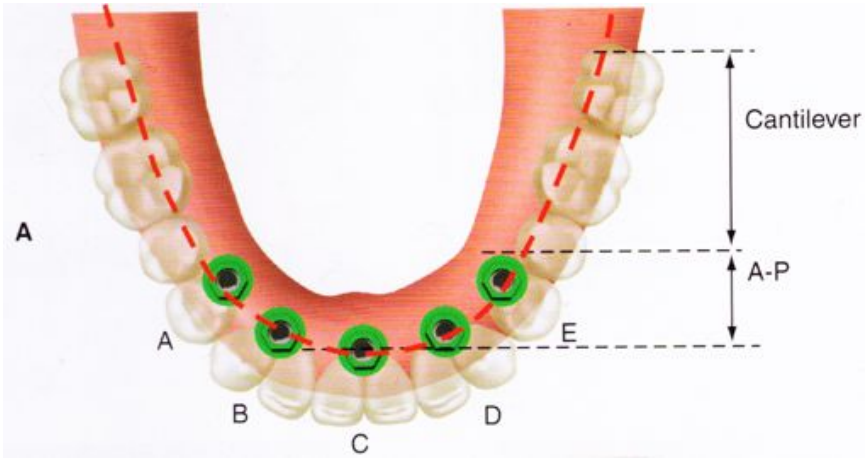


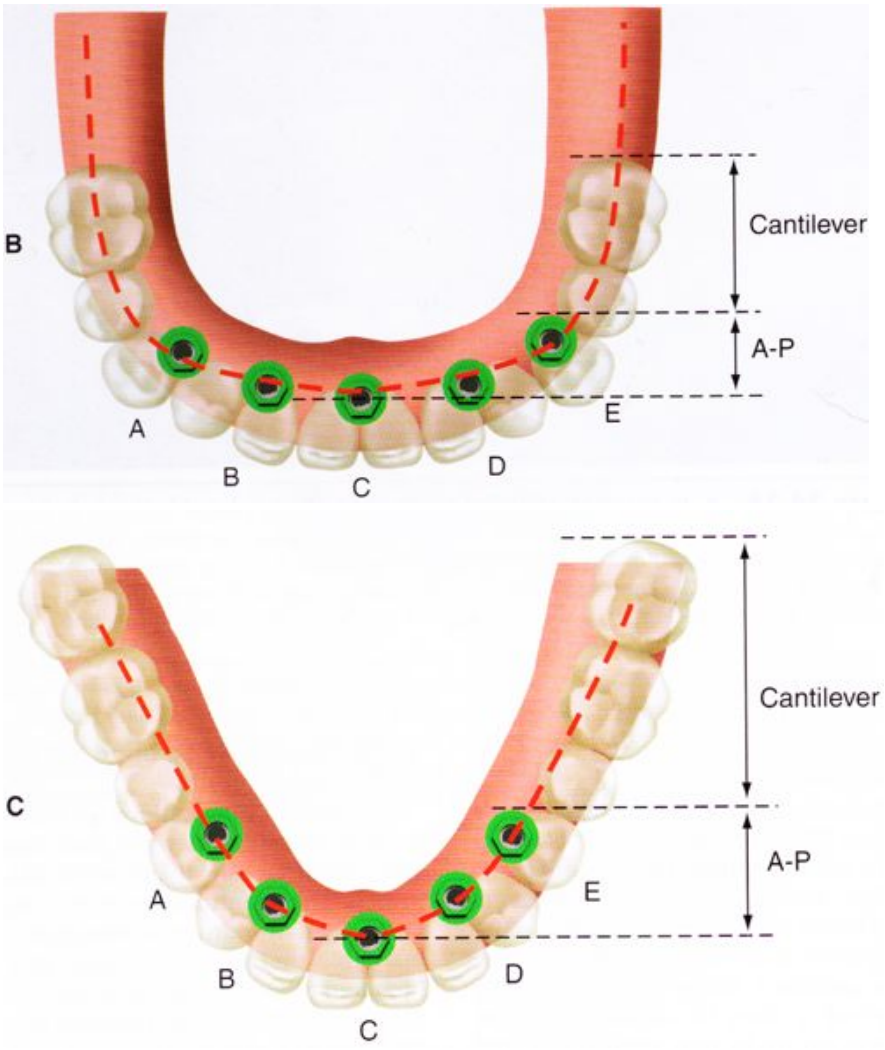
Img. By "Total Prosthesis and Overdenture on Implants. Step by Step procedures."

The masticatory forces distribution is the better the greater the size of the A-P spread.

A-Pspread is influenced by the arch shape: a triangular or V shape often has a favorable A-P spread (even greater than 8 mm) while a square or U shape is usually unfavorable (2-5 mm)

Figure 5 relationship between A-P spread and cantilever in arcate with shape: A ovoidale, square B, triangular C (Misch 2002).





Images By " Total Prosthesis and Overdenture on Implants. Step by Step procedures."

ANALYTICAL STUDY

BONE-LEVEL CONICAL DENTAL IMPLANTS: EVALUATION OF THE PREDISPOSING FACTORS RESPONSIBLE FOR THE MARGINAL BONE LOSS.

Introduction

The dentistry branch that deals with rehabilitating the patient function and aesthetics through the dental implants use is known as implantology. The importance of implant osseointegration was internationally accepted in 1982, the year in which Per-Ingmar Brånemark's discovery was celebrated. Following this success, the study on the possibility that dental implants obtain a bone tissue excellent response in which they are inserted in order to ensure osseoingration, maintain it over time and thus give rise to clinical success, was investigated.

The first stage of healing around the implant surface is based on the adhesive macromolecules absorption such as glycosaminoglycans, albumin and fibronectin [72]. Immediately afterwards, platelet adhesion takes place on the implant surface, with the growth factors release, osteoblasts mobilization, osteoid tissue formation and mineralized tissue deposition [73;74]. Titanium has an excellent physical property to make this process happen conveniently, moreover, it has a high resistance to compression and torsion forces, a low modulus of elasticity and a high resistance to corrosion [75].

The implant loading definition is defined as the moment in which the implant receives the prosthesis that will be subjected to the functional masticatory load. For this reason, two different load protocols are distinguished by referring to the concrete period that elapses between the implant location up to its subsequent loading. In the Brånemark study, an average wait of 4-6 months was recommended, to allow proper osseointegration, before subjecting the implant to loading.

The technology evolution in the last 10 years has made it possible to shorten this waiting period, thanks to modifications to the classic titanium implant surface, helping to improve the peri-implant bone cellular response, increasing clinical success [76] these surface modifications include the change in wettability, roughness, surface tension and chemical characteristics that determine the change in the surrounding cellular response [77].

Despite the successes achieved with the implant surfaces modifications with regard to the response and engraftment of the surrounding bone tissue cells which have ensured the implant osseointegration stability over time; the presence of peri-implant bone resorption remains at the implant-abutment connection level, which leads with high probability to the risk of mucositis and peri-implantitis [78]. Numerous retrospective studies have shown that during the first year of functioalization, implants undergo marginal bone loss ranging from 0.9mm to 1.6mm. Starting from the first, bone resorption is considerably reduced so that a bone loss about 0.1 mm is considered physiological each year [79]. But subsequently this affirmation was questioned up to asserting that no marginal bone loss greater than 0.00 mm should be considered acceptable, and that a bone loss in the first semester greater than 0.44 mm / year is linked to a future peri-implantitis [80].
The cause of marginal bone loss has been attributed over the years to mechanical factors, such as masticatory forces, and to microbiological factors, such as the Gram-negative anaerobes bacterial invasion in the implant micro-gap connection with the ubutment. One of the first widely used fixture-abutment connections presented an external hexagonal antirotational design, introduced by Branmark, the 0.7mm high hexagon. Subsequently, other anti-rotation mechanisms were introduced that had internal hexagon connection profiles, internal octagon, external octagon, conical with conomorse technology. Each of the connections subsequently offered on the market were proposed as the ultimate goal to improve the implant seal in order to obtain a perfect fit between the two surfaces in contact, in such a way as to prevent the bacteria passage and sedimentation and, in addition, to reach, the maximum homogeneity of load forces distribution on the implant axis. Fulfilling these criteria, marginal bone loss would be reduced to 0.00 mm, obviously by performing a correct surgical (operator-dependent) in healthy and correct oral hygiene (patient-dependent).

