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EFFECT OF PLATFORM SWITCHING ON MARGINAL BONE RESORPTION AROUND THE IMPLANT

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Trabalho apresentado à Universidade Fernando Pessoa como parte dos requisitos para a obtenção do grau de Licenciatura em Medicina Dentária.

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Pierre Karam

Resumo

0 conceito de plaform switching, em português, plataforma alterada, referenciado na literatura, no âmbito da implantologia, que parece permitir uma melhoria na preservação do osso peri-implantar. Dos estudos sobre esta temática surgem varias hipóteses e explicações para justificar as melhorias clinicas obtidas com a sua utilização.

Este trabalho procura rever e detalhar, tendo por base uma revisão da literatura cientifica, os fundamentos biológicos que suportam as vantagens clinicas obtidas com a utilização da técnica de plataforma alterada.

Uma pesquisa na base de dados "PubMed", foi efetuada considerando os artigos dos últimos 10 anos. A bibliografia obtida inicialmente foi selecionada pela leitura dos resumos e posteriormente pela leitura integral das publicações.

O mecanismo pelo qual a plataforma alterada apresenta melhorias clinicas quando comparado com as técnicas convencionais poderá estar relacionado com distintas ocorrências, nomeadamente devido a uma modelação biomecânica das componentes implantares, alteração da localização do microgap, modulação do infiltrado inflamatório peri-implantar e formação de um espaço biológico horizontal

Palavras chave: plataforma alterada; perda óssea peri-implantar; perda óssea alveolar coronal; conexão implante-pilar; revisão bibliográfica.

Abstrat

The concept of plaform switching, in Portuguese, changed platform, referenced in the literature, in the scope of implantology, which seems to allow an improvement in the preservation of the peri-implant bone. From the studies on this theme several hypotheses and explanations appear to justify the clinical improvements obtained with its use.

This work seeks to review and detail, based on a review of the scientific literature, the biological foundations that support the clinical advantages obtained with the use of the altered platform technique.

A search in the "PubMed" database was carried out considering articles from the last 10 years. The bibliography obtained initially was selected by the reading of the abstracts and later by the full reading of the publications.

The mechanism by which the altered platform presents clinical improvements when compared to conventional techniques may be related to different occurrences, namely due to a biomechanical modeling of the implant components, alteration of microgap location, modulation of the peri-implant inflammatory infiltrate and formation of a Horizontal biological space.

Keywords: altered platform; Peri-implant bone loss; Coronal alveolar bone loss; Implant-abutment connection; literature review.

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1. INTRODUCTION

It is not unreasonable to view technological progress as a self-perpetuating process. The more useful a technology is, the more rapidly and actively are its limits challenged by its users. In turn, user demand then drives the necessity for refinements and improvements in the technology. This is just as true in implant dentistry as in any other field or discipline.

The practicality and success rate of endosseous oral implants have seen it rapidly become a treatment of choice in many clinical situations. This surge in popularity has galvanized a constant evolution, demanding the use of implants in more challenging ways than were previously ever thought possible. This radical change has been enabled by a more profound understanding of individual case treatment planning and improvements in surgical procedures, but also through the advancement of the design of the implants themselves.

The platform-switched implant design is one of the latest fruits borne from this constant thirst for progress, and certainly one of its most promising. The concept was introduced by Gardner (2005), Lazzara and Porter (2006) and Vela-Nebot et al. (2006) when minimal vertical bone loss was noticed radiographically around implants with mismatched abutments. Great attention has been given to the concept since then by practitioners and manufacturers alike, and today, with a wealth of scientifically-backed theories and clinical experiments at our disposal, we finally find ourselves close to fully understanding its effects and implications.

It is with that in mind that this paper tackles the following questions: What is platform switching, and what is the scientific rationale behind it? What is its relationship with marginal bone loss, and does it truly succeed in reducing it? If so, what are the full implications of its use in clinical situations, and what new opportunities does it offer to the discipline of implant treatment?

2. MARGINAL BONE RESORPTION AROUND IMPLANTS

2.1. Generalities

The skeleton is a metabolically active organ that undergoes continuous remodeling throughout life. Bone remodeling involves the removal of mineralized bone by osteoclasts followed by the formation of bone matrix through the osteoblasts that subsequently become mineralized. The remodeling cycle consists of three consecutive phases: resorption, during which osteoclasts digest old bone; reversal, when mononuclear cells appear on the bone surface; and formation, when osteoblasts lay down new bone until the resorbed bone is completely replaced. Bone remodeling serves to adjust bone architecture to meet changing mechanical needs and helps to repair micro-damages in bone matrix preventing the accumulation of old bone (Hadjidakis & Androulakis 2006).

It enables the substitution of the primary bone (woven bone), which has low load-bearing capacity, with lamellar bone that is more resistant to load (Lindhe & editors 2008).

Bone remodeling is especially significant in oral implantology, where the success and longevity of dental implants is highly dependent on the relationship between the implant components and the surrounding oral tissues (Oh etal 2002) Indeed, the level of peri-implant marginal bone, being a sensitive parameter, is widely considered one of the most important reference criteria to monitor peri-implant health and evaluate the long-term success of dental implants.

2.2. Marginal Bone Loss around Implants

Crestal bone loss around oral implants has been reported in most clinical follow-up studies. In the majority of cases, marginal bone loss during the first year in function is larger than the annual bone loss during the following years (Laurel/ & Lundgren 2011).

This bone loss has been regarded as part of a bone remodeling phase (Albrektsson eta,2014).

It has been suggested that a successful implant might lose an average of 1.5 mm of bone on both axes during the first year in function and less than 0.2 mm annually in subsequent years (Albrektsson etal 1986, Astrand etal 2004, Cardaropoli etal 2006).

Meanwhile, a recent meta-analysis by Laurell and Lundgren (2011) compiled and compared data on peri-implant marginal bone level changes from prospective studies that have registered the marginal bone level radiographically at the time of prosthetic loading, and after 5 years of follow-up for implant systems currently available on the market (the Astra Tech Dental Implant System, the Bn1nemark System, and the Straumann Dental Implant System). The study concluded that these systems showed a mean marginal bone loss over 5 years well below what is generally accepted as success (Fig. 1, Fig. 2), suggesting that it could be time for a revision of the existing success criteria.

Implant system	Pooled MBLC (mm)	95% CI	Weighted MBLC (mm)	95% CI
AstraTech ($n = 338$)	−0.24	−0.345, −0.135	−0.27	−0.356, −0.179
Brånemark ($n = 1027$)	−0.75	−0.802, −0.693	−0.72	−0.776, −0.673
Straumann ($n = 708$)	−0.48	−0.598, −0.360	−0.56	−0.661, −0.481

AstraTech ≠ Brånemark, $p = .0000$.
AstraTech ≠ Straumann, $p = .0031$.
Brånemark ≠ Straumann, $p = .0001$.

Fig. 1: Pooled Mean and Weighted Mean Marginal Bone Level Changes (MBLCs) and 95% C/ for the Astra Tech, Brememark, and Straumann Implant Systems, from the Laurel/ and Lundgren (2011/-1 study.

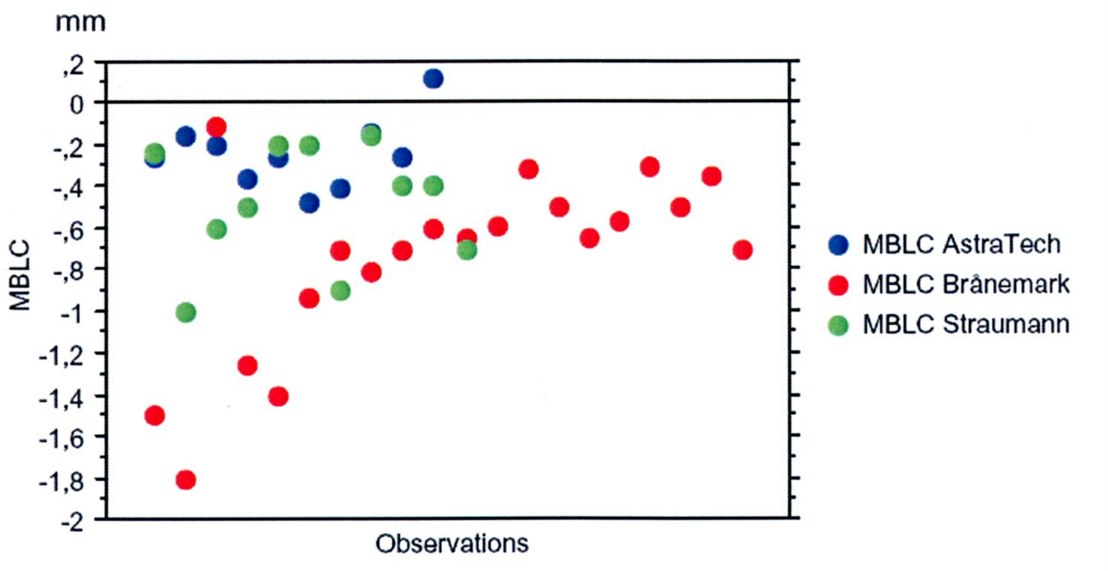

Fig. 2: Univariate scattergram showing mean values for marginal bone level changes (MBLCs) for the

2.3. Possible Causes of Early Bone Loss

There is an ongoing debate as to why greater bone loss occurred during the first year of healing and function than in following years. Many possible etiologies of early implant bone loss have been proposed (Oh et al. 2002).

2.3.1. Biologic Width

A term frequently used to describe the dimensions of the soft tissues that face the teeth is the biologic width of the soft tissue attachment (Lindhe & editors 2008). The development of the biologic width concept was based on studies and analyses by, among others, Gottlieb (1921), Orban and Kohler (1924), and Sicher (1959), who documented that the soft tissue attached to the teeth was comprised of two parts, one fibrous tissue and one attachment of epithelium. This complex protects the subjacent periodontal ligament and the alveolar bone from the attack of a pathogenic biofilm present in the oral cavity (Lindhe & editors 2008).

