Research Article

New Systematic Terminology of Cortical Bone Areas for Osseo-Fixated Implants in Strategic Oral Implantology

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Abstract

Immediate Loading in oral implantology requires safe cortical anchorage of the load transmitting surfaces of the implants, because even the most miraculous surface properties of dental implants alone will never lead to the possibility of immediate loading.

This article describes a new didactic approach for communicating the principles of this technology. The terminology which we propose should be used both for the purpose of denominating corticals suitable for load transmission and points of occlusion and slopes of mastication with respect to the positioning of the mentioned load transmitting areas.

We propose to use the "1-2-3 classification" for the identification of the 1st, 2nd and 3rd cortical as points of interest for positioning of the abutment (at 1st cortical) and for remote initial osseofixation (2nd or 3rd cortical) for axial basal implants in oral and maxillofacial implantology.

Furthermore, we propose to use the term "Supporting Polygon" to determine the position of occlusal contacts or masticatory slopes within or outside of a polygon drawn up by the load transmitting parts of the implants in the "2nd-" or "3rd cortical". The most significant locations at the polygon are implants on the corners or ends of it, i.e. implants in the area of the canines and the 2nd molars in both jaws. Today we name these position "strategic positions". If these positions are not equipped properly with implants, or if one or more of the implants in the strategic position is not anchored well in the 2nd and/or 3rd cortical the whole case is prone to failure [1].

Since this treatment concept completely disregards the "1st cortical" or spongious bone for the purpose of load transmission, it is suitable for axial basal implants (i.e. the concept of strategic implantology) and lateral basal implants.

Keywords: Oral Implantology; Strategic Implant®; Supporting Polygon; 1st Cortical; 2nd Cortical; 3rd Cortical; Osseofixation; Strategic Implant Position

Introduction

In traditional dental implantology there are numerous classifications available, which consider the height of the available bone and width of the alveolar ridge. Those classifications usually include the crestal (i.e. oral) cortical, the opposing cortical bone in the upper jaw and the spongious bone if present [2-4], and inform us about the limitations of implant placement by directing landmarks or guiding reconstructive procedures [5,6].

The floor of the nose cavity, the sinus in the maxilla or the mandibular canal in the distal mandible, are examples of limiting landmarks. Moreover, according to crestal implant concepts, the crestal bone should be wide enough to hold the vertical implant part in full. In basal implantology such a demand does not exist, because only the presence of the 2nd cortical is required for implant anchorage and because vertical parts of the implants may run outside of the alveolar bone for almost all of the implant length, as long as the thread is anchored in the 1st and 2nd cortical (Figure. 8). Therefore, cases with reduced alveolar bone dimensions (cases providing significant atrophy) are considered in strategic implantology not as difficult, as long as the 2nd cortical is available. We assume today that atrophied cases provide even higher chances of success, because macro-trajectorial forces through the bone, within the skeleton are (a) larger in relationship to the bone mass and hence stimulate the available bone towards developing or maintaining a higher degree of mineralization, and because (b) these forces per se prevent any further atrophy.

Treatment planning, placement and prosthetic regime for Strategic Implants® differ significantly from the traditional concepts in dental implantology. Therefore, also a novel concept of teaching and a novel terminology had to be developed to allow easy learning and precise communication between practitioners.

The Strategic Implant® functions according to the principles of traumatology and orthopedic (bone) surgery. Like in traumatology, immediate loading protocols are used [7-9]. One significant difference between traumatology and strategic implantology is found, however, in the origins of the load imposed on the bone: significant amounts of the forces, often by far the highest forces, are imposed from the opposing jaw to the implants and the splinting bridge. These forces are of occlusal and masticatory origin. This is not the case in traumatology, where almost all forces from the musculoskeletal system, the forces enter the bone through the joints and none of the forces on the bone and implant-system is directed onto the fracture plate itself and directly [10,11].

Hence in strategic implantology we have to cope with both macro-trajectorial forces which occur inside and along the bones of the maxillofacial skeleton, and in addition we have to consider and control forces which enter the bone through the fixed supra-structure, which came from the opposing jaw [12]. This novel treatment concept in oral implantology requires new terminology for teaching as well as clear communication among implantologists.

We have experienced that the concept of naming (counting up) the corticals significantly supports the rapidity of understanding for students and for implantologists who are learning the techniques.