For everything previously described, it was decided to perform a long-term retrospective study on a sample of 420 patients rehabilitated with "bone level" implants with conical connection, treated in a practice of faculty from school of dentistry, Granada (Spain). Therefore, the following retrospective study is aimed at carrying out an analytical study with a 5-year follow-up, performed between 2008 and 2019, which measures perimplantal marginal bone loss in a sample of patients with dental implants with conical morse cone connection.

Objectives

1. To analyze the clinical and radiographic success at 5 years of "bone level" implants with fixture-abutment interface presenting cone morse design under load.

2. Evaluate the marginal bone resorption dynamics, measuring the level change from the implant insertion moment up to 5 years passing through the prosthetic load.

3. To value the influence of other clinical factors depending on the implant site or the patient.

Novelty of the study

Will analyze the clinical and radiographic success at 5 years of "bone level" implants with fixture-abutment interface presenting cono morse design under load. The first will evaluate marginal bone resorption dynamics during 5 years of implant function. Furthermore, the influence of other clinical factors depending on the implant site or thepatient will be identified.

Ethical requirements:

The research ethics commission of the University of Granada, after the collegial evaluation of the committee in plenary session, which states that the proposed

research respects the principles established by international and national legislation in the field of biomedicine, biotechnology and bioethics, as well as the rights derived from the protection of personal data. It issues a favorable report in relation to the research entitled: “Bone-level conical dental implants: evaluation of the predisposing factors responsible of the Marginal Bone Loss.”
with NIF 26.211.833-K, being registered with the number. 487 / CEIH / 2018.
The protocol was developed in accordance with the World Medical Association's Helsinki Declaration and the Guide to Clinical Research for Medical Devices for Human Beings.

Materials and methods

A retrospective analytical study was conducted on a sample of 1532 patients treated between 2008 and 2019 at the University Dentistry of Granada; 498 patients with systemic immune disorders or those treated with therapies that could interfere with bone maintenance and health were discarded; of the remaining 1034, all those who did not have sufficient radiographic follow-up for the next 5 years after implant placement were deemed unsuitable for lack of presentation at the control visit or for difficulty in finding images related to problems in the software, the latter amounted to 614. in conclusion, the study was conducted on 420 patients rehabilitated with dental implants with conical connection at bone level and marginal peri-implant bone reabsorption was assessed by measuring changes at the mesial and distal levels at the time of positioning of the implant, after 1,2,3,4 and 5 years, passing through the positioning of the crown. Several radiographs were performed during the 5-year follow-up, minimum one every year, to assess the level of circumferential bone resorption in the implant loaded. Furthermore, other clinical variables of non-negligible relevance have been recorded, such as sex, the cause of the loss of the dental element, the Kennedy class for partial edentulism (some tooth) , the marginal bone loss of the neighboring dental elements, the distance between the tooth and the implant, implant-implant distance, the location of the implant, diameter and length of the implant and height of the abutment.

Selection criteria

Criteria of inclusion and exclusion of the study were:

1. Inclusion

a) Patient> 18 and <75 years;
b) Lack of dental elements class of Kennedy I, II, III, IV;
c) Radiographic follow up for at least 5 years

2. Exclusion

a) Need for maxillary sinus elevation in the same session
b) Severe smoker (> 10 cigarettes / day)
c) Uncontrolled type 1 or 2 diabetes (HgA1c> 8)
d) Hematological disorders such as haemophilia or leukemia
e) Autoimmune diseases
f) Liver and kidney dysfunction
g) In cancer treatment, or after 18 months from the same
h) Oral bisphosphonates use for over 10 years
i) Intravenous bisphosphonates clinical history
j) Pregnant or lactating women

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1								Implant Placement							
2		Gender	kennedy's class	Cause of Tooth loss	Location	Diameter	Length	Date_0	T_T_0	AT_MBLd_0	PT_MBLm_0	I_AT_0	I_MBLm_0	I_PT_0	I_MBLd_0
3	R001	1	S	2	46	4,50	13,00	12/05/10	12.893	1.028	2.118	4.578	+0.838	5.792	+0.554
4	R002	1	S	3	12	3,50	11,00	11/11/09	6.010	3.661	3.547	1.393	-0.958	1.045	0.000
5			k2	3	26	4,00	13,00	09/07/14	12.324	0.000	0.000	3.135	+0.430	4.757	+0.207
6			k2	3	27	4,00	13,00	09/07/14		0.000		4.447	+0.283		+0.057
7	R003	1	k3	3	24	3,50	13,00	04/06/13	5.572	-1.044	0.000	0.698	+0.569	1.814	+0.888
8			k3	3	25	3,50	11,00	04/06/13	6.219	+4.406	0,000	1.947	+0.227	1.295	+0.419
9	R004	1	S	1	43	3,50	9,00	29/09/14	7.875	-3.125	-1.132	2.250	0,000	2.500	0,000
10	R005	1	K3	1	46	4,50	11,00	05/10/09	13.805		-1.346	4.666	0.000	5.194	+1.251
11			K3	1	45	3,50	9,00	19/01/10	9.573	1.487	0.744	2.883	0,000	2.887	0,000
12	R006	2	K3	1	15	4,50	13,00	28/03/11	7.924	2.075	0,000	0.685	+2.349	2.648	.+1.111
13			K3	1	16	4,50	13,00	28/03/11	7.629	0,000	0,000	2.648	,+1.142	0.782	0,000
14			K3	1	17	5,00	15,00	28/03/11	8.833	0,000	-4.420	0.782	0,000	2.803	0,000
15	R007	1	K3	3	35	4,00	11,00	29/12/08	12.428	-3.674	0,000	1.945	+0.721	5.944	+0.452
16			K3	2	36	4,00	11,00	29/12/08	13.509	0,000	0,000	5.944	+0.557	3.352	+0.419
17			K3	1	37	3,50	11,00	29/12/08	15.722	0,000	-1.896	3.352	+0.300	7.102	+0.437
18	R008	2	K3	1	14	4,50	13,00	09/06/11	18.867	0,000	0,000	1.860	+0.185	12.046	+0.299
19	R009	1	K4	2	11	5,00	15,00	25/01/10	13.253	+4.469	-1.943	7.101	+0.633	1.266	+0.416
20			K4	1	22	5,00	15,00	25/01/10	14.278	0,000	0,000	7.382	+0.703	1.654	+0.416
21			K2	2	25	4,00	13,00	13/10/09	7.613	0,000	0,000	0.869	+0.290	2.870	+0.390
22			K2	1	26	4,00	13,00	13/10/09	12.524	0,000	0,000	2.870	+0.455	5.479	+0.432
23			K2	1	27	4,00	13,00	13/10/09		0,000		5.479	+0.538		+0.626
24			K3	2	15	4,50	13,00	10/11/09	7.430	4.050	0,000	1.130	+0.539	1.575	+0.538
25			K3	1	16	4,50	11,00	10/11/09	9.785	0,000	0,000	1.575	+0.416	2.701	+0.290
26			K3	1	17	4,50	11,00	10/11/09	12.034	0,000	3.601	2.701	+0.381	4.612	+0.475

Here we can see the table Excel where the data and the relative mirurations performed at each follow up were collected. specifically, in the table we see the measurements made at the implant placement.