In a publication by Gargiulo et al. (1961) , histometric assessments were made to describe the length of the sulcus (not part of the attachment), the epithelial attachment (today called junctional epithelium) and the connective tissue attachment (Fig. 3). It was reported that the average value of sulcus depth was 0.69 mm, and the average values for the epithelial attachment and connective tissue attachment were 0.97 mm and 1.07 mm, respectively. The biologic width included the latter two, the epithelial attachment and connective tissue attachment, which was 2.04 mm. Mean values of the biologic widthobtained from two recent meta-analyses (Kosyfaki et al. 2010, Schmidt et al. 2013)

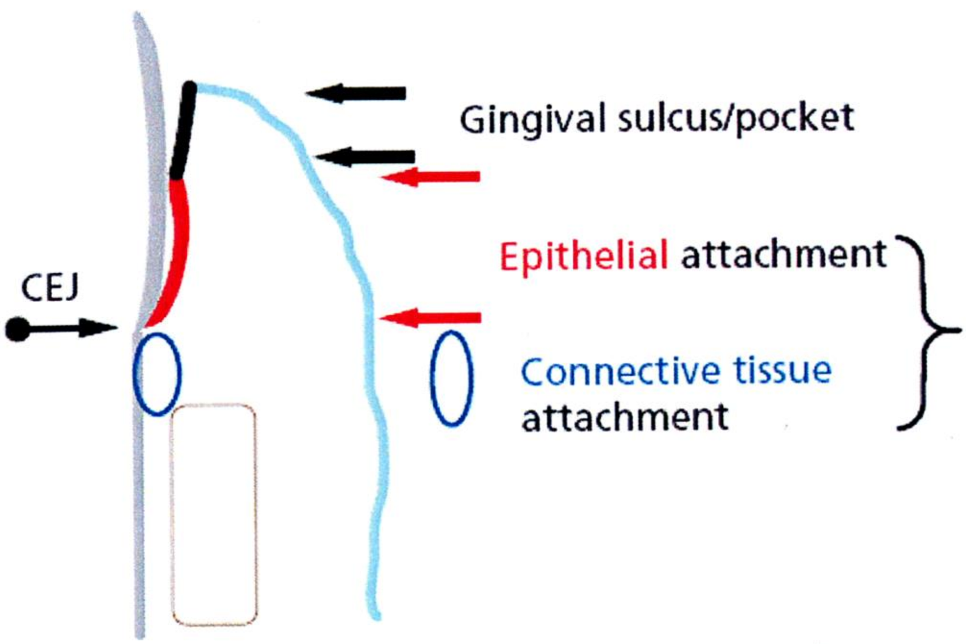

Fig. 3: Drawing describing the "biologic width" of the soft tissue attachment at the buccal surface of a tooth with healthy periodontium. The combined length of the junctional epithelium (epithelial attachment) and the connective tissue attachment is considered to represent the "biologic width" of the soft tissue attachment (Lindhe & editors 2008)

Likewise, around dental implants, the epithelial attachment and connective tissue attachment exist, comprising the biologic seal around dental implants that acts as a barrier against bacterial invasion and food debris ingress into the implant-tissue interface. (McKinney et al 1984, Cochran et al 2013)38 85 Cochran et al. (1997)37 documented the soft tissue dimensions and described the biologic width around non-submerged, one-piece dental implants. This study supported previous reports on soft tissues around implants (Berglundh et al 1991, Abrahamsson et al1996), and showed that an area of epithelial attachment with the implant surface occurs similar in morphology to that which is found around natural teeth. In addition, an area of connective tissue contact was found between the apical extension of the junctional epithelium and the alveolar bone comprising the first bone-to-implant contact. The dimensions of this biologic width for non-submerged, one-piece implants were demonstrated to be similar to the dimensions for the same tissues described for natural teeth. In addition, Hermann et al. (2000) histometrically evaluated the dimensional change of the biologic width around non-submerged implants and observed that each dimension of the sulcus depth, epithelial attachment, and connective tissue attachment changed over time, but within the overall biologic width dimension. A histologic study by Cochran et al. (2013) presents a more recent confirmation of these notions.

A notable difference between the biologic seal observed around natural teeth and that which exists around implants is the orientation of the collagen fibers surrounding the tooth or implant. Around a natural tooth, the collagen fibers of the periodontal ligament are radially oriented to the dental surface in the cervical area, a direction that maximizes resistance to tensile forces (Lindhe & editors 2008). In contrast, longitudinal and circumferential fibers, the axes of which are parallel or oblique to the implant surface, have been observed around the titanium neck in dental implants (Lindhe & editors 2008).

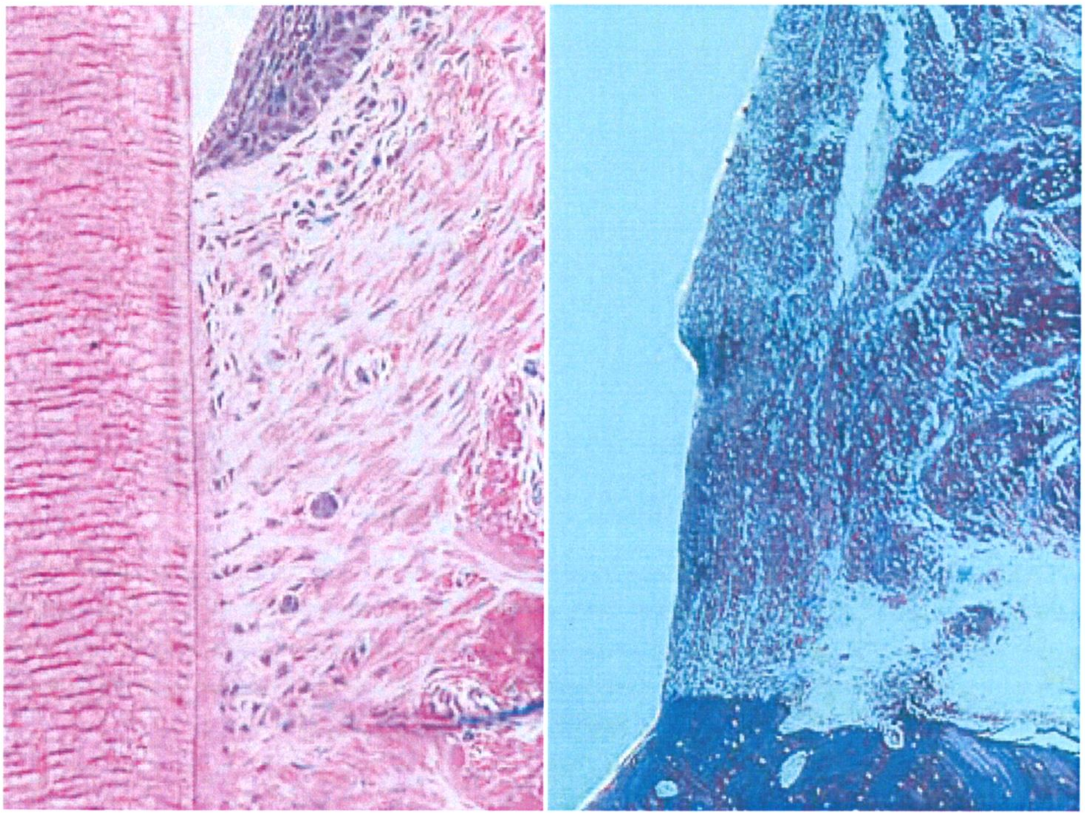

Fig. 4: Microphotograph of a tooth with marginal periodontal tissues (left) and of the peri-implant mucosa and bone at the tissue/titanium interface (right). Note that the fibers are orientated more or less perpendicular to the root surface in natural teeth, while their orientation is more or less perpendicular to the implant surface (Lindhe & editors 2008)

The potential of the biologic width to influence bone remodeling was made apparent in an animal study conducted by Berglundh and Lindhe (1996) I, when the dimension of peri-implant mucosa was studied in a beagle dog model. At sites where the ridge mucosa prior to abutment connection was made thin (less than or equal to 2 mm), wound healing consistently included bone resorption and the establishment of an angular bone defect (Fig. 5). This implied that a certain minimum width (3 mm) of the peri-implant mucosa (biologic seal) may have been required, and that bone resorption may have taken place to allow a stable soft tissue attachment to form. This notion was further verified in subsequent studies (Pontes et al. 2008, Canullo et al. 2011) , and has arguably been one of the most credible bases for the majority of current theories surrounding marginal bone loss around implants.

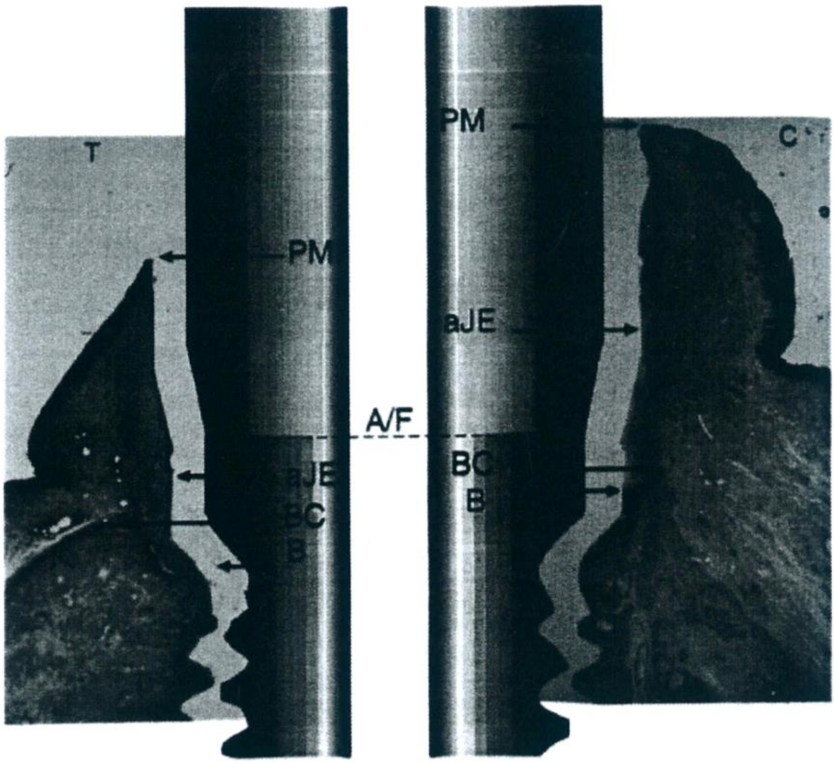

Fig. 5: Microphotograph of one test (T) and one control (C) site. Note in the test side, the presence of an angular bone defect. PM: the marginal portion of the peri-implant mucosa; aJE: the level of the apical termination of the junctional epithelium; AIF: the abutment/fixture junction, BC: the bone crest, i,e, the most coronal portion of the peri-implant bone; B: the marginal/eve/ of bone to implant contact (Berglundh & Lindhe 1996)

2.3.2. Periodontal Biotype

The term periodontal biotype was first described by Seibert and Lindhe (1989) and then more recently by De Rouck et al. (De Rouck et al. 2009), with two main biotypes being identified: a thick-flat biotype and a thin-scalloped biotype. The importance of the biotype is recognized especially in relation to the esthetic appearance (Vervaeke et al. 2014). Subjects with a thin-scalloped biotype are more prone to gingival recessions, whereas thick-flat biotypes seem more resistant to trauma and hence protected against gingival recessions (Olsson et al. 1993).

Marginal bone loss around implants seems to be related to periodontal biotypes as well (Berglundh et al. 2007, Linkevicius et al. 2009, Vervaeke et al. 2014) Linkevicius et al. (2009) evaluated the influence of gingival tissue thickness on crestal bone loss around dental implants, and concluded that initial gingival tissue thickness at the crest may be considered as a significant influence on peri-implant marginal bone stability. If the tissue thickness was 2.0 mm or less, crestal bone loss up to 1.45 mm could occur, despite a supracrestal position of the implant-abutment interface. These results were consistent with those of a previous animal study which showed the potential for thin tissues to cause crestal bone loss during the process of biologic width formation (Berglundh et al. 2007) A recent study by Vervaeke et al. (2014) further confirms these findings.