The Strategic Implant® is anchored cortically by the surgeon, and the process of creating this anchorage has been denominated as "osseo-fixation" [13]. Secondary osseo-integration into spongious bone areas through which endosseous parts of the implants are projecting is expected to happen in any case later. However for primary stability, i.e. for the success of the treatment, the macro-mechanic anchorage (osseo-fixation) in the 2nd or 3rd cortical is decisive [14,15].

Other than in traumatology, forces on dental implants do not (only) stem from the skeleton, but mainly from the bridge. The bridge takes over the function of a fracture plate and at the same time if functions as chewing device. On this chewing device two types of forces are imposed: occlusal forces (mainly in vertical direction), as masticatory forces (stemming from lateral jaw movements under contact) of the mandible against the maxilla, along the slopes of the cusps which are installed on the bridge.

In conventional (crestal) implantology, where implants are integrated into the 1st cortical and the underlying spongious bone, it is rarely possible to mobilize already integrated (2-stage) implants after the "healing time" through wrong occlusal contacts or masticatory slopes in unfavorable angulation to the plane of the bite. Such overloaded implants would rather fracture, or their abutments, additional screws, or the bridge-work might fracture. But they will not loose osseo-integration. However, in immediate loading protocols on osseo-fixated implants the situation is different: around the osseo-fixated threads postoperative remodeling in adjacent bone areas takes place [16] and if in this very moment inadequate forces stemming from occlusion or mastication would be imposed, unwanted additional traumatic remodeling will take place and the whole implant will become mobile and will be subsequently lost. Hence meticulous prosthetic work on immediately loaded Strategic Implants® is the key to success [17]. This is true for axial basal implants (screw types) or the older lateral basal implants, e.g. BOI®. Differences in the design and usage of screwable and lateral designs are shown in Figures 9a, 9b, and Figure. 10.

Immediate splinting is one of the principal aims of traumatology. This aim is so important, because it is, e.g. for reduction of fractures unthinkable to first integrate the holding screws

into both ends of the fractured bone, and to place the fracture plate later i.e. after the healing time. Such treatment protocol would leave the patients untreated during the healing time and they would require two massive, separate interventions, while the ends of the fractures are left to a number of uncontrolled and unwanted developments. In immediate loading protocols the implants are splintend right away (i.e. within maximum 72 hours). The splinting is important, whereas the occlusal and masticatory loading is only a "side-effect". This "side-effect" is in reality the decisive point for the patient to decide for this type of treatment and not for lengthy 2-stage protocols. Splinting is usually done through fixed bridges. It makes no sense to provide the patient with fixed bars and removable dentures thereon, because this almost doubles the costs for the services of the dental laboratory. In any case, patients prefer to receive fixed super-structures.

In conventional crestal implantology a delay in treatment ("2-stage") has a long tradition. The reason is that so far knowledge about the full and elegant use of available 2nd and 3rd cortical have not yet reached broad groups of treatment providers. More qualified education is necessary to make the already active treatment providers acquaintant with new technology and to educate novices right away in the right direction. In our view, 2-stage implantology will then be limited to a few single tooth restorations in the aesthetic zone (often including bone augmentation) while the vast majority of the cases will be treated in immediate loading protocols with implants such as the Strategic Implant®.

Devices

Strategic implants are a non-homogenous group of oral implants. Their load transmission areas are positioned in resorption stable cortical areas of the mandible and the maxilla as well as the midface. The implants are osseo-fixated in the 2nd or 3rd cortical, whereas anchorage in the 1st cortical is completely missing (e.g. in extraction sockets) or minimal (in healed bone areas) until the implant undergoes later osseo-integration. Cortical anchorage and immediate primary prosthetic splinting yield enough stability for treatment in immediate loading protocol. The traditional term basal implants/basal implantology did not include the concept of the 1st, 2nd and 3rd cortical, and was used for many years only for lateral basal implants, such as the French Diskimplants®[1] and Swiss BOI®[2] [1,18].

Lateral basal implants are inserted from the lateral aspect of the jaw bone into the vestibular and lingual/palatal cortical. Although these devices (i.e. "Diskimplant®", "BOI®") served and serve well, the preferred devices for contemporary strategic implantology are screw-like basal implants, e.g. the Strategic Implants®.