Clinical procedure

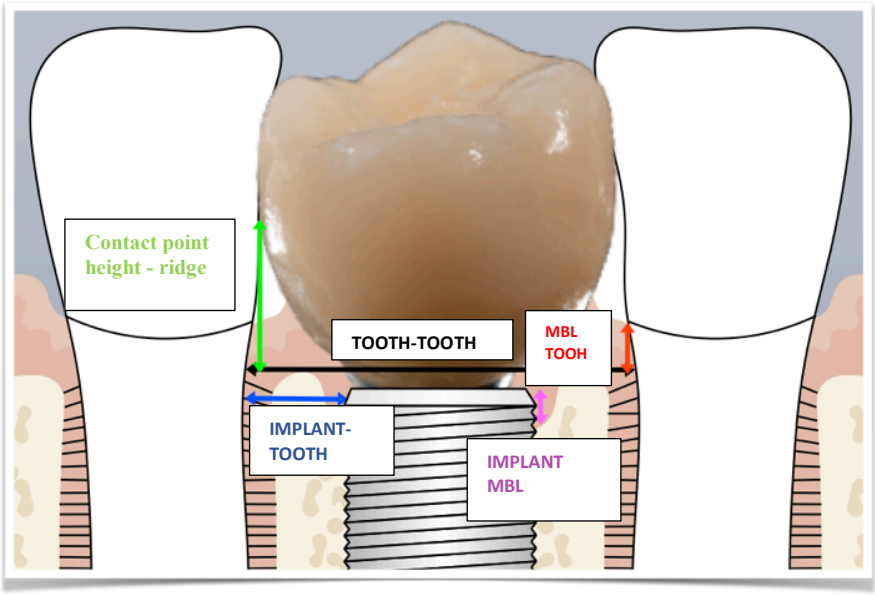
Data were collected for each patient such as: gender, type of edentulism, in relation to the kennedy classes, implant site, diameter and height of the same, date of each radiographic survey carried out during the follow-up, starting from the implant positioning going through the prosthetic load up to the last check recorded at 5 years. During the first visit to each patient, a complete history was taken, as well as a radiological examination (orthopantomography) of the study area. After screening, the implant was placed in the space determined during the second visit. The patient was summoned respectively to two or three months for the impression of precision. At this point, the crowns were made and subsequently delivered about 12-14 days later. From this moment, the expected clinical and radiographic data will be collected at each subsequent follow-up visit.

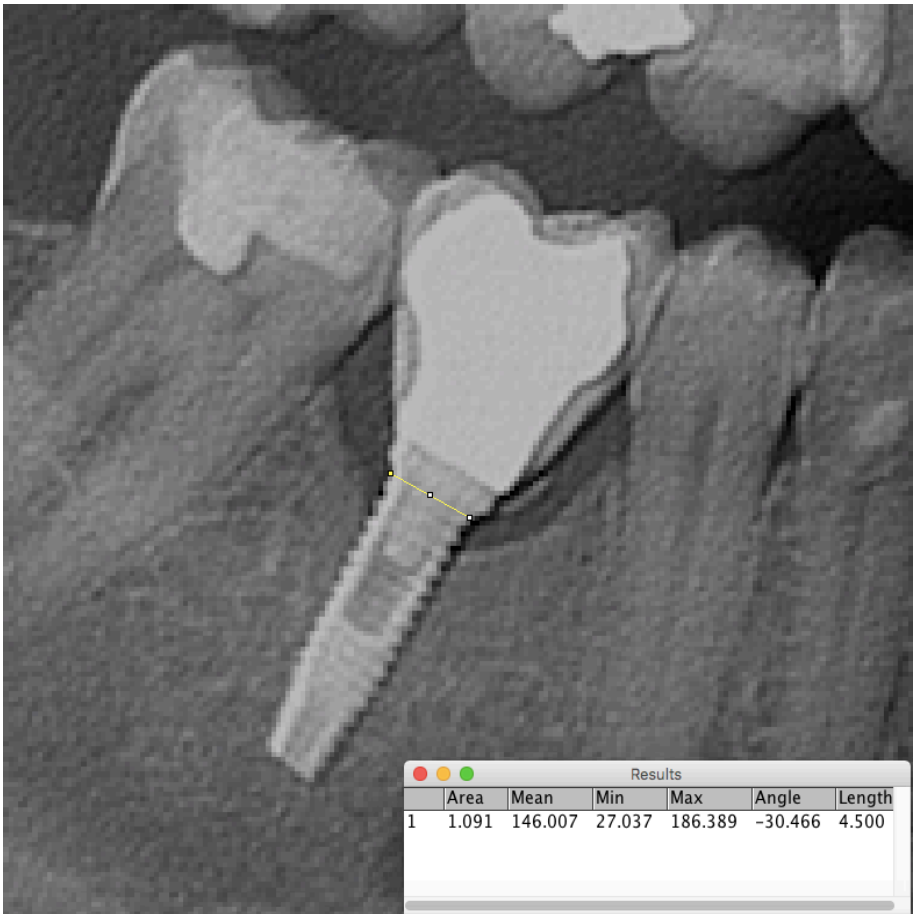
Clinical and radiographic examination: data collection.

Standardized digital panoramic x-rays (Kodak ACR-2000; Eastman Kodak Company, Rochester, NY, USA) obtained during treatment planning, after implant

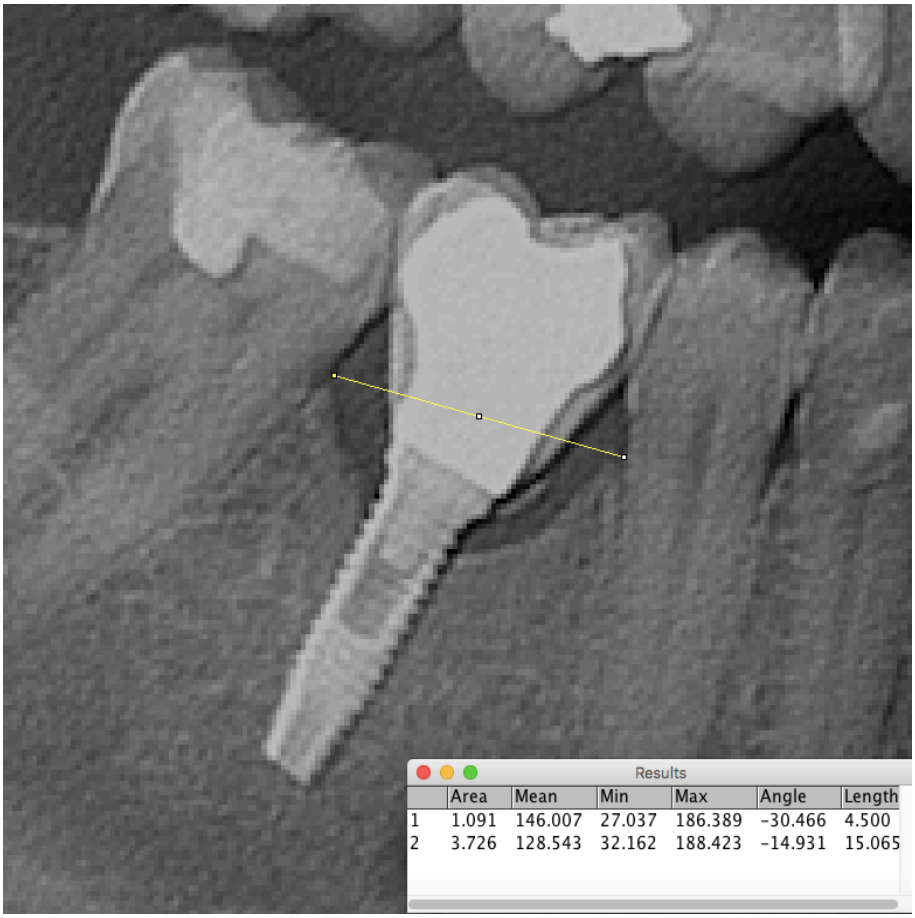
surgery (basal), at the final delivery of the restoration (5 months after implantation), and at 1 2 3 4 and 5 years after functional loading, they were exported to a software program for further analysis (IMAGE "J"). The MBL was determined from linear measurements selected by an independent examiner calibrated on each panoramic radiogram from the most mesial and distal point of the platform connected to the crestal bone. The aggrandizement of the orthopantomographs was corrected using the clinical data (length and width) for each implant. Each linear measurement corresponding to the MBL was calibrated and recalculated based on the size of the radiographic image using a simple mathematical calculation.The use of panoramic radiographic techniques could be considered a limitation, although they have been validated for this type of study [81;82]. New technologies, such as conical beam computed tomography, offer greater precision in MBL radiographic measurements and the possibility of performing three-dimensional analysis. However, it was excluded for this study to avoid multiple exposures of patients to radiation, as requested by our institution's ethics committee. Furthermore, periapical radiographs have also been described as the ideal technique to measure peri-implant MBL [83], the limited standardization of intraoral radiographic techniques for the jaw indicates that a bisector technique should be used, reducing reproducibility of sequential radiographic images. On the contrary, panoramic radiographs are performed using a repetitive standardized parallel technique, facilitating the reproducibility of radiological analyzes.
Follow-up data collection was obtained by measuring the OPTs with the “Image J” program, calibrating each image according to the known implant diameter.
The following data were collected:

- Mesio-distal distance of the edentulous space, at the level of the bone crest.
- Shoulder height of the implant - mesial crest.
- Contact point height - mesial ridge.
- Shoulder height of the implant - distal ridge.
- Contact point height - distal ridge.
- Implant distance - adjacent mesial tooth at bone crest level.
- Implant distance - adjacent distal tooth at bone crest level.
- Height attachment loss of the mesial tooth distal wall.
- Height attachment loss of the distal tooth mesial wall.
- Abutment height.

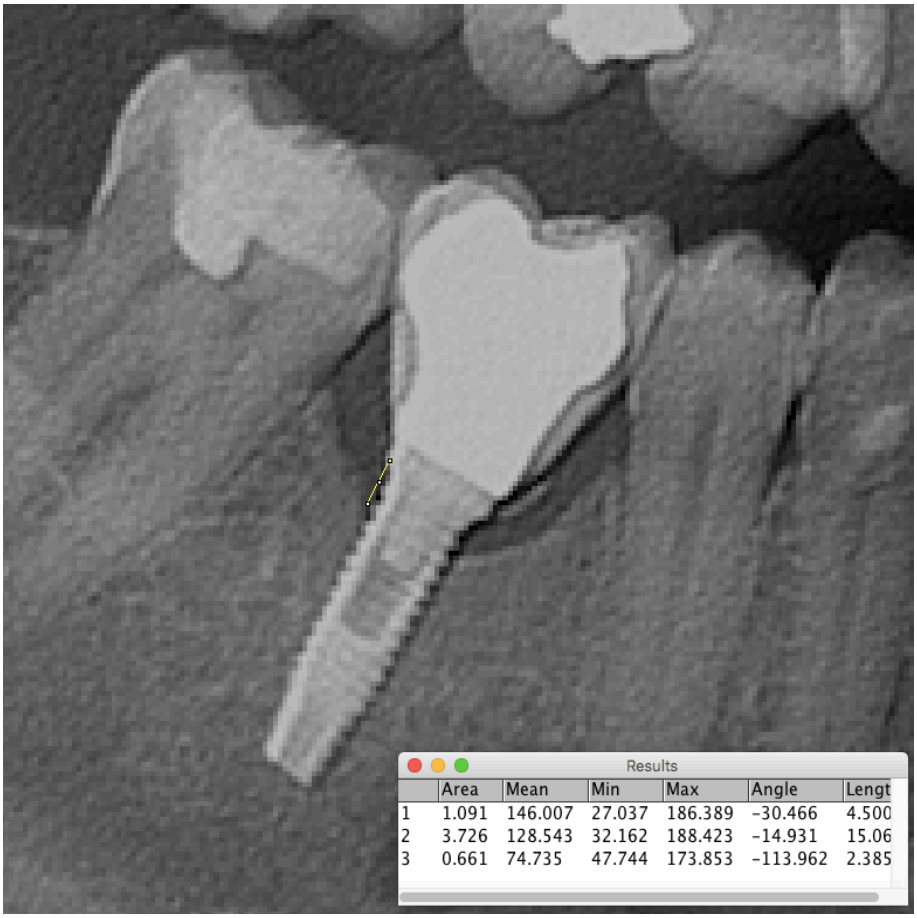




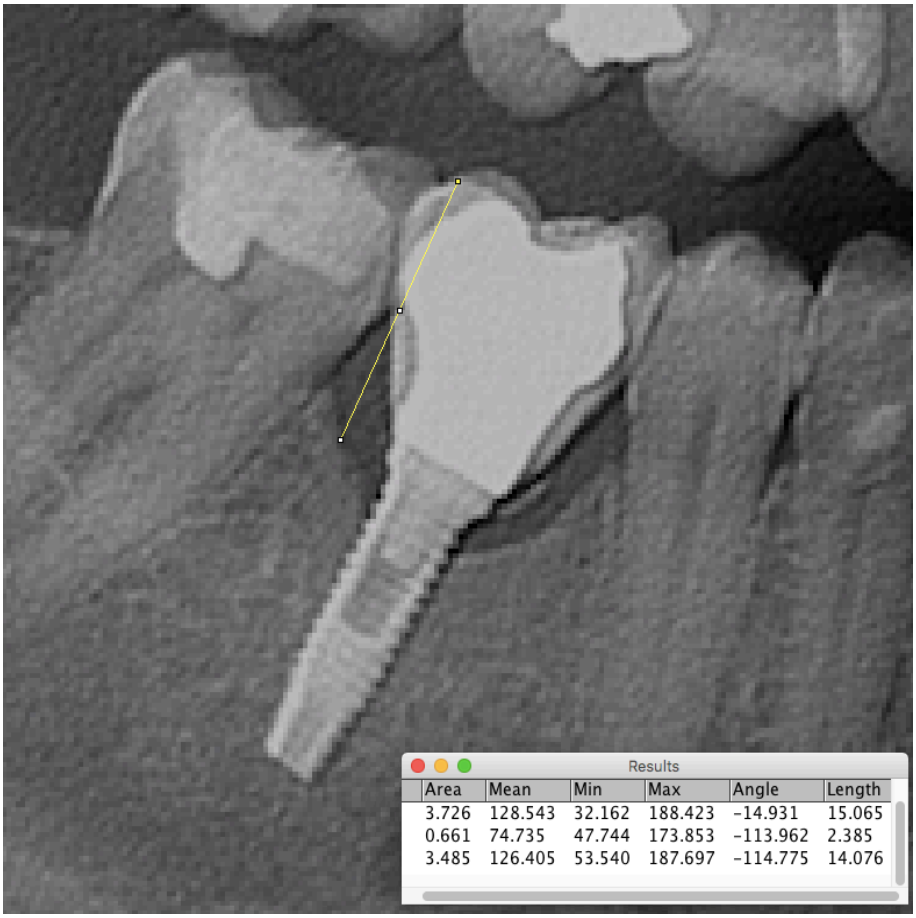
The set scale is set on the know distance of the implant diameter (4,50 mm)