Fig. 6: Thick biotype (top) with periodontal probe not visible through the gingival sulcus. Thin biotype(bottom) with periodontal probe visible through the gingival sulcus (Arora et al. 2013)

2.3.3. Microgap

In implant dentistry, there are two basic approaches to placing endosseous implants: submerged (2-stage) and non-submerged (1-stage) implants. In most 2-stage implant systems, after the abutment is connected, a microgap exists between the implant and abutment at or below the alveolar crest. In nonsubmerged implant designs, the implant itself extends above the alveolar crest level; therefore, such a microgap does not exist at the level of the bone (Oh et al. 2002) The implant/abutment microgap in 2-stage implants has been suggested as a contributor of marginal bone loss (Ericsson et al. 1995, Hermann et al. 2000 & 2001, Cochran et al. 2009, Koutouzis et al. 2014).

Some studies have shown that bone resorption around the implant neck does not begin until the implant is uncovered and exposed to the oral cavity, which invariably leads to bacterial contamination of the gap between implant and supra-structure. Quirynen and van Steenberghe (1994) found microbial species cultivated from internal surfaces of submerged implants or their restorative component parts. The study implied that a microbial leakage from the abutment-fixture microgap in submerged implants is the most probable origin for this contamination.

Several in vitro studies have since described the occurrence of bacterial leakage along the implant-abutment interface of systems with different internal connection designs in static or dynamic loading conditions (Steinebrunner et al 2005, Tesmer et al 2009, Aloise et al 2010, Koutouzis etal 2011).Moreover, microleakage has been confirmed to occur in both directions, from the inner parts of the implants to the external environment and vice versa (do Nascimento etal 2012), and the degree of leakage is dependent on the type of implant-abutment connection and loading (Koutouzis et al 2014, Canullo et al 2015) and the amount of micromovement (Steinebrunner etal 2005).

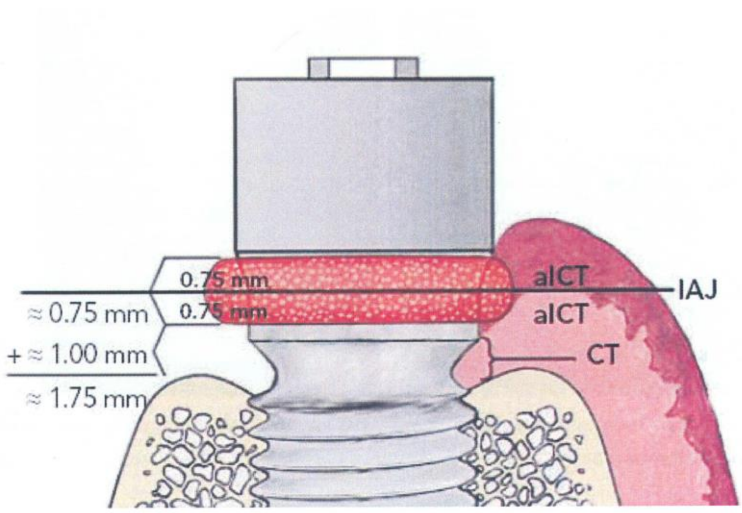

Fig. 7: Composite approximation of soft tissue interface dimensions according to Ericsson et al (1995)-17 and Abrahamsson et al. (1997/ JAJ = implant-abutment interface; a!CT = 1.5-mm abutment inflammatory cell infiltrate (0.75 mm above IAJ to 0.75 mm below IAJ); CT = zone (approximately 1.0 mm) of healthy connective tissue between the base of a!CT and bone (Lazzara & Porter 2006)

This concept is further validated by the presence of an inflammatory infiltration zone at the abutment-implant junction. Berglundh et al. (1991) and Lindhe et al. (1992)

evaluated the microgap of the Branemark 2-stage implant and found that inflamed connective tissue existed 0.5 mm above and below the abutment-implant connection which resulted in 0.5 mm bone loss within 2 weeks after the abutment was connected to the implant. Additionally, Berglundh and Lindhe (1996) and Ericsson et al. (1995) observed in histologic sections of crestal bone and soft tissue that crestal bone is always separated from the base of the abutment inflammatory zone by an approximate 1 mm-wide zone of healthy connective tissue, as depicted in Fig 7. This was further demonstrated when radiologic investigations in animals and humans showed that the first bone-to-implant contact is always established at a certain vertical distance apical to the microgap, regardless of the initial vertical position of the microgap with respect to the surrounding bone level (Astrand et al 2004, Cochran et al 2009, Weng et al 2011)

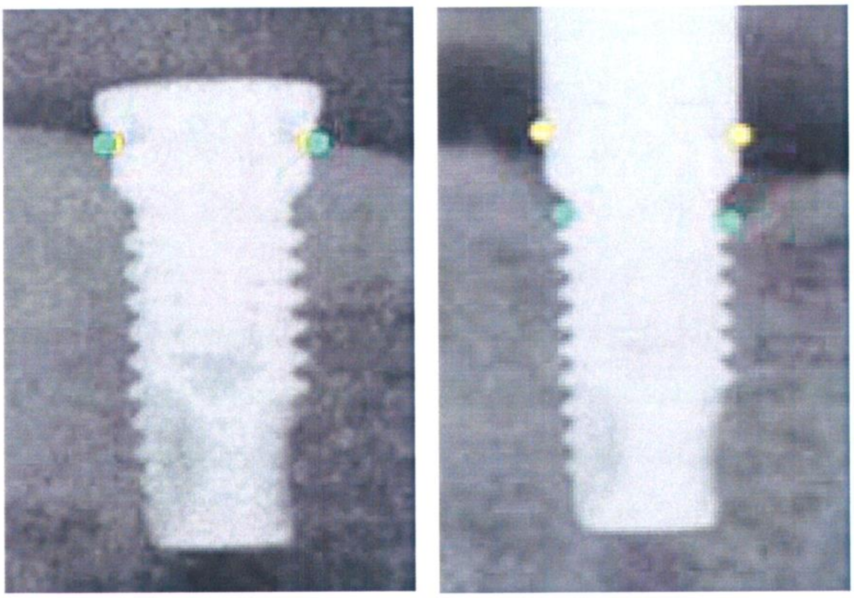

Fig. 8: Radiographs of implant in dog model (left) immediately after implant placement and (right) 6 months later. Yellow dots = microgap; green dots= radiographic bone level (Weng etal 2011)

2.3.4. Plaque-induced Peri-implantitis

The 6th European Workshop on Periodontology (Lindhe & Meyle 2008)80 confirmed that peri-implant diseases are infectious in nature. It described peri-implant mucositis as an inflammatory lesion that resides in the mucosa, while peri-implantitis also affects the supporting bone.

The 7th European Workshop on Periodontology (Lang & Berglundh 2011)73 further stated that peri-implantitis can be diagnosed by changes in the level of the crestal bone in conjunction with bleeding on probing with or without concomitant deepening of peri-implant pockets, while pus can also be a common finding in peri-implantitis sites.

A correlation between plaque accumulation and progressive bone loss around implants has already been reported in previous experimental studies (Schou et al 1993, Mombelli 1999) and clinical studies (Adell etal 1981) Recently, ligature-induced periodontal breakdown around implants has helped further observe the cause-and-effect relationship between bacterial load from plaque and peri-implant bone loss (Albouy etal 2012)

2.3.5. Excess Cement

Fixed dental restorations can be retained on implants either by screws or cementation. In the case of cementation, excess cement left in the peri-implant sulcus has been shown to cause a loss of biologic attachment (Wilson 2009, Korsch et al 2013 & 2014), leading to bone resorption. The presence of excess cement promotes the formation of a biofilm (Busscher etal 2010, Obst etal 2012), leading to inflammation in the peri-implant tissue (Wilson 2009, Korsch et al 2014 & 2015). This inflammation disappears after the removal of the excess cement (Wilson 2009, Korsch etal 2015). The implant diameter (Korsch et al 2013, Vindasiute et al 2013) and the depth of the cementation margin (Santosa et al 2010) have been identified as predictors of excess cement. In the cases of larger implant diameters and deeper cementation margins, significantly more excess cement was found. According to Korsch et al. (2014), it must be assumed that the complete avoidance of excess cement is clinically impossible.

Fig. 9: Abutment with undetected excess cement after removal (Korsch et al. 2015/ 7

2.3.6. Occlusal Overload

Bone is a dynamic tissue that remodels remarkably in response to mechanical, nutritional, or hormonal influences. It responds favorably to functional forces by improving the quality of its structure and the bone-implant interface. It has been suggested, however, that an over-function beyond the threshold of tolerance of the structures supporting a successfully-osseointegrated implant could result in marginal bone loss as well as a total loss of integration (lsidor 1996, Tawil 2008).
Most of the suggestions are, however, speculative in nature, due to the difficulty in quantifying the magnitude and direction of physiological occlusal forces, as opposed to what is defined as excessive (Isidor 2006). Thus, the impact of excessive loading on dental implants, and whether this could cause or contribute to marginal bone loss or loss of osseointegration, continues to be a point of controversy (Mattheos etal 2013).

Experimental animal studies have so far failed to show a clear role for excessive loading in the loss of osseointegration (Chambrone et al 2010, Mattheos et al 2013). An animal experiment conducted by Duyck et al. (2001) provided evidence of marginal bone remodeling when the implant was excessively loaded, without leading to implant loss, supporting earlier theories presented by Adell et al. (1981) and Esposito et al. (1998). This was contradicted by more recent animal experiments that did not show loss of bone or osseointegration when the implants were subjected to excessive force in the absence of plaque. It was even reported that excess occlusal load increased bone to implant contact (Heitz-Mayfield etal 2004, Kozlovsky etal 2007) Chambrone et al.(2010) remarked that the presence of excessive occlusal loading has lead to early, pre-osseointegration implant failures, but it has not shown to consistently compromise osseointegration of successfully integrated dental implants when oral hygiene standards were maintained. Recently, Mattheos et al. (2013) presented a human case report with the aim of clarifying the influence of occlusal overload on osseointegrated implants. The two cases indicated that the loss of osseointegration in the absence of plaque-induced peri-implants inflammation is possible, although rarely observed in marginal cases of compromised bone conditions.

The group further noted that the clinical manifestations in these cases were different to these of peri-implantitis, as the occlusal loading did not result in marginal bone loss.

Finally, a recent systematic review conducted by Naert et al. (2012) noted that randomized and/or controlled trials of treatment interventions of oral implants designed to study overload are nearly lacking, making it difficult to reveal any solid relationship between occlusal overload and marginal bone loss. The study does go on to conclude, however, that the systematic review of included animal experimental data provided evidence for a differential peri-implant bone tissue response to overload depending on the mucosal health. Supra-occlusal contacts acting in an uninflamed peri-implant environment did not negatively affect osseointegration and were even beneficial to the net bone tissue. In contrast, supra-occlusal contacts in the presence of inflammation significantly increased the presumed plaque-induced bone resorption.