[1]Diskimplant® is a French national trade mark of Victory SA, Nice, France
[2]BOI ® is a trademark of Biomed Est., Liechtenstein

Lateral basal implants are nowadays used almost exclusively in maxillofacial implantology for orbital and nasal epithesis anchorage [19,20].

Screw-like basal implants are inserted from the crest of the alveolar bone in such a way and depth, that they reach an opposing corticalis and anchor there.

Novel Terminology

1. "1-2-3" Denomination of Corticals

In our proposal for denomination all crestal corticals are denominated "1st cortical", as pointed out through the yellow arrows in Figure. 1.
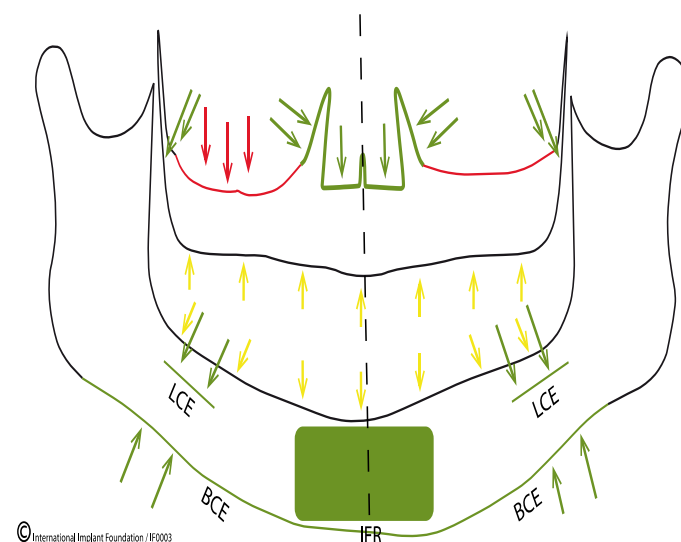

Figure 1. Schematic overview on the corticals in connection to the maxilla and the mandible. Yellow: 1st corticals.
Green arrows in mandible mark 2nd corticals. In the distal mandible both lingual cortical engagement (LCE; cross cuts are shown in Figures 9 and 10) and basal cortical engagement (BCE) are possible for screw-like strategic implants. Most patients provide a highly mineralized inter-foraminal region (IFR) which provides in most cases enough stability from inside the mandible for the implant anchorage without additional 2nd cortical engagement.
Green 2nd corticals in the maxilla: the floor of the nose, parts of the basal sinus corticals, bone of the outer distal maxilla.
Red lines: Resorption prone cortical areas of the sinus floor, having a tendency to allow "sinusal expansion".

Screwable basal implants are not root-form implants, they function differently. They are positioned in such a way into bones, that apical load transmitting threads of the implants are positioned (fixated) directly into the cortical distant (opposite) to the oral cavity. If this next cortical belongs to the same bone (i.e. the maxilla), we denominate it as "2nd" cortical. If cases when the load transmitting threads are projecting out

of the maxillary bone and are anchoring into an adjacent bone, we denominate this cortical a "3rd" cortical. Examples for true 3rd corticals are the zygomatic bone, the pterygoid plate of the sphenoid bone as well as the infra-orbital rim (Figure. 2). "3rd cortical" engagement is not possible for mandibular implants because there is no other bone available which would move synchrone to the functioning mandible.
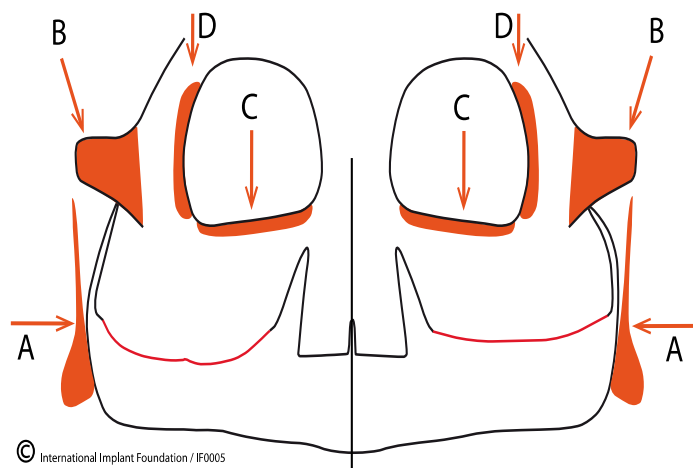

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Figure 2. Overview on 3rd corticals in the midface available for oral implant anchorage.
A: Pterygoid plate of the sphenoid bone.
B: Body of the zygomatic bone.
C: Infra-orbital rim. This region may be used for anchorage in cases with defects in the midface.
D: Lateral vestibular rim of the orbita: These areas are used for epithesis anchorage, especialy for eye replacement.