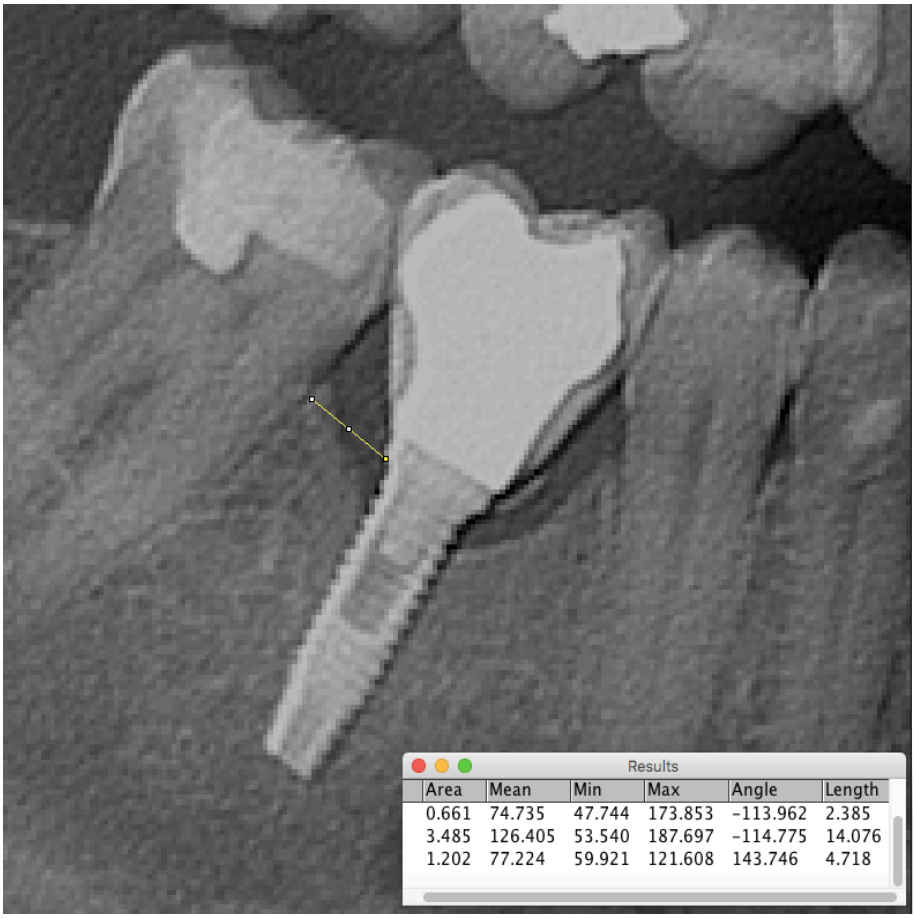
Elaboration by mathematical calculation of the tooth-tooth distance (15.065 mm)



Elaboration by mathematical calculation of I_MBL_d (-2.385 mm)



Elaboration by mathematical calculation of Co-Cr_d (14.076 mm)



Elaboration by mathematical calculation of I_Td distance (4.718)

Discussion and Statistical procedure

Statistical analysis: establishing a statistical significance of $p < 0.005$. According to each type of variable, percentage, average, standard deviation and error are calculated. A linear regression econometric model was used to test the significance of each variable on: I_MBL and A_P_T_MBL. The analysis, therefore, focuses mainly on a qualitative aspect of the significance rather than the estimation of the quantitative impact. Two models have been estimated: I_MBL and A_P_T_MBL. The F test and the confidence interval were used and in case of discrepancy, between two tests, in the estimation of variables significance the confidance interval was preferred, given the limited number of observations. The results are reported below in tables 1-6 togheter with the descriptive statistics of the main variables.

807 implants of 237 patients were analyzed (excluding those in which a unitary rehabilitation was performed and the abutment height was always 1mm but the computer did not detect it as marked with the letter "u"). leaving out this gap that limits the study because due to these missing data concerning the rehabilitations of single implants we have a known error of 183 patients rehabilitated with crown on abutments of height 1mm. We could then repeat or deepen the study by evaluating only the rehabilitated implants with crowns supported by abuntment of a height of 1 mm to analyze the percentage of marginal bone loss and compare it with that already obtained in this study. For all the other implants returned to the study, the Marginal Bone Loss (MBL) was first of all referred to the measurement taken immediately after the surgery, which was then used as an MBL zero point. So, following "Berglund", we classified the MBL as 0 (less than 0.5), -1 (1 to 0.5 mm), -2 (1.5 to 1 mm), -3 (from 2 at 1.5), -4 (From 2 to 3), -5 (from 3 to 4), -6 (from 4 to 6) and -7 (> 6).

Linear mixed model

The linear mixed model was used to test for the effects of the variables of interest, Time from loading, Teeth quadrant (upper left/right, lower left/right), Kennedy class, Loss cause, implant length, implant diameter, implant abutment, while controlling for teeth-teeth distance, Co-Cr distance, distance of the implant to the anterior/posterior teeth. Following the Schwartz Bayesian Information Criterion (BIC), the best covariance structure was autoregressive, AR(1).
A preliminary analysis showed no first order interactions between the factors. Thus, we modeled only main effects.

IMPLANT MARGINAL BONE LOSS

Type III[a] fixed effects tests

Origin	df of numerator	df of denominator	F	Sig.
Intersection	1	1580,121	4,116	,043
MesialDistal	1	2695,085	,001	,971
Time from Surgery	1	2765,733	83,475	,000
Kennedy	1	762,877	3,266	,071
CauseLoss	2	4299,953	1,914	,148
Length	8	4406,129	5,790	,000
Abutment	4	3295,965	6,909	,000
T_T	1	1917,373	1,013	,314
Co_Cr	1	3163,702	10,065	,002
I_AP_T	1	4826,606	70,010	,000
Locateeth	3	4156,684	9,505	,000

Variable dependent: I_MBL. In this table are examined all the variables that can have a effects on the MBL, the degrees of freedom of the numerator and the denominator, the values obtained with the F test and those obtained with the confidence interval. Time from surgery slope was -0.000118 ($p<0.001$), which indicate that, as expected the larger time elapsed from surgery the larger MBL.

Form the regression analysis emerges that the main effects of Time from Surgery, implant length, Abutment height, and the covariates Co-Cr distance, Implant-Teeth distance, and Teeth Location (all $p<0.001$). These results confim prevois estimates and therefore give more support to the existing literarture. In the following tables we repor the main descriptive statisitics.

2. Length[a]

Length	Media	Desv. Error	gl	95% Confidence Interval	
				Lower limit	Upper límit
6,0	-,120[b]	,081	2139,963	-,278	,038
9,0	-,145[b]	,036	740,167	-,216	-,075
11,0	-,155[b]	,030	440,166	-,215	-,096
13,0	-,110[b]	,033	579,153	-,175	-,045
15,0	-,203[b]	,036	727,934	-,274	-,132

Length variables: Average, standard deviation and degrees of freedom for each implants length were calculated. the confidence interval values obtained do not show any significant impact on the effect that the various lengths have on the MBL; but positive values were found for short implants.

3. Abutment[a]

Abutment	Media	Desv. Error	df	95% Confidence Interval	
				Lower limit	Upper limit
0,5	-,367[b]	,069	1953,482	-,503	-,232
1,0	-,147[b]	,051	1882,210	-,247	-,048
2,0	-,112[b]	,048	1772,203	-,207	-,017
4,0	-,218[b]	,057	2091,240	-,329	-,107
6,0	-,132[b]	,079	2902,219	-,286	,023

Larger abutments are associated to less MBL. The various abutments heigts were evaluated. Have been calculated: the average, standard deviation and degree of freedom. The most significant confidence interval is found for higher abutments (0,023)

4. Teeth Location

Locateeth	Media	Desv. Error	df	95% Confidence Interval	
				Lower limit	Upper límit
1	-,212[b]	,051	2070,174	-,311	-,112
2	-,226[b]	,052	2144,218	-,327	-,124
3	-,103[b]	,053	1942,038	-,208	,001
4	-,241[b]	,053	1894,863	-,345	-,136

Less MBL was observed in lower left quadrant. The location of teeth was evaluated. Have been calculated: the average, standard deviation and degree of freedom. The most significant confidence interval is found for the elements located in third quadrant (0,001)

TEETH (ANTERIOR/POSTERIOR) MBL

The same linear mixed model was applied, but we included also the first order interactions of the anterior/posterior factor with the remaining factors.