2.3.7. Other Factors

Marginal bone levels around implants can also be influenced by other factors, such as the implant surface roughness (Hermann etal 2011, Schwarz etal 2014), the proximity between adjacent implants (Tarnow et al 2000) surgical trauma during implant placement (Oh et al 2002), patients smoking habits (DeLuca & Zarb 2006, Chrcanovic etal 2015) and diabetes (Accursi 2000, Chrcanovic etal 2014).

2.3.7.1. Implant Surface Roughness

Titanium with different surface modifications shows a wide range of chemical and physical properties depending on how it is prepared and handled (Chrcanovic et al 2015). It has been observed that implant surface topography can have an important influence on the bone response after implant placement (Balshe et al 2009). Some authors (Hermann et al 2011, Schwarz et al 2014) have also suggested that this influence extends to marginal bone resorption.

Fig. 10: Implant with a relatively smooth machined titanium collar (left). The rough surface of both implants is a sand-blasted, large-grit, and HC1/H2S04 dual acid-etched (SLA) surface (Alomrani et al.2005)

However, the effect of surface roughness on marginal bone loss around implants remains a controversial point. While some studies have shown that rough implant collars tend to favor marginal bone retention compared to smooth surfaces (Alomrani et al 2005) reviews by Abrahamsson and Berglundh (2009) and Bateli et al. (2011) concluded that controlled prospective studies on the matter are few, and that the ones available show little evidence that rough surfaces are superior to smooth surfaces in marginal bone preservation. Other studies, meanwhile, have shown that peri-implant crestal bone reactions can be influenced by a rough-smooth implant border placed at different levels in relation to the crest of the bone. A recent literature review by Schwarz et al. (Schwarz et al 2014) studied three animal studies (Hermann et al 2000, Schwarz et al 2008, Hermann etal 2011) that used the canine model for research on the impact of the positioning of the machined collar on crestal bone level changes. The mean difference between machined collars placed either above or below the bone crest amounted to 0.835 mm, favoring an epicrestal positioning of the rough/smooth border.

2.3.7.2. Proximity between Implants

In a study conducted by Tarnow et al. (2000), a crestal bone loss of just 0.45 mm was observed when the distance between two adjacent implants was 3 mm. This was in stark contrast to the 1.04 mm of bone loss observed when the inter-implant distance was smaller than 3 mm. A correlation between inter-implant distance and marginal bone loss was thus established, considering a 3 mm distance to be a guideline for adjacent implant placement.

Subsequent animal studies have emphasized the value of inter-implant distances of 3 mm from other perspectives, as well. Traini et al. (2008) placed implants at 2 and 3 mm intervals in adult dogs. All the values on longitudinal collagen fiber, transverse collagen fiber, marrow spaces, and mineral density that were produced by a 2 mm interval showed significantly reduced values compared to those produced by a 3 mm interval. The same authors (Traini et al. 2010) later performed an evaluation of the vascularization level for de novo bone formation, contact osteogenesis, and bone remodeling in groups of 2 and 3 mm distances in adult dogs. They observed better vascularization in the latter group.

2.3.7.3. Surgical Trauma

Surgical trauma has been regarded as one of the most commonly suspected etiologies proposed for early implant failure (Albreksson et al. 1986, Esposito et al. 1998, Eriksson and Albrektsson 1984) reported that the critical temperature for implant site preparation was 47°C for 1 minute or 40°C for 7 minutes, and that when the bone is overheated, risk of implant failure is significantly increased. Wilderman et al. (1970) reported that the mean horizontal bone loss after osseous surgery with periosteal elevation is approximately 0.8 mm. A more recent review conducted by Oh et al. (2002), however, noted that the signs of bone loss from surgical trauma and periosteal reflection are not commonly observed at implant stage 2 surgery in successfully osseointegrated implants, adding that the pattern of bone loss in implants is more likely to be vertical than horizontal. Thus, they concluded that the hypothesis of the surgical causes of early implant bone loss remains to be determined.

2.3.7.4. Smoking Habit

De Luca and Zarb (2006) investigated the effects a smoking habit might have on marginal bone loss. They observed that a positive smoking history was associated with a higher rate of peri-implant bone loss, and that long-term heavy smokers could be at a slightly higher risk of late implant failure and are susceptible to more marginal bone loss over the long-term, irrespective of their smoking status at the time of implant placement. A recent systematic review and meta-analysis conducted by Chrcanovic et al. (2015) arrived at similar conclusions.

2.3.7.5. Diabetic Patients

With respect to marginal bone loss around implants in diabetic patients, another systematic review and meta-analysis by Chrcanovic et al. (2014) found a significant difference in favor of non-diabetic patients, with less marginal bone loss observed compared to diabetic ones. However, it should be noted that the difference was based on the only 2 publications (Accursi 2000, Tawil 2008) that were available.

2.4. Consequences of Marginal Bone Loss around Implants

The crestal bone supports the gingival architecture. Therefore, the stability of the crestal bone is believed to be the key factor for maintaining stable soft tissue dimensions over time (Vervaeke et al 2014). This has lead several authors (Albrektsson et al 1986, Papaspyridakos etal 2012) to consider the peri-implant bone level as a main criterion to assess the success of dental implants.

Its importance in preserving the integrity of gingival margins and interdental papillae means that marginal bone loss could compromise the final esthetic and functional outcome of the implant, and thus contribute in the failure of the treatment. Moreover, vertical peri-implant bone loss can alter the initial crown/implant ratio and even invert it, creating an unfavorable situation that reduces the long-term predictability of the restoration (Vela-Nebot etal 2008)

2.5. Proposed Solutions

Several new concepts have arisen to combat marginal bone loss. Roughened-surface implants have proved to have a higher survival rate than machined-surface implants, while different abutment shapes and connection types have also shown promising results.

One concept that seems to be particularly efficient, however, is platform switching, where the inward shifting of the connection microgap has been shown to significantly reduce crestal bone remodeling and open up a host of new possibilities in implant treatment.

3. PLATFORM SWITCHING AS A SOLUTION TO EARLY CRESTAL BONE LOSS AROUND IMPLANTS

3.1. Discovery

Historically, two-piece dental implant systems have been restored with prosthetic components that locate the interface between the implant and the attached component element at the outer edge of the implant platform. In 1991, Implant Innovations introduced wide-diameter implants with matching wide-diameter platforms. During that time, however, matching-diameter prosthetic components were not yet commercially available, and many of the early 5.0- and 6.0-mm-wide implants received standard- diameter (4.1-mm) healing abutments and were restored with standard-diameter (4.1-mm) prosthetic components (Lazzara & Porter 2006).

Long-term radiographic follow-up of these platform-switched, wide-diameter dental implants demonstrated a smaller than expected vertical change in the peri-implant crestal bone height than is typically observed around implants restored conventionally with prosthetic components of matching diameters. This observation suggested that the post- restorative biologic process resulting in the loss of crestal bone height is altered when the outer edge of the implant-abutment interface is horizontally repositioned inwardly and away from the outer edge of the implant platform (Lazzara & Porter 2006). It led to the introduction of the concept of platform switching by Gardner in 2005 and Lazzara and Porter in 2006.

Several clinical reports (Vela-Nebot et al. 2006, Hiirzeler et al. 2007, Canullo & Rasperini 2007) then demonstrated more favorable soft and hard tissue responses using implants placed with platform switching compared to standard platform-matched implants. Consequently, an increasing number of implant systems incorporated platform switching into their designs as an innovative feature for preserving the peri-implant bone (Atieh et al. 2010)

3.2. Concept and Rationales

The concept of platform switching suggests the use of a smaller-diameter abutment or supra-structure on a larger-diameter implant collar. This configuration results in a circular horizontal step and the inward horizontal repositioning of the implant-abutment junction (Gardner 2005, Lazzara & Porter 2006)

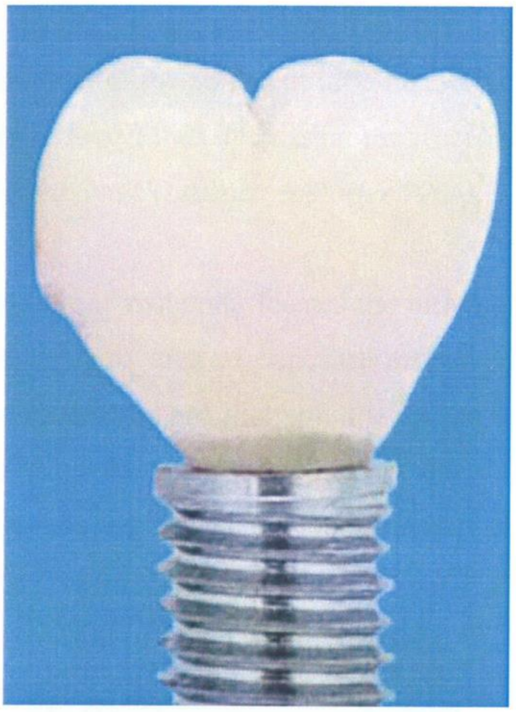

Fig. 11: Platform switching is demonstrated. A 0. 95-mm circumferential horizontal mismatch in dimension is created when a 4.1-mm-diameter prosthetic UCLA abutment is placed on a 6.0mm diameter implant with matching 6.0mm diameter platform (Lazzara & Porter 2006)

Several theories have been suggested to explain the potentiality of platform switching to preserve peri-implant marginal bone (Annibali et al. 2012).

3.2.1. Biologic Rationale

A biologic rationale has been established to understand why there appears to be little or no crestal bone remodeling following the placement of an implant with a platform- switched design. This rationale suggests that the inward positioning of the implant- abutment junction (IAJ) influences the bone remodeling process in two ways (Lazzara & Porter 2006).

First, the inward positioning of the implant-abutment interface exposes the implant seating surface, thus creating an additional horizontal surface area. This allows the biologic width to be formed horizontally, reducing the amount of crestal bone resorption necessary to expose a minimum amount of implant surface to which the soft tissue can attach (Lazzara & Porter 2006). Second, by repositioning the IAJ inward and away from the outer edge of the implant and adjacent bone, the overall effect of the abutment inflammatory cell infiltrate (ICT) on the surrounding tissue may be reduced, thus decreasing the resorptive effect of the abutment ICT on the surrounding crestal bone (Lazzara & Porter 2006).

It is also suggested that platform switching locates the inflammatory infiltrate within an approximate :::; 90-degree confined area of exposure instead of a :S 180-degree area of direct exposure to the surrounding hard and soft tissues, as depicted in Fig. 12. As a consequence, the reduced exposure and confinement of the platform-switched abutment ICT may also contribute in reducing its inflammatory effect (Lazzara & Porter 2006).