If the implant enters the upper alveolar crest and penetrates the vertical-palatal alveolar bone in order to anchor in the horizontal palatal plate, we still denominate this cortical a "2nd cortical", because it is a maxillary cortical (Figure. 3).
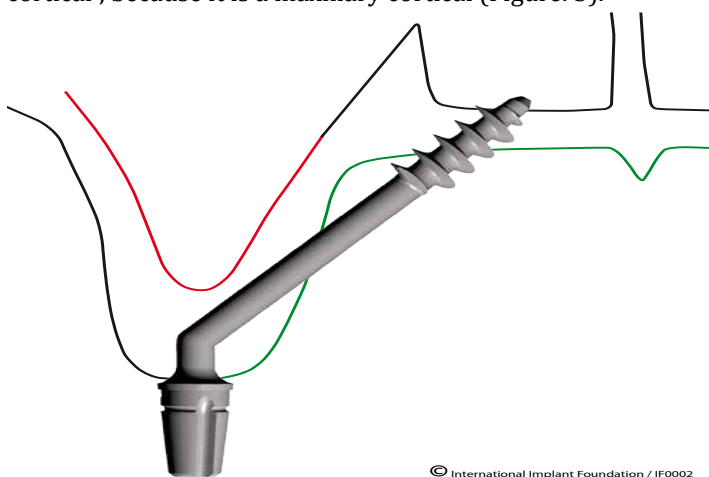

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Figure 3. In cases where the implant exits the alveolar bone of the maxilla and reaches through the soft tissue of the palate to the palate process of the maxilla (opposing cortical), the resulting engagement of the threads will be in the "2nd cortical".

Just as in maxillofacial traumatology the cortical of the maxillary sinus is used as a "2nd cortical" (Figure. 1), however we have to consider that not all of the basal cortical of the sinus is stable (red sections of the line showing parts of the sinus floor which have a tendency to remodel: this process has been named "expansion of the maxillary sinus" or "pneumatisation of the maxillary sinus").

Corticals of different bones may act together to form functionally one cortical. This spatial relationship is found in the distal maxilla at the junction between the maxilla and the pterygoid plate of the sphenoid bone (Figure. 2, Region A).

It should be considered, that remote bone areas such as the pterygoid plate of the sphenoid bone or the zygomatic bone also provide "1st" and "2nd"cortical, because bones in general are surrounded by corticalis. Anchorage in the two corticals is in almost all cases possible, however, for our purposes of planning the treatment and the "supporting polygon" we can neglect the fact that two corticals are given and utilize either one of them or both. Regardless of this, we consider this bone clinically to have one cortical, and we denominate this in our system of terminology as the "3rd cortical".
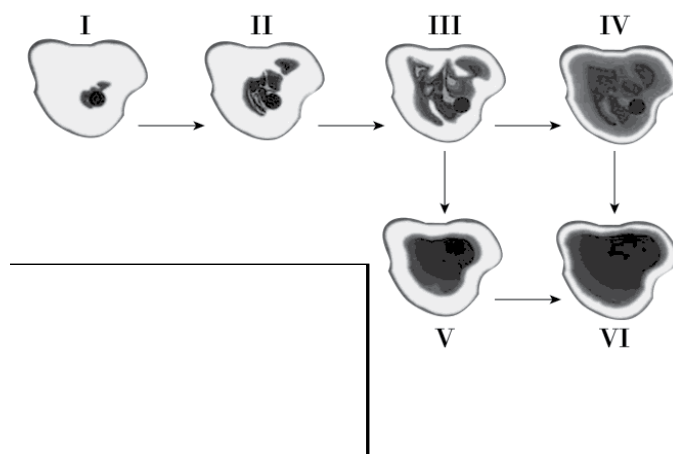

Figure 4. Paraskevic V.L. proposed the Classification "D5" (for mandibles with stable cortical but without spongious bone areals) and "D6" (for mandibles with reduced thickness of the corticals and without spongious bone areals). "D5" and "D6" describe mandibular sections, where this bone has turned into a true hollow bone without any remnants of spongious bone. This classification is applied only to mandibles. The classifications for the density D1 – D4 had been proposed by Lekholm & Zarb (1985). (Figure. 4 adopted from: Paraskevich V.L., Dentalnaya implantologiya, MIA Publishing, Moscow 2011).