Type III[a] fixed effects tests

Origin	df of numerator	df of denumerator	F	Sig.
Intersection	1	407,357	,009	,924
MesialDistal	1	4359,832	,209	,647
Meas_Time	1	3233,894	1,517	,218
Kennedy	1	2140,691	,114	,736
CauseLoss	2	5588,005	,919	,399
Length	8	4667,317	1,804	,071
Abutment	4	4976,102	6,193	,000
T_T	1	2130,835	1,963	,161
Co_Cr	1	4683,214	1,461	,227
I_AP_T	1	4604,458	528,106	,000
Locateeth	3	3897,066	1,227	,298
MesialDistal * Locateeth	3	3473,164	5,933	,000
MesialDistal * CauseLoss	2	4394,653	4,714	,009
MesialDistal * Length	8	4560,391	1,706	,092
MesialDistal * Abutment	4	3963,197	7,811	,000
MesialDistal * Meas_Time	1	3240,842	,017	,896
MesialDistal * I_AP_T	1	4428,472	121,538	,000
MesialDistal * T_T	1	4245,873	872,716	,000
MesialDistal * Co_Cr	1	3604,021	,040	,842
MesialDistal * Gender	2	349,843	,613	,542

a. Dependent variable: A_P_T_MBL. In this table are examined all the variables that can have a effects on the A_P_T_MBL, the degrees of freedom of the numerator and the denominator, the values obtained with the F test and those obtained with the confidence interval. The variables with the most significant confidence interval on the A_P_T_MBL were: the height of the abutments, the implant tooth distance, the localization of the tooth and the tooth-tooth distance. both for the anterior and the posterior sector. Here MesialDistal stands for Anterior/Posterior Teeth.

Main effects of abutment height, Implant-Teeth distance, Anterior/Posterior teeth interacted with location of the teeth, the cause of the teeth loss, the abutment height, the implant-teeth distance, and the Teeth-Teeth distance.
The slope of the I-Teeth distance was 1.421, $p<0.001$), which suggest that the larger the distance the lower the MBL (in average, i.e.: not taking into account the anterior/posterior factor).
The slope of the Implant-Teeth distance to MBL was larger for the anterior than for the posterior teeth (2.245, $p<0.001$), but was lower for the anterior than for the posterior teeth in the case of the T-T distance (-2.995, $p<0.001$).

The variable with the greatest impact is the height of the abutment, of which we report the table

3. Abutment[a]

				95% Confidence Interval	
Abutment	Media	Desv. Error	df	Lower limit	Upper límit
,5	-,077[b]	,080	1777,003	-,234	,079
1,0	-,001[b]	,062	1102,275	-,123	,121
2,0	-,125[b]	,060	993,906	-,242	-,008
4,0	,005[b]	,068	1351,010	-,128	,137
6,0	-,075[b]	,091	2602,429	-,253	,103

Abutment variables: Average, standard deviation and degrees of freedom were calculated for each of the abutment heights. The confidence interval obtained shows that short abutments have a significant effect on A_P_T_MBL

All the estimated values were obtained through measurements, in turn carried out by two different observers The distribution by gender was 57.143% females, 42.857 males.

The observer agreement was calculated using the Pearson correlation coefficient for distance and marginal loss measurements. The quadratic averages of the differences in the measurements between the two observers were also calculated to estimate the average measurement error. The results were:

Variable	r	MSE
T_T	0.98	0.058
AT_MBLd	0.52	0.131
PT_MBLm	0.44	0.119
I_AT	0.98	0.044
I_MBLm	0.76	0.042
Co_Crm	0.85	0.071
I_PT	0.98	0.033
I_MBLd	0.86	0.033
Co_Crd	0.3	0.276

where r is the correlation coefficient, MSE the quadratic mean of the differences between observers, TT is the tooth-tooth distance, AT_MBLd and PT_MBLdm are the marginal losses in anterior (AT) and posterior (PT) teeth, I_MBLm and I_MBLd are the losses Implant margins from mesial and distal, I-AT and I-PT are the distances from the implant to the anterior and posterior teeth, Co-Crm and Co-Crd are the Corona-Crest distances from mesial and distal.

As you can see, the agreement between the observers is from high to very high in the distances, except Co-Crd, medium-high in the marginal losses of the implant and low or very low in marginal tooth losses (0.52 and 0, 44, with average errors 0.13 and 0.12 mm). The case of Co-Crd is particularly negative, given that with an agreement of 0.3, the average error is 0.276 mm.

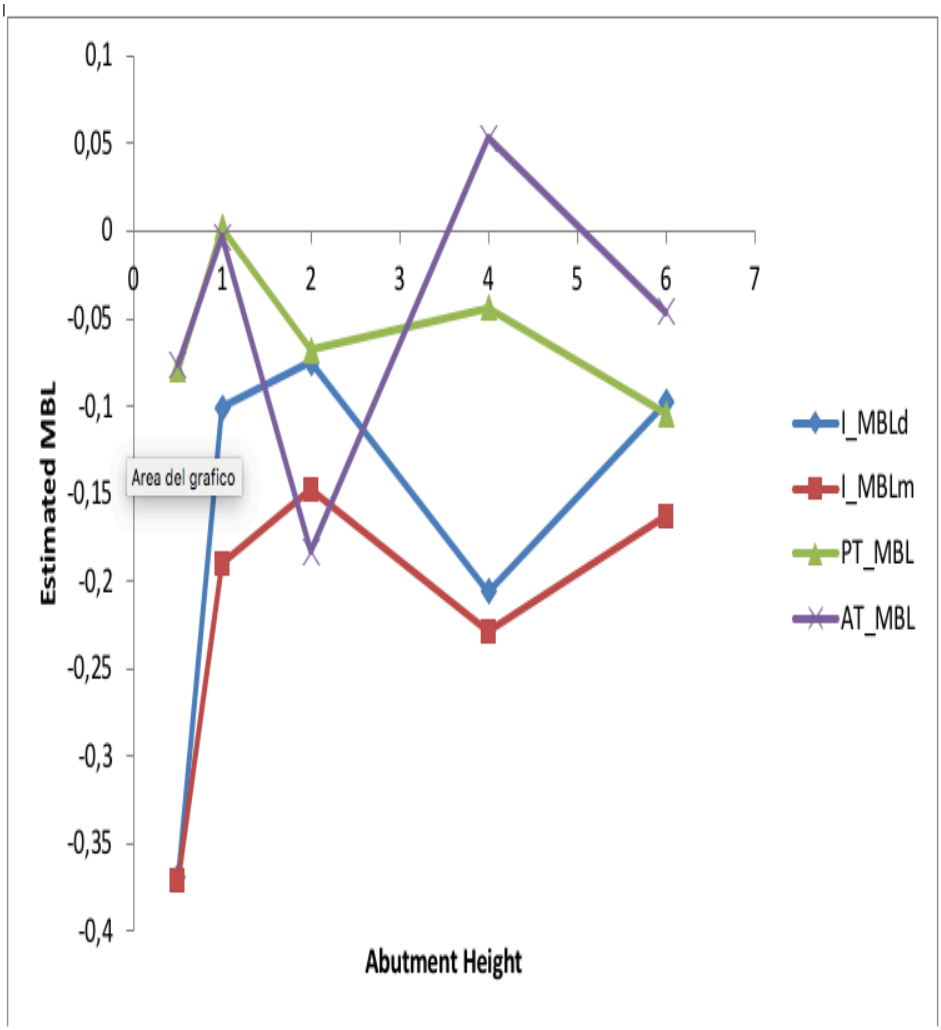
In this situation, it should be noted that the conclusions may be relatively valid regarding the marginal losses of the implant and the distances, but they are not reliable in the case of marginal tooth losses. Below we describe the other main variables.