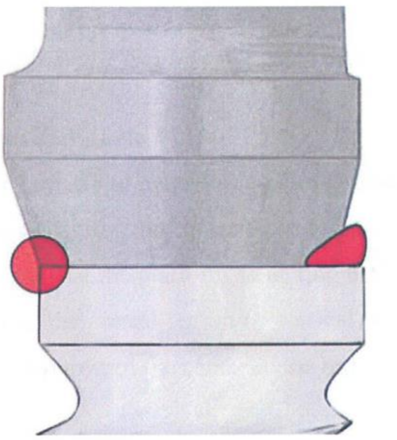

Fig. 12: Amount of exposure the abutment JCTwill have with the surrounding bone and soft tissue when positioned at the outer edge of the implant (left). In contrast, the inward, horizontal re positioning of the abutment JCT (right) will move the abutment JCT away from the crestal bone and into a more confined area (Lazzara & Porter 2006).

These concepts were further supported by animal (Cochran et al. 2009, Farronato et al. 2012, Cochran et al. 20l3 and human (Luongo et al. 2008, Degidi et al. 2008, Canullo et al. 2011) histological studies.

3.2.2. Biomechanical Rationale

Another theory, supported by finite element analysis, exammes the biomechanical advantages of the platform switching configuration in terms of stress distribution in and around the implant. It suggests that the platform switching design reduces the stress at the one-implant interface and in the crestal region of cortical bone by shifting stress away from the bone-implant interface toward the center of the implant (Maeda et al. 2007).

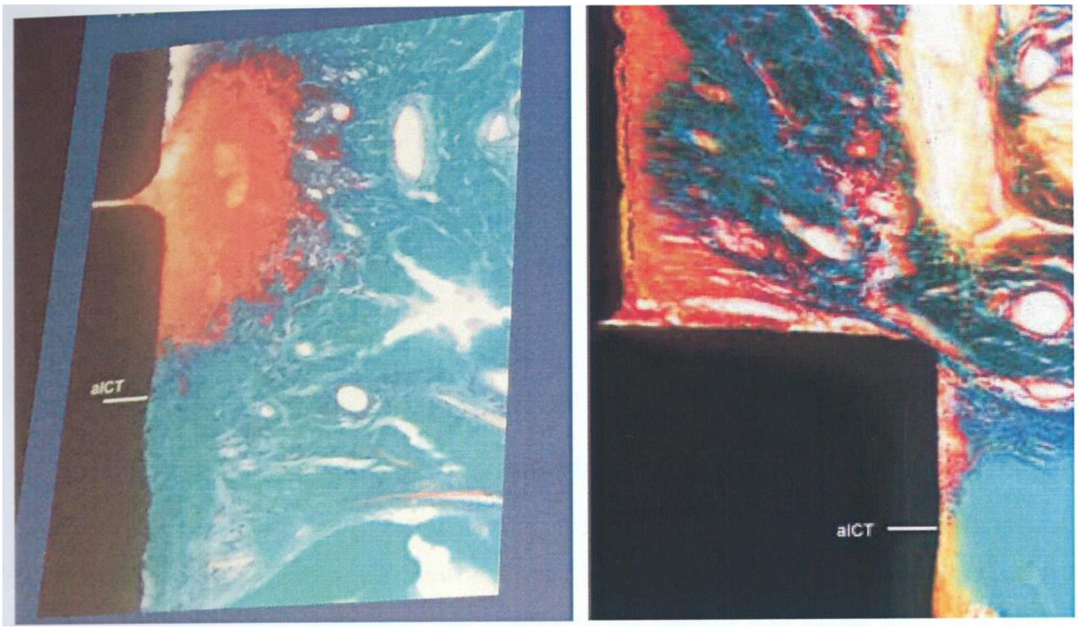

Fig. 13: Mixed chronic inflammatory cell infiltrate at the implant-abutment interface (abutment ICT) over a study period of 24 weeks conducted by Becker et al. (2009). The abutment ICT seems to be limited to an approximate 90-degree confined area of exposure in the platform-switched implant (right) instead of a 180-degree area in the platform-matched implant (left).

These concepts were further supported by animal (Cochran et al 2009, Farronato et al 2012, Cochran et al 2013) and human (Luongo et al 2008, Degidi et al 2008, Canullo etal 2011) histological studies.

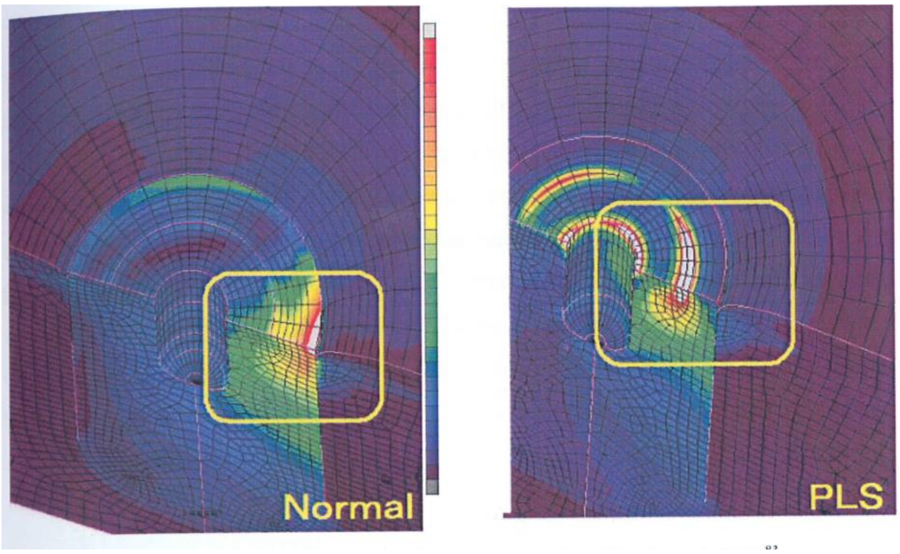

Fig. 14: Strain energy density distribution in the implant (Maeda et al 2007)

In a three-dimensional finite element analysis, Maeda et al. (2007) discovered a high-stress area around the periphery of the implant's top surface and along its lateral surface as well as in the bone facing that area in the normal model, while this high stress area shifted toward the center of the implant in the platform-switched model (Fig. 14). Also, the strain energy in the normal model implant was more widely spread along its lateral surface down toward the implant tip, while it was concentrated near the abutment-implant interface area in the platform-switched model. Strain energy in the cortical bone surface was higher in the normal model than in the platform-switched model.

These results were later supported by studies conducted by Chang et al. (2010), Tabata et al. (2011) and Yang and Maeda (2013) who observed that Von Mises, maximum (tensile), and minimum (compressive) principal stress were reduced in implants and peri- implant bone tissue when the platform switching concept was used. It was suggested that wide-diameter implants had a large influence in reducing stress values (Tabata et al. 2011)

The decrease in stress values observed may provide a biomechanical explanation as to why platform switching seems to reduce the expected post-restoration crestal bone remodeling. The lower concentration of stress in the peri-implant bone tissue would lead to less microdamage in the bone, resulting in minimized crestal bone loss (Cardaropoli et al. 2006, Hiirzeler et al. 2007). The model can also contribute in reducing shearing stress, which is most likely to cause disintegration (Sugiura et al. 2000). Another possible explanation lies in the distance between the bone surface and the stress- concentrated area on the implant surface. As microorganisms are likely to move toward the high-energy area by the mechanism of interface micromovements, it is advantageous to have a large distance between the stress concentration area and bone surface (Assenza et al. 2003, Guindy et al. 2004)

3.2.3. Proof of Concept

Since its breakthrough into the professional conscwusness, the platform switching concept has been continuously put to the test by a host of studies and experiments. Today, the literature contains enough evidence to transcend platform switching from the realm of theory to the realm of scientific truth.

Early studies showed encouraging results. In a randomized clinical trial, Canullo and Rasperini (2007) studied 10 platform-switched implants during a follow-up period of 18 to 36 months and observed a smaller mean marginal bone loss than what was reported by the literature for regular implants. A prospective study by Hiirzeler et al. (2007) compared the marginal bone loss around 14 platform-switched implants to that around 8 platform-matched implants and concluded that a platform-switched configuration reduced peri-implant bone loss by a significant margin. Later comparative studies (Prosper et al.2009, Vigolo & Givani 2009, Canullo et al. 2010, Canullo et al. 2012, Telleman et al. 2014, Guerra et al. 2014) continued to show better bone preservation around platform-switched implants when compared to regular platform-matched implants (Fig. 15, Fig. 16, Fig. 17).

Group	Time 1	Time 2	Time 3	Time 4	Time 5
A1 (n = 42)	0.9 ± 0.3	1.0 ± 0.3	1.0 ± 0.3	1.1 ± 0.3	1.2 ± 0.3
A2 (n = 43)	0.8 ± 0.2	0.9 ± 0.3	0.9 ± 0.3	1.0 ± 0.3	1.0 ± 0.3
A overall (n = 85)	0.9 ± 0.3	1.0 ± 0.3	1.0 ± 0.3	1.1 ± 0.3	1.1 ± 0.3
B1 (n = 50)	0.6 ± 0.2	0.6 ± 0.2	0.6 ± 0.2	0.6 ± 0.2	0.6 ± 0.2
B2 (n = 47)	0.5 ± 0.2	0.5 ± 0.2	0.5 ± 0.2	0.5 ± 0.2	0.5 ± 0.2
B overall (n = 97)	0.6 ± 0.2	0.6 ± 0.2	0.6 ± 0.2	0.6 ± 0.2	0.6 ± 0.2

Fig. 15: Vigolo and Givani (2009) followed up 182 implants placed in the posterior region for 5 years. A statistically significant difference was detected in crestal bone changes in wide-diameter implants restored with matching wide-diameter prosthetic components (group A) and wide-diameter implants restored with platform-switched prosthetic components (group B). After I 2 months of function, the group B implants showed less bone loss than the group A implants. The data did not change during the following 4 years of function.

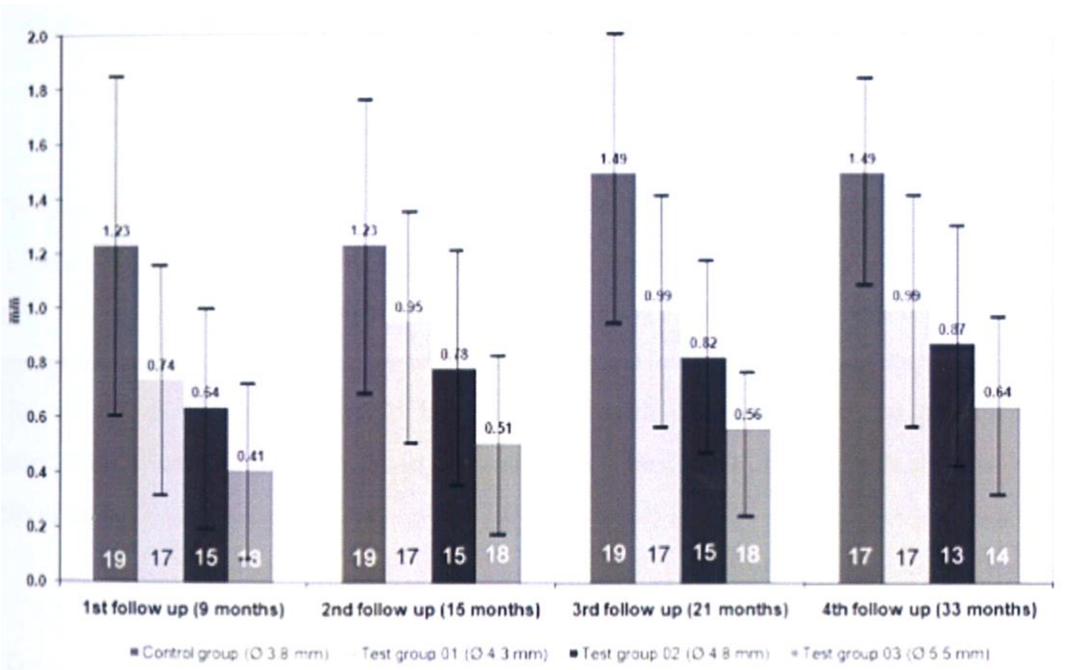

Fig. 16: Canullo etal (2010) placed 80 posterior implants divided according to their platform diameter into four groups: 3.8 mm (control group), 4.3 mm (test group 1), 4.8 mm (test group 2) and 5.5 mm (test group 3). Radiographic bone height was measured at the time of implant placement and after 9, 15, 2 1 and 33 months. After 21 months, radiographic evaluation showed a mean bone loss of0.99 mm for test group 1, 0.82mmfor test group 2 and 0.56 mm for test group 3. These values were significantly lower compared with the control group (1.49 mm).