In the distal mandible suitable 2nd corticals can be found on the lingual and on the vestibular aspect (Figures. 9). In the inter-foraminal region the base of the mandible (being a 2nd cortical) is accessible with long implants.

Examples of the usage of lingual and vestibular corticals in the distal mandible are shown in Figureures 9, 10, 11.

2. The "Supporting Polygon"

In crestal implantology the penetration areas (of several implants) through the 1st cortical form a supporting polygon and the load transmission areas of all implants form another polygon. It is easy to overview the load situation when considering the polygon (Figure. 5). In this concept it becomes clear that the regions of the canines and the 2nd molars are important strategic positions of the polygon. Almost all other implants are positioned inside this polygon and they increase the cortical support but not the size of the polygon.
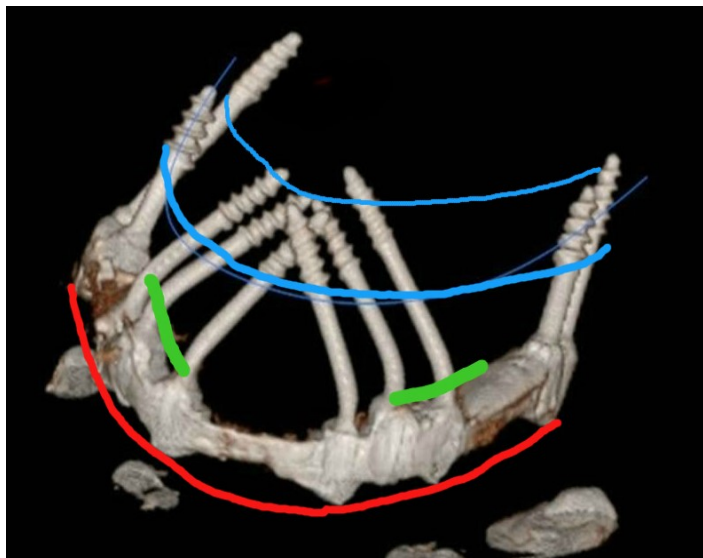

Figure 5. 2-dimensional display of the 3-dimensional spatial situation of a circular bridge in the upper jaw on 10 Strategic Implants. All threads of the implants are cortically anchored somewhere between the upper and the lower blue line, i.e. in the 2nd cortical. Green lines mark anchorage borders in the 1st cortical. The red line marks the outer border of the occlusal contact area (compare to the red points in Figures 12 b and 12 c).
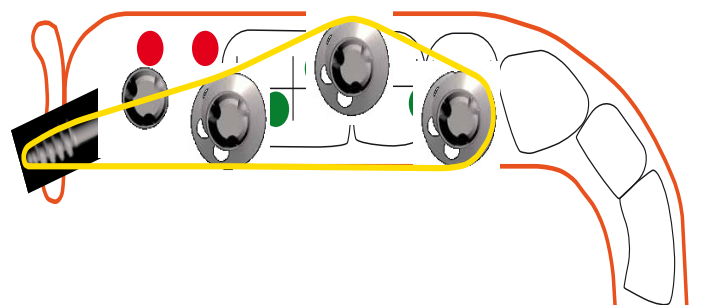

Figure 6. A typical supporting polygon (yellow line) drawn up for a segment bridge in the upper jaw. The tubero-pterygoid region is equipped with a BCS 3.6 17mm implant, and anterior to this implant three BCS 5.5mmd implant are anchored. The surgeon has tried to place all imlants not in a line to broaden the polygon. Green occlusal contact points on the 1st and 2nd premolar and the 1st molar are visible. From this projection it becomes clear, that contact points and masticatory slopes in 2nd molars (red points) are in most cases located out-