As for the abutments, the estimated data are these:

Abutment	n im-plants	Variable	n im-plants	SE	MBL
0.5	41	I_MBLm	41	0.084413	-0.371
0.5	41	I_MBLd	41	0.084554	-0.369
0.5	41	AT_MBL	41	0.092281	-0.076
0.5	41	PT_MBL	41	0.092308	-0.079
1	221	I_MBLm	221	0.064114	-0.19
1	221	I_MBLd	221	0.064151	-0.101
1	221	AT_MBL	221	0.073515	-0.003
1	221	PT_MBL	221	0.073525	0.002
2	434	I_MBLm	434	0.061477	-0.148
2	434	I_MBLd	434	0.061488	-0.075
2	434	AT_MBL	434	0.070874	-0.183
2	434	PT_MBL	434	0.070989	-0.068
4	88	I_MBLm	88	0.070581	-0.229
4	88	I_MBLd	88	0.070261	-0.206
4	88	AT_MBL	88	0.078668	0.053
4	88	PT_MBL	88	0.078556	-0.044
6	23	I_MBLm	23	0.097178	-0.163
6	23	I_MBLd	23	0.097077	-0.098
6	23	AT_MBL	23	0.10539	-0.046
6	23	PT_MBL	23	0.10541	-0.104

SE is the typical error, MBL is the estimated average marginal loss.
the lesser I_MBL averages were obtained with 2mm and 6MM abutments, but those most used were those with 2mm height

Here a graph (without typical error to not hide the result)



In the graph we can observe the estimate of the MBL in relation to the height of the abutmen. The higher levels of MBL are related to the use of short abutments (0.5mm)

And here a table of the MBL averages with the untransformed measurements (with the original data):

Abutment	Variable	n im-plants	Surgery	T1	T2	T3	T4	T5
0.5	I_MBLm	41	0.000	-0.081	-0.081	-0.170	-0.194	-0.222
0.5	I_MBLd	41	0.000	-0.086	-0.086	-0.309	-0.343	-0.378
0.5	AT_MBL	41	-0.696	-0.696	-0.696	-0.696	-0.696	-0.696
0.5	PT_MBL	41	-0.852	-0.852	-0.852	-0.852	-0.852	-0.852
1	I_MBLm	221	-0.058	-0.502	-0.502	-1.098	-2.021	-2.044
1	I_MBLd	221	-0.035	-0.401	-0.401	-1.052	-1.072	-1.195
1	AT_MBL	221	-0.458	-0.502	-0.502	-0.533	-0.533	-0.533
1	PT_MBL	221	-0.185	-0.265	-0.265	-0.268	-0.268	-0.268
2	I_MBLm	434	0.005	0.000	0.000	-0.047	-0.055	-0.070
2	I_MBLd	434	0.003	0.000	0.000	-0.046	-0.056	-0.067
2	AT_MBL	434	-0.321	-0.440	-0.450	-0.481	-0.471	-0.471
2	PT_MBL	434	-0.325	-0.352	-0.359	-0.363	-0.357	-0.355
4	I_MBLm	88	0.033	-0.012	-0.012	-0.132	-0.137	-0.147
4	I_MBLd	88	0.022	-0.020	-0.020	-0.048	-0.054	-0.062
4	AT_MBL	88	-0.095	-0.154	-0.154	-0.154	-0.154	-0.154
4	PT_MBL	88	-0.032	-0.136	-0.136	-0.136	-0.136	-0.136
6	I_MBLm	23	0.000	0.000	0.000	0.000	0.000	0.000
6	I_MBLd	23	0.000	0.000	0.000	0.000	0.000	0.000
6	AT_MBL	23	-0.525	-0.525	-0.525	-0.525	-0.525	-0.525
6	PT_MBL	23	-0.181	-0.181	-0.181	-0.181	-0.181	-0.181

It is clear how the I_MBLm / d values are elevated to T5 when there is a loss of over 0.502 mm / year between T1 and T2 (post-load period). The 6mm abutments report optimal values for I_MBLm / d

Here is a table (in Berglund) with the number of implants showing a marginal loss over time, according to the categories of loss:

Implant MBLd	Distal T1	T2	T3	T4	T5	Surgery
-Inf_-6	1	1	2	2	2	1
-6_-4	0	0	2	2	2	0
-4_-3	0	0	0	0	1	0
-3_-2	1	1	6	7	12	0
-2_-1.5	1	1	6	9	16	0
-1.5_-1	2	2	16	18	5	0
-1_-0.5	0	0	6	0	0	0
-0.5_0	799	799	766	767	767	802
0_0.5	0	0	0	0	0	0
0.5_1	0	0	0	0	0	0
1_1.5	0	0	0	0	0	1
1.5_2	0	0	0	0	0	1
2_3	0	0	0	0	0	0
3_4	0	0	0	0	0	0
4_6	0	0	0	0	0	0
Total general	**804**	**804**	**804**	**805**	**805**	**805**

In the majority of implants that reported an MBLm/d between 0 and 0.5 mm in T1 and T2, a low level of MBL was also found in T5, after 5 years.

Implant MBLm	Mesial T1	T2	T3	T4	T5	Surgery
-Inf_-6	1	1	3	3	3	1
-6_-4	0	0	1	2	2	0
-4_-3	1	1	2	3	4	0
-3_-2	2	2	7	6	11	2
-2_-1.5	2	2	7	14	16	0
-1.5_-1	0	0	15	10	4	0
-1_-0.5	0	0	4	2	1	0
-0.5_0	799	799	767	766	765	802
0_0.5	0	0	0	0	0	0
0.5_1	0	0	0	0	0	0
1_1.5	0	0	0	0	0	0
1.5_2	0	0	0	0	0	0
2_3	1	1	0	0	0	2
3_4	0	0	0	0	0	0
4_6	0	0	0	0	0	0
Total general	**806**	**806**	**806**	**806**	**806**	**807**

In the majority of implants that reported an MBLm/d between 0 and 0.5 mm in T1 and T2, a low level of MBL was also found in T5, after 5 years.

	Mesial						Distal					
	Surgery	T1	T2	T3	T4	T5	Surgery	T1	T2	T3	T4	T5
-Inf_-6	0.1%	0.1%	0.1%	0.4%	0.4%	0.4%	0.1%	0.1%	0.1%	0.2%	0.2%	0.2%
-6_-4	0.0%	0.0%	0.0%	0.1%	0.2%	0.2%	0.0%	0.0%	0.0%	0.2%	0.2%	0.2%
-4_-3	0.0%	0.1%	0.1%	0.2%	0.4%	0.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%
-3_-2	0.2%	0.2%	0.2%	0.9%	0.7%	1.4%	0.0%	0.1%	0.1%	0.7%	0.9%	1.5%
-2_-1.5	0.0%	0.2%	0.2%	0.9%	1.7%	2.0%	0.0%	0.1%	0.1%	0.7%	1.1%	2.0%
-1.5_-1	0.0%	0.0%	0.0%	1.9%	1.2%	0.5%	0.0%	0.2%	0.2%	2.0%	2.2%	0.6%
-1_-0.5	0.0%	0.0%	0.0%	0.5%	0.2%	0.1%	0.0%	0.0%	0.0%	0.7%	0.0%	0.0%
-0.5_0	99.4%	99.1%	99.1%	95.2%	95.0%	94.9%	99.6%	99.4%	99.4%	95.3%	95.3%	95.3%
0_0.5	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
0.5_1	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
1_1.5	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
1.5_2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
2_3	0.2%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
3_4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
4_6	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

The same result is reported in percentages. a significant percentage is observed at 5 years of all those implants that had an I_MBLm / d lower than 0.5mm in T1 and T2.