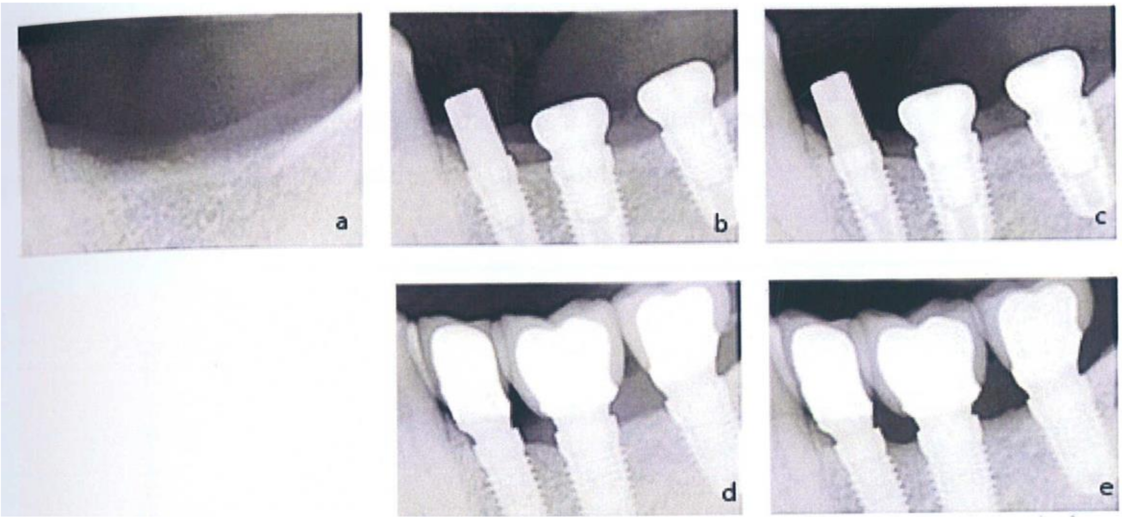

Fig 17: In a study by Guerra et al (2014), 146 implants were radiographically observed: 74 platform-switched implants and 72 platform-matched The difference of mean marginal bone level change from surgery to 12 months was significant between the two groups, with the platform-switched group showing superior bone preservation and gain. Standardized peri-apical radiographs were taken before implant placement (a), immediately post-surgery (b), before (c) and after abutment/crown placement (d) and at I year post-loading (e).

In a recent systematic review and meta-analysis covering 28 publications reporting on 1216 platform-switched implants and 1157 platform-matched implants, Chrcanovic et al. (2015) concluded that platform-switched implants resulted in significantly less marginal bone loss than platform-matched implants. However, the group mentioned that the results of the review should be interpreted with caution due to the presence of uncontrolled confounding factors in the included studies, most of them with short follow- up periods.

3.3. Design Specifications and Variations

The effects of platform switching are influenced by a number of factors. The following modifications have been observed to play at least a small part in the bone-preserving properties of platform switching.

3.3.1. Extent of Platform Mismatch

While there does not seem to be a clear indication as to what the ideal extent of implant/abutment mismatch is, some systematic reviews and meta-analyses have suggested that an implant/abutment mismatch of at least 0.4 rnrn is more beneficial for preserving marginal bone (Atieh et al. 2010, Annibali et al. 2012) Atieh et al. (2010) also noted that the changes in marginal bone levels were more favorable with increasing the extent of mismatch between implants and abutments. A similar observation was made in a more recent review and meta-analysis conducted by Chrcanovic et al. (2015), as demonstrated in Fig. 18.

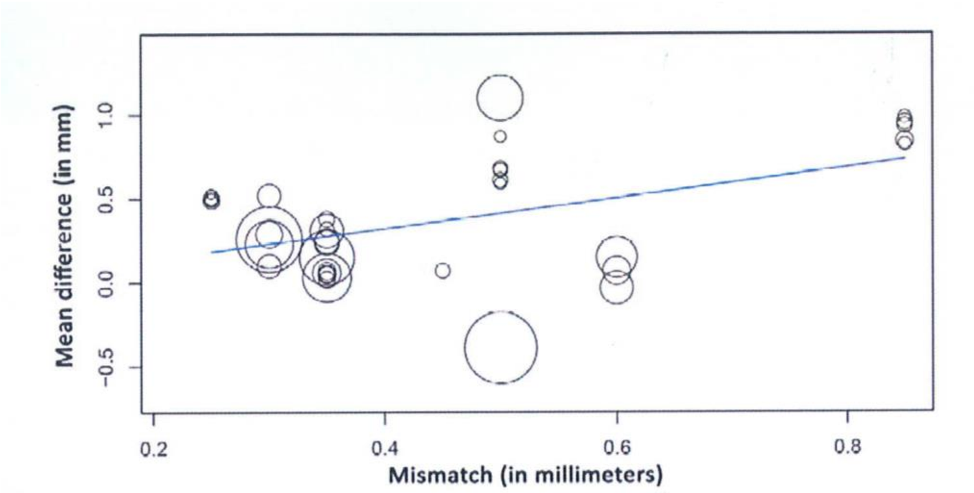

Fig. 18: Scatter plot for the meta-regression with the association between the mean differences (in millimeters) of the marginal bone loss between the two procedures (platform-switched vs. platform-matched) and the mismatch (in millimeters) (Chrcanovic etal 2015)

Indeed, the effect of platform switching on marginal bone levels seems to be "dose dependent." In a randomized control trial, Canullo et al. (2010/ 4 demonstrated that the greatest platform-abutment mismatch resulted in the least marginal bone loss and concluded that the degree of platform switching could have a significant influence on peri-implant marginal bone remodeling (Fig. 19). It was speculated that these findings could be attributed to a wider space for horizontal repositioning of the biological width and/or a better distribution of loading stress at the bone/implant interface.

It has been suggested that the findings of reduced bone remodeling accompanying a larger implant-abutment difference may be due to an increased implant diameter rather than to the platform, because a bigger mismatch is often caused by the use of a wider diameter (Enkling etal 2013). However, comparative studies of implants with different diameters in relation to marginal bone loss did not show different outcomes (Canullo et al 2012)

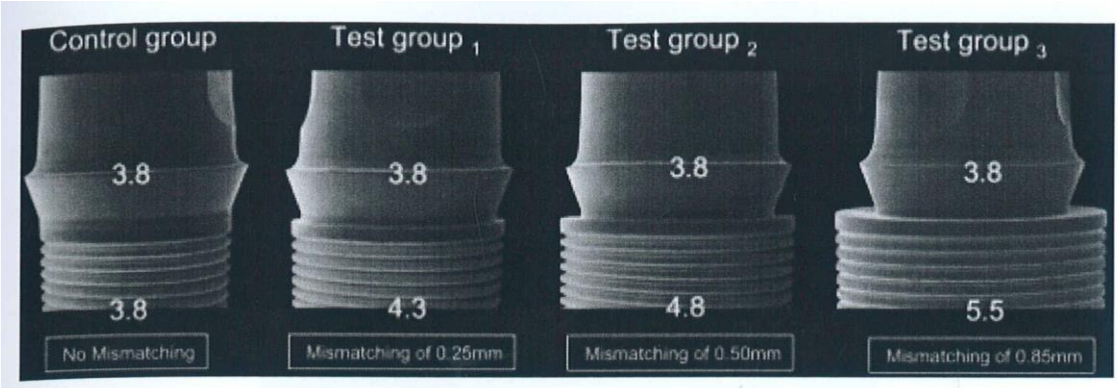

Fig. 19: SEM image of implants of the control and test groups from the Canullo etal (2010) study. According to implant platform diameter, implants were divided into four groups: 3.8 (control group) with no mismatching, 4.3 (test group 1) with a mismatching of0.25mm, 4.8 (test group 2) with a mismatching of 0.5mm and 5.5mm (test group 3) with a mismatching of 0.85mm. The abutment diameter was 3.8mm in all groups. In this study, it was observed that marginal bone levels were even better maintained with increasing implant/abutment mismatching.

3.3.2. Apical-Coronal Location of the Microgap

Marginal bone loss around implants is influenced by the location of the microgap in relation to the level of the crestal bone (Cochran et al. 2009, Weng et al. 2011). As such, the apical-coronal level of the implant platform should be taken into consideration when evaluating the efficacy of platform switching on the maintenance of marginal bone.

In their clinical human study, Veis et al. (2010) noted that the beneficial effect of the platform switching concept was evident only in subcrestal implants, not in crestal or supracrestal ones. Barros et al. (2010) also found in a histomorphometric animal study that subcrestally-placed, platform-switched implants with rough surfaces at the implant collars yielded less marginal bone loss with respect to platform-matched implants. A retrospective study conducted by Donovan et al. (2010) reported that subcrestal placement of dental implants with a platform-switched Morse taper connection resulted in minimal marginal bone loss and a high percentage of implants with mineralized hard tissue on the implant platform. Similar results were found in a randomized prospective clinical study conducted by Koutouzis et al. (20I4), where it was reported that implants placed with the implant/abutment interface 1 or 2 mm apical to the buccal aspect of the bone crest demonstrated less marginal bone loss apical to the implant platform, and a greater percentage of implant surfaces showed bone on the implant platform, compared to implants placed with the implant/abutment interface at the level of the buccal aspect of the alveolar bone crest.

In a recent systematic review, however, Chrcanovic et al. (2015) noted that, as the implant platform varied from study to study and this information was not always provided, it may still be difficult to unequivocally interpret the available evidence about implant/abutment interface placement in platform-switched implants.