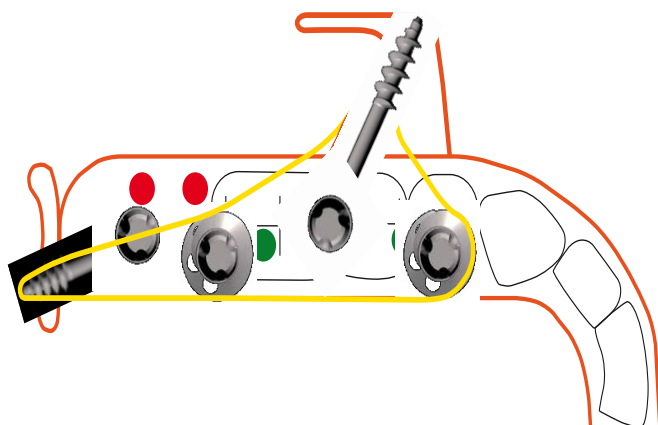side of the supporting polygon. Therefore in Strategic Implantology 2nd molars are not used.

Figure 7. If zygomatic implants are included into the treatment, they increase the size of the supporting polygon in the area of the 1st and 2nd premolar, but not in the area of the 2nd molar.

Figure 8. Well integrated screwable strategic implant positioned palataly to the extremely thin ridge (knife edge), and anchored in the cortical of the floor of the nose (2nd cortical). 2 yrs. post-operative control. In this case the 1st and the 2nd cortical are close to each other. Because the implant is polished, any part of it may be positioned eventlessly in the oral or nasal mucosa or even penetrate into the nasal cavity without creating irregularities.

It should be noted that after healing, a long Strategic Implant® provides a short cantilever on the tooth side of the 1st cortical, while the intra-bony side– towards the 2nd cortical– provides a long lever. Hence, large occlusal and masticatory forces are minimized for the 2nd cortical through a long lever and this explains, why minimal amounts of 2nd corticals still allow balancing large masticatory forces. Note also, that in case implants are placed under an angle (with respect to the occusal plane) the long intra-bony surface under pressure will provide addi-
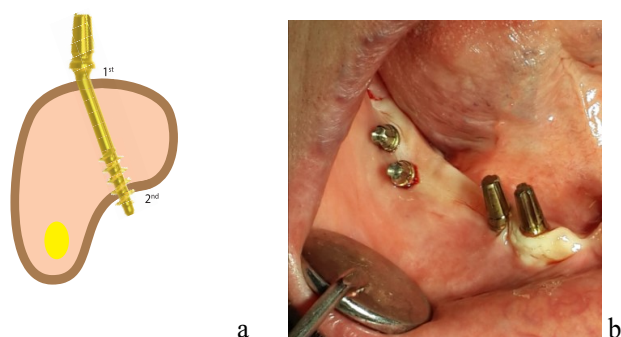
tional resistance against intrusive forces.

a b

Figure 9 a, b. Schematic cross cut through the edentulous distal mandible in the area of the 2nd molar. Schematic drawing and clinical picture (before bending for parallelity). Using the lingual 2nd cortical is easier compared to using the vestibular cortical (see Figure. 10 a, b), because the drilling can be done with the straight handpiece and insertion can be done with handgrip (instead of the ratchet). The anterior implants are place vertically from the beginning and almost no bending of the heads is necessary.
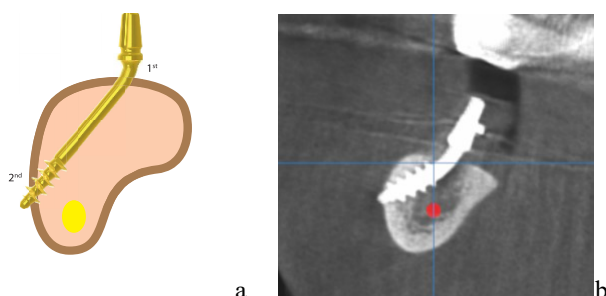

a b

Figure 10 a, b. Schematic cross cut through the edentulous distal mandible (a: schematic drawing; b: clinical picture) in the area of the 2nd molar. In this example the implant was places by using the vestibular cortical as 2nd cortical and the abutment head was bent upwards.
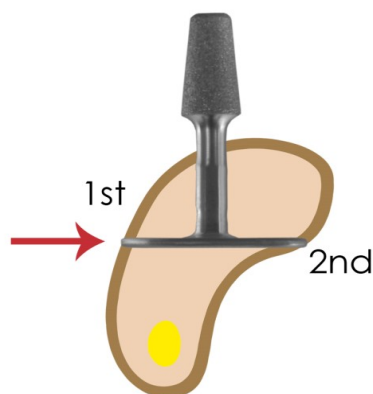