Results

Marginal bone loss rates were significantly affected by BLT, abutment and bone substratum. Bone loss rates at 5 years were associated with initial bone loss rates: 96% of implants with an MBL of >2 mm at 5 years had lost 0.502 mm or more at 1 year post-loading.

A total 237patients, including 807 implants, were enrolled in this study. The early MBL at T1 was an independent predictor variable for the marginal bone alterations that were assessed at T5 ($p < 0.001$).

MBL rates at 3 and 5 years were mainly affected by the abutment height but were also significantly influenced by the bone substratum, found a lower mean MBL for type IV bone. MBL rates were higher for prosthetic abutment < 2 mm vs. ≥ 2 mm.

Discussion.

The presence of peri-implant bone is of primary importance for the success of dental implants over time. The most used determinants to evaluate the results in implantology are related to the implant, the peri-implant soft tissue and the prosthesis, in addition to the subjective evaluation of the patient [84]. These factors are linked to the stability of the tissue, which determines the progression of marginal bone loss (MBL) around healthy implants. MBL is influenced by multiple variables related to surgical trauma [85], pros-thetic rehabilitations, typology of the implant, to the underlying bone tissue [86], vices and habits of patients [87], implant-abutment connection and the general health of the individual. Klinge defined an MBL> 2 mm after prosthesis placement compared to initial radiographs, in combination with bleeding on probing, as an alarm for the dentist.
It is also certain that the MBL depends purely on the implant characteristics and the general health conditions of the patient. Therefore it can be affirmed that, the success or failure of the implant is bonding to careful anamnesis of the patient and an evaluation of the implant characteristics, in order to obtain a favorable prognosis.
Although it is established that the MBL is caused by numerous variables, such as the type of connection, the type of bone, gender, age and periodontitis, this study emphasized that the 5-year result is highly correlated to bone loss type (BLT), the which appears different for each implant.
In the present study, MBL levels were mainly related to the implant localization, the type of abutment and the distance between tooth-tooth and implant-tooth.

A fundamental finding was that the levels of peri-implant bone loss at 5 years were associated with the initial level of bone loss. The results indicated that are more likely to occur higher T5 rates in implants with high rates between T1 and T2. Almost all implants (96.1%) with MBL> 2 mm at 5 years shown a high rate of bone loss at T2 (defined as> 0.502 mm at 6 months). These results describe that the marginal loss immediately after the restoration can indicate a clear danger for the MBL of the implants and reach a failure in the medium or long term.
As already mentioned in the Introduction, the success criteria accepted by the dental community establish 2 mm as the maximum acceptable MBL after 1 year of loading to consider an implant a success [88]. Several authors have used this radiographic criterion to define peri-implantitis. However, a general confusion

remains concerning this definition in comparison to other proposals, brought about by factors such as the measurement of the exposed implant turns.[89].

It is therefore essential to determine not only the etiological cause, but also the acceptable levels of peri-implant MBL in order to recognize health or pathology. The persistent focus is to identify the factors that influence the MBL, currently controversial, and to distinguish between physiological and pathological losses. The majority of peri-implant bone loss occurs between the connection of the abutment and the position of the crown [90;91], in support of the concept of initial loss defined by Albrektsson et al. (1986).
This theory is also supported by current results, which show that MBL levels are scarcely relevant from the surgical positioning of the implant (T0) to T1 compared to those between T2 and T3 and become more significant in the T3-T4 period. These results suggest that MBL is more related to the prosthetic phase than to the post-surgical healing and bone remodeling process.
According to other authors, the origin of MBL around endosseous implants can be biomechanical [92] or microbial [93]. It has been stated in literature that dental implants behave like natural dentition and that a process similar to periodontitis can infect implants, generating peri-implantitis.

The majority of MBL cases around implants in periodontopathic patients are not caused solely by a predisposition to the disease. Indeed, a history of periodontal disease was not significantly related to the MBL in the present study, revealing only marginal effects. In contrast, a more important MBL can initiate bacterial colonization and faster advancement of peri-implantitis; therefore, the presence of an initial lesion leads to a worst progression.
It was agreed that the 1-year peri-implant MBL is between 1.6 and 2.0 mm, but a significant decrease in implant-dependent MBL has been proposed [94;95]. Differences in the prosthetic connection for the same implant system [96] or "platform-switching" have proven to generate an evident decrease in peri-implant MBL [97].
The present study has shown that parameters such as the type of connection, the presence of platform switching, the size of the abutment and the distance between the implant teeth can modify the peri-implant MBL, reducing it extensively and that in case of a greater loss of MBL> 0.502 mm 6 months, there is a future increase in the MBL rate. Therefore, the initial MBL rates reveal a favorable or

unfavorable prognosis during the first year allowing to identify the probability of achieving MBL failure values.

Main conclusion.

In line with the objectives of the study we can state that:

1. the clinical and radiographic evaluation of the 5-year follow-up of conical bone implants showed satisfactory results. Various clinical factors that depend on the site or the patient did not significantly influence marginal bone loss. In carrying out this analytical study, some limitations were found. Being a retro-spective study, it was not possible to totally homogenize the sample, although our statistical methodology minimized this problem. We also used panoramic radio-graphy, which is less sensitive than periapical techniques for measuring MBL, but provides data on the features of the posterior maxilla that can influence the behavior of the implant (for example, the type of bone). Furthermore, periapical radiography at this location requires the use of the bisecting technique and the consequent angulation differences can alter the MBL measurements.

2. the peri-implant marginal bone loss during the first post-operative year is a predictor of bone alterations that may occur after 5 years of treatment, implants with an increase in MBL rates in the early stages (healing and post-load periods) will probably reach the MBL values which compromise the final result. The initial rates of MBL (healing, post-load) around an implant of over 0.502 mm / year are an indication of the progression of peri-implant bone loss;

3. In conclusion we can affirm that, from the analysis of the influence of each variable on the observed phenomenon, in line with the literature regarding the MBL, the fundamental variables for the success of the implant are:

    the height of the abutment, our results indicate that the choice of a shorter abutment can increase the MBL. The height of the prosthetic abutment was the variable with the greatest influence on the MBL, greater around the implants with shorter abutments. This parameter must be taken into consideration for adequate maintenance over time of the bone level around the implants.

the different types of prosthetic rehabilitation, based on the edentulous class of Kennedy I, II, III, IV, it was observed less MBL around the implants that support a fixed partial prosthesis compared to those that support an overdenture of totally edentulous patients, which can be explained by differences in load distribution and biomechanics [98].

the distance of the implant tooth, the latter does not affect marginal bone levels either at the implant level or at the tooth level. the only detail is that in this study, there was a minor marginal bone loss in the smallest spaces;

Furthermore, were not found significant difference in MBL between implants with length greater than or less than 10 mm

Clinical recommendation

On the basis of the conclusions drawn from our study, however, we can suggest as clinical recommendations to prevent the MBL from limiting bone resorption as much as possible, keeping it lower than 0.502 mm in the first post-load year, opt for the choice of higher abutments (equal or higher to 2.0mm), give preference to fixed partial rehabilitations overdenture totals, also for the rehabilitation of totally edentulous patients, maintaining a tooth-implant distance of 1,421 mm for rehabilitations in restricted spaces.
The results of the present study support the view of Papaspyridakos et al. on the need to question the widely accepted success criteria of up to 2 mm MBL at 1 year followed by a maximum of 0.2 mm annually.

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