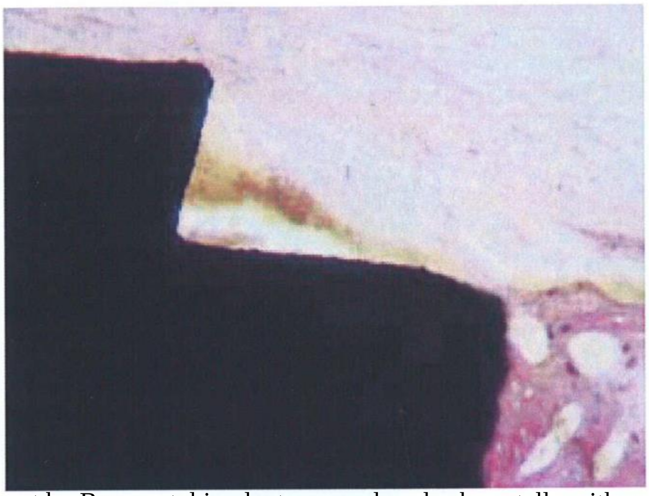

Fig. 20: In an experiment by Barros etal implants were placed subcrestally with an interimplant distance of J mm. No vertical bone resorption was observed and the first bone-to-implant contact coincided with the shoulder of the implant. No connective fibrous tissue was present at the implant interface (Barros etal 2010)

In a study by Leon et al. (2014), a finite element analysis was conducted on anterior, platform-switched implants to investigate the biomechanical implications of the subcrestal positioning of the implants. It was concluded that the position of the implant/abutment interface has an important role in the stress distribution in peri-implant bone. The group also suggested that a subcrestal positioning of 0.5 mm might be appropriate to avoid the risk of overloading the implant, with the added benefit of concealing the implant neck and establishing an adequate emergence profile.

3.3.3. Platform Design

In their systematic review and meta-analysis, Chrcanovic et al. (2015) suggested that the large variation in results between some studies may have been partly influenced by the implant-abutment connection type and different platform designs.

When talking about platform designs, one example is the difference between the horizontal platforms of the Brfmemark (Nobel Biocare) and (Biomet) implants when compared to the inclined platform of the Straumann (Straumann AG) and Astra (Astratech AB) implants. It is, however, yet unknown to which magnitude these differences in platform design may affect the results (Chrcanovic et al. 2015)

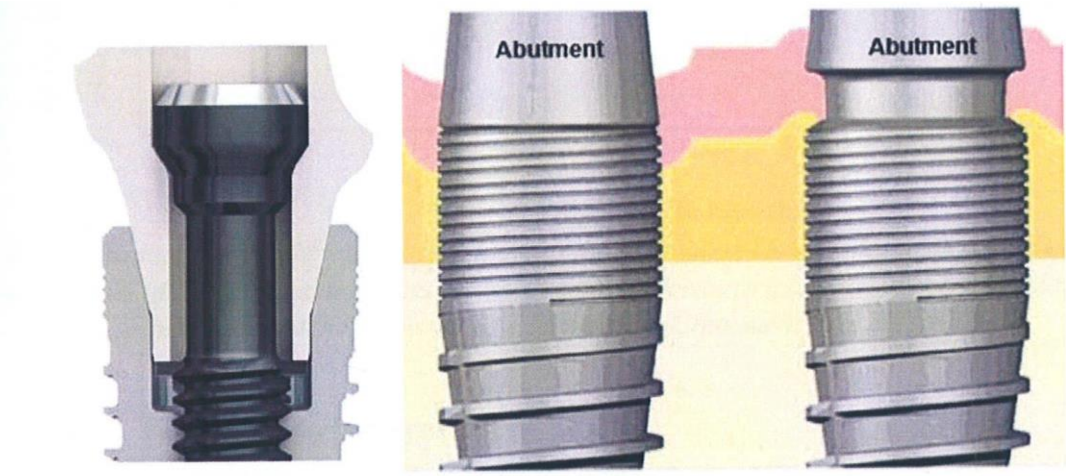

Fig. 21: A platform-switched Brtmemark implant with a horizontal platform (left), a platform-matched Straumann implant (center) and a platform-switched Straumann implant with an inclined platform (right).

3.4. Platform Switching in Relation to Other Concepts

An advanced appreciation of platform switching demands its application with respect to other established concepts, whether to better understand the extent of its effects or to open up new treatment possibilities.

3.4.1 Marginal Bone Loss with Respect to Time

The results of a systematic review and meta-analysis conducted by Chrcanovic et al. (2015) suggested that that there is an increase of the mean difference of marginal bone loss between the platform-switched and platform-matched approaches with the increase of the follow-up time (Fig X). The group stressed, however, that the existence of only a few studies with long-term follow-ups is problematic to the conclusiveness of these findings.

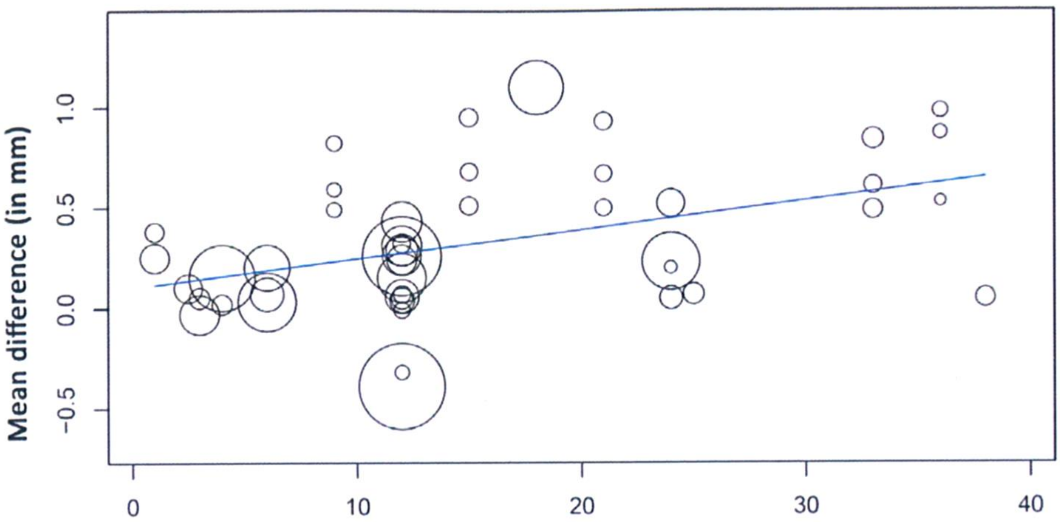

Fig. 22: Scatter plot for the meta-regression with the association between the mean differences (in millimetres) of the marginal bone loss between the two procedures (platform-switched vs. platform-matched) and the follow-up time (in months) (Chrcanovic etal 2015).

3.4.2. Proximity to Natural Teeth

Esposito et al. (1993) evaluated implants with matching implant-abutment platforms and reported increased bone loss to adjacent teeth as the horizontal tooth-implant distance between the two structures decreased. Subsequent studies further validated these findings, leading many authors to recommend a minimum of 1.5 to 2 mm between the tooth and implant to avoid causing bone loss around them. This makes it impossible to place a 4 mm diameter implant in a mesio-distal space of 7 mm (Vela et al 2012), causing a potential hurdle to the treatment.

Platform-switched implants seem to pose a solution to this. A study by Vela et al. (2012) using platform-switched implants demonstrated a 0.37 mm mean bone peak resorption at a mean tooth-implant distance of 0.9 mm. These values (Fig. 23) were much lower than those found in the study conducted by Esposito et al, suggesting that a tooth- implant distance of 1 mm was sufficient to maintain the bone peak. Similar findings were observed in a more recent study by Urdaneta et al. (2014).

	N	Minimum	Maximum	Mean	SD
ITD	70	0.19	1.49	0.99	0.35
HBR	70	0.02	1.00	0.36	0.26
VBR	70	0.02	1.90	0.43	0.37

Fig. 23: Means, standard deviations (SDs), and minimum and maximum measurements obtained for lTD (distance between implant and tooth), HBR (horizontal bone resorption) and VBR (vertical bone resorption) (Vela 2012)

3.4.3. Proximity to Other Platform-switched Implants

While it has been shown that a minimum of 3 mm must be kept between two adjacent platform-matched implants (Tarnow etal 2000, Traini etal 2008 & 2010) thesame does not appear to be the case when using platform-switched implants.

A histomorphometric animal study about the effect of interimplant distance on crestal bone loss was conducted by Elian et al. (2011) • The group inserted platform-switched internal connection implants with 2 and 3 mm intervals in Gottingen minipigs, and reported no significant differences on inter-implant crestal bone heights 2 months after the implantation. This was in agreement with previous animal experiments on the matter (Novaes et al 2006, Barros et al 2010) Human studies also seem to confirm these findings. Chang and Wennstrom (2010) analyzed peri-implant bone change using radiographic evaluation for 5 years and reported that the mean change of inter-implant crestal bone around close-proximity posterior implants 1 year after the abutment connection was found to be -0.13 ± 0.34

mm. The change after 5 years of connection reached -0.32 ± 0.6 mm. These values compare favorably with those found in the Tarnow et al. (2000) experiment.

A more recent human trial conducted by Jo et al. (2014) was in accordance with these findings: the inter-proximal distance with platform switched internal connection implants did not show a significant influence on crestal bone loss (Fig. 24), and the horizontal vertical marginal bone loss was found to be too small to result in an overlapping loss of inter-implant crestal bone.

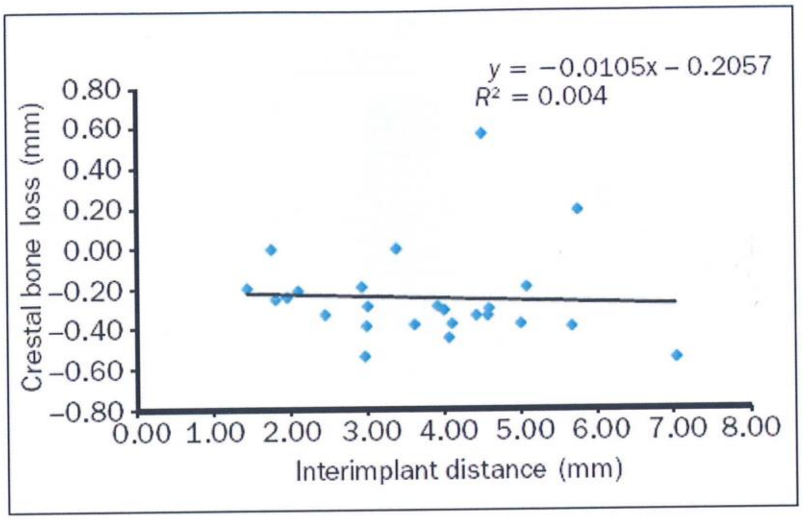

Fig. 24: Correlation between crestal bone loss and inter-implant distance from the Jo et at. (2014) study.

3.4.4. Disconnection and Reconnection of Platform-switched Abutments

In two piece implants, the abutment is typically disconnected several times during the prosthetic phase of treatment. The disruption of the soft tissue that occurs each time the implant components are disconnected and reconnected is thought to influence bone resorption around the implant (Abrahamsson et al. 1997, Rodriguez et al. 2013). Standard clinical protocols may require the removal of an abutment up to four times: for implant-level impressions, try-in of the metal framework, try-in of the porcelain before the final firing and glazing, and delivery of the definitive prosthesis (Rodriguez et al. 2013).