Figure 11. Lateral basal implants are inserted from the lateral into the jaw-bone, after a T-shaped slot has been prepared. For success bi-cortical anchorage (rest within both corticals) of the base-plate is necessary. In strategic implantology the load transmission areas of the implants are supplying stability. Their location is not visible intraorally, although the surgeon will strive to create a large

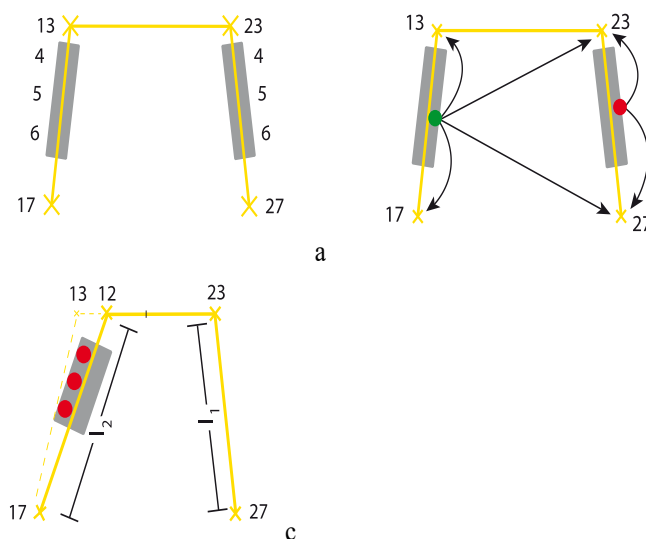supporting polygon by choosing adequate 2nd corticals for the implant (Figure. 6).

a

c

Figure 12.
a: Implant positions for a circular bridge. Strategic positions are the two canines and both distal implants.
b: If occlusal contacts are within the polygon (green point on the bridge) all implants can receive intrusive forces; if however occlusal forces are outside of the supporting polygon (red points on the bridge), some implants are (over-)loaded on intrusion, others on extrusion. Both the overloaded implants, and implants in tension zones (loaded on extrusion) can become mobile.
c: If the surgeon fails to place the Strategic Implant ® into the strategic position (here: Area 13 was missed), even those contacts which would under optimum conditions are inside strategic polygon, are found suddenly outside (red points in this figure).

Discussion

To be useful, new terminology must have significant advantages for explanation of the significant aspects. We now intend to compare the new terminology to the existing one and we will compare the application, the meanings and the advantages of different denominations.

D1-D4 Classification (Lekolm and Zarb)

This classification is used worldwide to describe mineral content (i.e. the internal state of use/disuse and the atrophy) of those bone areas which are determined to receive implants. Whereas D1 contains almost only highly mineralized cortical, D2-bone contains fewer minerals and D3-bone, even fewer minerals than D2. Finally, D4-bone contains almost no minerals at all and the cortical is almost missing. This classification does not really distinguish between the outer cortical bone areas and spongious bone areas. The Lekolm and Zarb - classification was and is used for evaluating bone areas as potential

place of anchorage and for pre-determining the required healing time [21,22].

Paraskevich [23] added D5 and D6 to the "D1-D4"-classification. D5 and D6 define specifically the thickness of the corticals in the distal mandible as shown in Figure. 4. For the strategic implantology his classification is useful, because it allows estimating if a residual cortical should be considered for use.

In strategic implantology only cortical bone is considered and necessary for implant anchorage. The amount of spongious bone between the 1st and the 2nd cortical and its "quality" is for a Strategic Implant® not of great importance. Even sections without any spongious bone between the corticals may receive treatment: in trans-sinusal implant placements we see such a typical situation. If there is spongious bone between the corticals available, it may later lead to additional osseo-integration along the implant`s surface. The classifications according to Leholm & Zarb as well as Paraskevich describe aspects of bone quality and these denominations do not compete with our new terminology.