In an animal study, Abrahamsson et al. (1997) showed that vertical peri-implant bone resorption increased from 0.78 mm prior to any abutment disconnection to 1.49 mm after five changes. A more recent animal study by Rodriguez et al. (2013) aimed to confirm the resorptive effect of disconnecting and reconnecting abutments while presenting platform switching as a potential solution. After four disconnections, the vertical and horizontal bone resorption values for the platform-matched and platform-switched implants were similar to the values normally found in similar studies (Fig. 25).

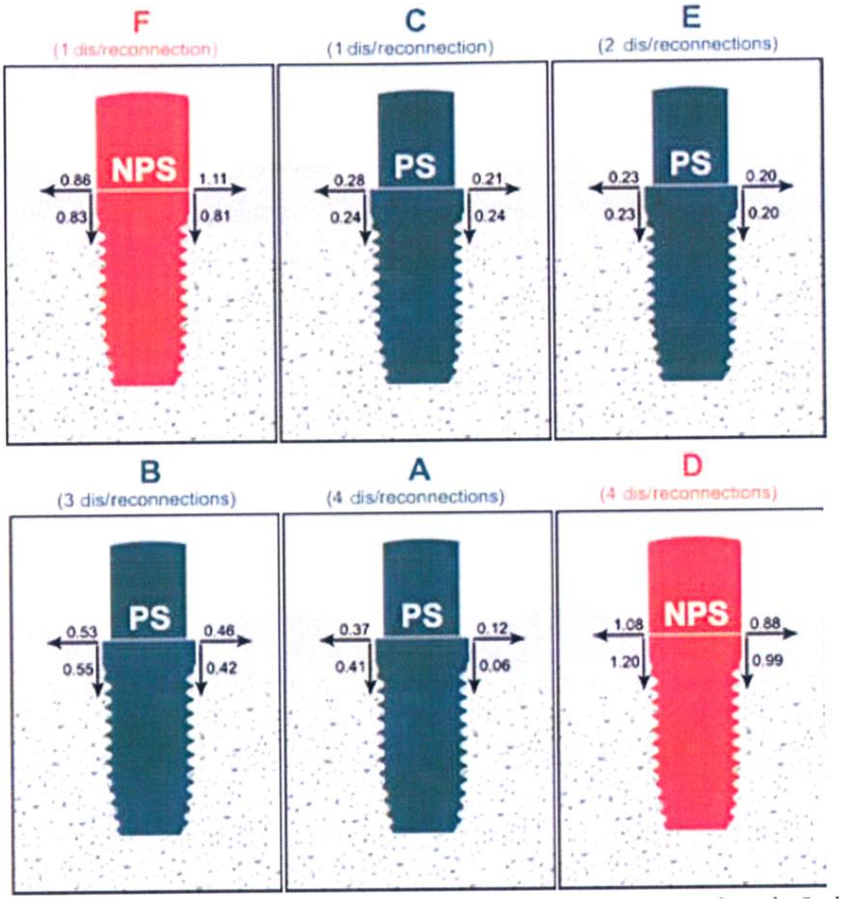

Fig. 25: Horizontal and vertical peri-implant bone resorption on each implant site from the Rodriguez et al. study. After four dislreconnections, vertical peri-implant bone resorption in matched implants was 1. 1 mm and horizontal was 0.98 mm, while peri-implant bone resorption in platform-switched implants was 0.24 mm horizontal and 0.40 mm vertical (Rodriguez etal 2013)

Considering the remaining results, however, Rodriguez et al. (2013) concluded that implants with a platform-switched design show less peri-implant bone resorption during the healing process and as their abutments are disconnected than do dis/reconnected platform-matched implants. In addition, a single dis/reconnection of the platform-matched abutments may generate a peri-implant bone resorption similar to that produced by four dis/reconnections. On platform-switched implants, meanwhile, a greater number of dis/reconnections generate more peri-implant bone resorption, but at least two times, two weeks apart are needed to trigger statistically significant bone resorption. These findings confirm the importance of reducing the number of abutment dis/reconnections when attempting to minimize peri-implant bone resorption and hinted at platform switching's superior contribution to that cause.

3.5. Advantages and Disadvantages of Platform Switching

3.5.1. Advantages

The esthetic replacement of teeth has become an important standard for implant dentistry, but the ability to restore implants esthetically has been fraught with obstacles and sometimes has not been attainable. Two main concerns remain the loss of implant papilla and the exposition of the metal collar at the implant shoulder in the esthetic zone (Leblebicioglu et al. 2007) Moreover, the creation of the biologic width can cause vertical peri-implant bone loss that alters the initial crown/implant ratio and even inverts it, creating an unfavorable situation that reduces the long-term predictability of the restoration (Fig. 26) (Vela-Nebot et al. 2008).

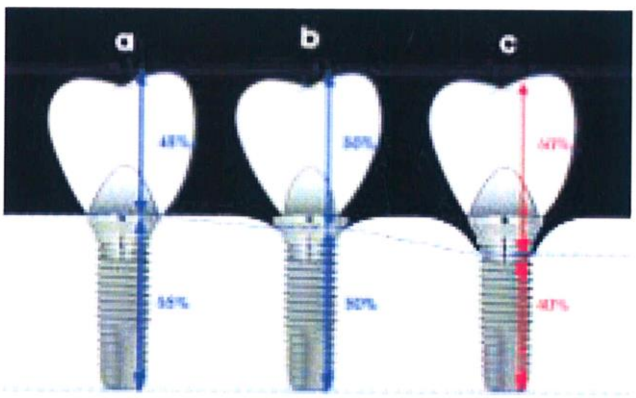

Fig. 26: Variations in crown/implant ratio. (a) Initial situation without platform switching. (b) Peri-implant bone loss with platform switching. (c) Peri-implant bone loss without platform switching (Vela-Nebot etal 2008)

Platform switching presents a clear potential to negate some of these obstacles. This is achieved through better preservation of the marginal bone around platform-switched implants compared to conventional platform-matched implants (Chrcanovic et al. 2015) and a better distribution of biomechanical forces (Yang & Maeda 2013).

Based on this, platform switching has a range of clinical benefits:

(1) Platform switching helps retain peri-implant crestal bone, thus providing better support for the soft tissues. This is extremely important in anterior restorations, in which preserving the buccal plate and maintaining the peri- implant crestal bone determines gingival aesthetics and the health of the implant-supported restorations (Fig 27) (Vela-Nebot et al. 2008).

(2) Platform switching makes it possible to place implants at a closer proximity to other implants and to natural teeth when the prosthetic guide requires it, while still preserving the adjacent bone level. This allows for better functional and esthetic results in cases where the mesio-distal space is limited (Rodriguez- Cuirana et al. 2009, Vela et al. 2012)

(3) Platform switching permits a superior management of occlusal stress (Maeda et al. 2007, Yang & Maeda 2013), better protection of peri-implant soft tissues from abutment dis/reconnection (Rodriguez et al. 2013) and its effect is stable with time (Chrcanovic et al 2015), thus allowing for more predictability in the implant treatment.

Fig. 27: Tooth II restored with a platform-switched implants after three years of follow-up (Vela-Nebot et al 2008)

3.5.2 Disadvantages

While platform switching has the biomechanical advantage of shifting the stress concentration away from the bone-implant interface, it has been suggested that higher stress occurred around the outside of the abutment and implant connection area, possibly causing problems such as abutment screw deformation over the elastic limit (Maeda et al. 2007). In addition to this, it has been reported that probing and achieving an adequate prosthetic emergence profile can become slightly trickier due to the unconventional profile of the platform-switched implant, but these claims have yet to be substantiated by scientific evidence.

3.5.3. Indications

Taking the advantages and disadvantages of platform switching into consideration, a number of possible indications can be presented:

(1) Anterior esthetic zone (Vela et al. 2012)

(2) Limited mesio-distal space (Vela et al. 2012)

(3) Implant-related interventions that require a careful management of occlusal forces, such as sinus grafts (Rodriguez-Ciurana et al. 2009(4) Short implant (Rodriguez-Ciurana et al. 2009)

(5) Oblique loading (Yang & Maeda 2013)

4. CONCLUSION

Marginal bone loss around the implant neck has long been considered an unavoidable obstacle in the way of an ideal implant restoration, a necessary evil to be borne despite the clinician's best efforts to avoid it. Such has been the implantologist's powerlessness in the face of it that a marginal bone resorption of 1.5 mm during the first year and 0.5 mm during every subsequent year became considered as a criterion of implant success (Albrektsson et al. 1986l. Today, however, advancements in implant design and individual case treatment planning provide ways to control marginal bone loss. The concept of platform switching is one such advancement.

Platform switching is a new concept in implant design that promises a solution to peri-implant marginal bone loss. It revolves around the use of a smaller-diameter abutment or supra-structure on a larger-diameter implant collar, resulting in a circular horizontal step and the inward horizontal repositioning of the implant-abutment junction (Lazzara & Porter 2006). On a biologic level, this achieves two things: a horizontal platform for the biologic width to establish itself on and the repositioning of the abutment inflammatory cell infiltrate (ICT) away from the surrounding bone, reducing its resorptive effect (Lazzara & Porter 2006, Cochran et al. 2013). On a biomechanicallevel, platform-switched implants yield better stress distribution along the implant and reduce stress levels on the implant/bone interface (Maeda et al. 2007, Yang & Maeda 2013). Several studies (Chrcanovic et al. 2015) have since confirmed platform switching's potential to preserve marginal bone. Its effect has also been shown to be influenced by the extent of the platform mismatch (Canullo et al. 2010) and the apical-coronal location of the microgap (Leon et al. 2014) and has positive implications on previous limitations such as the proximity of placement next to other implants (Jo et al. 2014) and natural teeth (Vela et al. 2012) and the repeated disconnections/reconnections of abutments (Rodriguez et al. 2013). It has been confirmed that platform switching achieves a better preservation of marginal bone (Chrcanovic etal 2015) and a superior management of occlusal stress (Maeda et al 2007, Yang & Maeda 2013) compared to conventional implants. This brings with it several clinical benefits. Platform switching helps retain peri-implant crestal bone, thus providing better support for soft tissues, an extremely important criterion in esthetic anterior restorations (Vela-Nebot et al. 2008) Platform switching also preserves bone levels when placing implants in close proximity to each other or to natural teeth (Rodriguez-Ciurana et al. 2009, Vela et al 2012), improves the biomechanical properties of implant-supported restorations (Vela-Nebot etal 2008) and protects the peri-implant soft tissues (Rodriguez etal 2013).

Platform switching's impressive results bring with them an exciting revelation: marginal bone loss is not as unavoidable as it has long been considered. The concept's implications are as beneficial to implant treatment as marginal bone loss has been detrimental, and its mastery and continuous refinement opens up a host of new possibilities and opportunities in implant treatment. As in any other technology, however, one must fully understand its underlying science to truly be able to wield it to its full effect.

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