Classification of Atrophy and Bone Location Lekholm & Zarb (1985)

Lekholm and Zarb (1985) proposed a classification for residual jaw shapes and bone resorption patterns following extraction which was originally based on radiographic evaluation. Their findings are generally accepted today and standard teaching material for novices in implantology. This classification may be used independently; it gives insight in the probable future development of the bone site and into its long term availability.

Atwood/ Cawood & Howell Classification

Classification of edentulous jaws regarding the shape of the mandible and maxilla alveolar processes. It was primarily proposed by Atwood and later modified by Cawood and Howell.

It focuses on changes in the shape of the alveolar process in the vertical and horizontal axes after tooth extraction. Such a classification serves to simplify description of the residual ridge and helps in selecting appropriate surgical and prosthodontic technique. It was divided in I-VI class where class I describes the shape of toothed alveolar process and class VI– depressed ridge. Therefore, it is a useful tool in describing the ridge's shape, although it does not necessarily describe its internal structure. Nevertheless, it does not compete with our new terminology [24-26].

Seibert/Allen Classification

Seibert's nomenclature classifies the defects of partially deformed edentulous ridge from Class I to Class III. Similar classification based on Seibert`s and given by Allen classifies the defects from type A to type C. In this analysis the severity of bone loss in vertical and horizontal direction was evaluated. According to these classifications the vertical component of the ridge defect is more difficult to reconstruct than the horizontal one. This classification does not compete with our new terminology as well [27,28].

All these classifications are useful in implantologic treatment in cases when alveolar bone augmentation is needed. In Strategic Implantology philosophy we do not consider/find (or there is no indications for) bone augmentation procedures. For example, in really difficult situations like Seibert`s class III, using Strategic Implant we simply position implants more palatal (Figure.8). As far as we do not assess the ridge's shape regarding effectiveness of implantation, those classifications do not compete with our terminology.

The "1-2-3 Classification"

The "1-2-3 classification" does not replace or modify any of the classifications mentioned above. This system allows to identify locations in corticals, describe clearly if load transmitting areas ofthe implant have reached the 2nd or 3rd cortical (a fact which is considered critical to success). The "1-2-3 classification" can be applied in all cases which fit into all classification according to Lekholm & Zarb, Parskevich, Seibert&Allen, as well as Atwood/Cawood & Howell. For example in postoperative diagnosis the surgeon might find 9 out 10 implants anchoured in the 2nd or 3rd cortical which would be enough. If on the x-ray only 5 out of 10 implants penetrate into the cortical, surgical correction is required.

It must be understood, that the "1st" and the "2nd" corticals are cortical areas of the same bone, regardless of how intricate or specific the anatomy of the bone may be. They are specifically denominated in order to organize the brain of the surgeon and focus both planning, surgery and post-operative control on the really important, decisive point for success.

Considerations Regarding the "Supporting Polygon" and "Strategic Implant Positions"

When combined, the "1-2-3" system and the concept of the "supporting polygon" allows setting up a 3-D-treatment plan and getting control over the positions of the 2nd and 3rd corticals and their relationship to the occlusal points and to the masticatory slopes in each jaw. This approach is necessary for cortically anchored, osseo-fixated implants in immediate loading protocols, for the survival of the implants for the first 3-6 months, until more endosseous parts of the implants become integrated through the process of "biologic osseo-integration". Thanks to the combination of the logic of the "supporting polygon" and the logic behind the "strategic implant position", we

understand well, why in cases where e.g. no implant is placed in the canine position (but near to it), failures of the whole case are seen in Figure. 11.

When considering treatment plan including zygomatic implants (Figure. 7) it becomes clear that strategic zygomatic implants which, by design, feature some elasticity have good stabilization against lateral masticatory forces, but not against intrusive forces. It is however necessary to understand that the supporting polygon refers to the insertion area of the implant into the 1st cortical. The thread area in the 2nd cortical has a counter-balancing function and may be far away from the supporting polygon or from this insertion area (Figure. 5) [29].

Conclusion

From our experience we can conclude that - the "1st -2nd -3rd" denomination of maxilla-facial corticals helps describing necessary aspects of the treatment and allows precise communication between practitioners and in literature the concept of the" Supporting Polygon" helps the treatment provider to plan and imagine such a polygon and evaluate its supported area.

We recommend to use this new terminology for the purpose of teaching, for communicating, as well as for evaluating the clinical work on the Strategic Implant®.

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