INFLUENCE OF PLATFORM-SWITCHING ON CRESTAL BONE CHANGES AT NON-SUBMERGED STRAIGHT AND INCLINED IMPLANTS RETAINING MANDIBULAR OVERDENTURES

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ABSTRACT

The purpose of this clinical trial was to study the influence of platform-switching concept on crestal bone changes at non-submerged straight and inclined implants retaining mandibular overdentures. Eight patients received 2 implants one straight and the other inclined in the canine region of the mandible. Mandibular overdentures were retained using spheroflex abutment attachments, with reduced platform width in relation to the implant diameter. Standardized digital radiographs were obtained for evaluation of the crestal bone levels at the time of the installation of the final restoration and at a 2-year follow-up. Crestal bony levels were measured at the mesial and distal surfaces of each implant using digital image analysis. The mean crestal bone level changes from baseline to one and two years followup in both straight and inclined implants were 0.07, 0.15 and 0.18, 0.30 at the mesial side and 0.07, 0.17 and 0.13, 0.22 at the distal side, respectively. The concept of the platform-switching appears to limit crestal bone resorption in both straight and inclined implants and seems to preserve periimplant bone levels. However, a significant difference concerning the mesial periimplant bone height of the inclined implant compared to that of the straight one was still detected.

INTRODUCTION

A mandibular overdenture supported by 2 implants is an effective treatment alternative for the maladaptive denture wearer (1). It has been recommended that implants be placed parallel to one another and to the path of insertion of the prosthesis, especially when ball attachments are contemplated. Clinically, these guidelines may not be fulfilled dependent on the anatomy and morphology of bone and misalignment of implants may result (2,3). Non-parallel implants, when used to retain overdentures, may present a restorative challenge, particularly when using attachments (4).

Concerns have been expressed that horizontal forces directed to implants may contribute to bone resorption or angular defects (5-10). It has been recommended that implants, especially when individual ball attachments are contemplated, be placed parallel to one another and to the path of insertion of the planned denture (11,12). It
has also been suggested that the implants be positioned as perpendicular to the occlusal plane as possible so that they are loaded axially without producing a bending moment. Furthermore, it has been advised that the two implants be placed such that a line joining them would be parallel to the hinge axis. However, the optimal placement of implants is also dependent on the anatomy and morphology of the bone, meaning that, in clinical practice, all of the foregoing guidelines may not be fulfilled.

The professional literature and instructions accompany ing various prefabricated attachments have stressed parallelism of the patric components. When these types of overdenture attachments are considered for nonparallel implants, there are concerns regarding incomplete seating of the prosthesis, unpredictable retention, and premature wear of the retentive matrices and/or patric es. Because of the generally held belief that ball attachments cannot be used when the implants are not parallel, many restorative dentists revert to using angled abutments, flexible attachments, or bar and clip assemblies to compensate for these situations. This increases the cost and complexity of fabrication and maintenance.

A technique using angle-correcting abutments has been recommended. The ability of these abutments to correct the misalignment is limited to the preangled shape. The technique is further complicated because most of the steps must be performed intraorally as opposed to in the laboratory. It has been suggested that the divergence or convergence of approximately 10 degrees between 2 non-splinted implants can usually be tolerated, excessive wear may result from wider angles.

Ortego’n et al outlined the importance of aligning the attachments to the path of insertion and withdrawal of the prosthesis in a parallel approach in both parallel and non-parallel implants. This finding potentially validate the use of resilient parallel attachments to correct non-parallel implants without changes in retention values.

Postrestorative reductions in crestal bone height around endosseous dental implants have long been acknowledged to be a normal consequence of implant therapy involving two-stage hexed implants. Such remodeling does not typically occur as long as the implant remains completely submerged, but rather develops when an abutment is connected during second-stage surgery, when a two-stage implant is placed and connected to an abutment in a one-stage procedure, or when an implant is prematurely exposed to the oral environment and bacteria.

Crestal bone levels are typically located approximately 1.5 to 2 mm below the implant-abutment junction (IAJ) at 1 year following implant restoration, but are dependent on the location of the IAJ in relation to the bone crest. Therefore, the inevitable microgap of the IAJ and its microbial colonization seems to play a major role in this remodeling process. This is also confirmed by the finding that crestal resorption is not evident as long as the implant remains completely submerged, but develops once an implant has been exposed to the oral environment. Various explanations as to why the margin between implant and abutment appears to activate resorptive proceedings in the adjacent bone have been presented. Ericsson et al found histologic evidence that an inflammatory cell infiltrate is located 1 to 1.5 mm adjacent to the IAJ. Furthermore, Berglundh and Lindhe showed that approximately 3 mm of peri-implant mucosa is required to generate a mucosal seal around dental implants. Taken together with the findings that bone is always encircled by approximately 1 mm of healthy connective tissue, it can be assumed that crestal bone remodeling may take place to create space between the bone and microbial contaminated tissue to establish a biological seal. The purpose of this biological seal seems to be the isolation of the underlying crestal bone and the protection from the oral microbiologic environment.

In addition to several ideas to limit crestal bone resorption, the concept of platform-switching (PSW) refers to the use of a smaller diameter abutment on a large diameter implant collar. This connection shifts the margin of the IAJ inward, towards the central axis of the implant. The inward movement of the IAJ is believed to shift the inflammatory cell infiltrate to the central axis.
of the implant and away from the adjacent crestal bone, which is thought to limit crestal bone resorption (24).

Platform-switching can provide clinical benefits in at least three areas:

• Where a wider-diameter implant makes sense for surgical reasons but the prosthetic space is limited.

• Where preservation of the bone results in improved esthetics, as under the papillae or on the labial aspect of anterior restorations.

• When short implants must be used (29).

In 1991, the 3i wide diameter 5.0 and 6.0 mm implants were designed with a matching diameter seating surface to be used mainly for poor quality bones to achieve improved stability. However, when introduced, there were no matching diameter prosthetic components available, and as a result, most of the initially placed implants were restored with standard 4.1 mm diameter components, which created a 0.45 mm or 0.95 mm circumferential horizontal difference in dimension.

Radiographical reviews after the initial 5 year period revealed that when matching diameter implants and restorative components are used, the crestal bone contacting the implant normally remodeled to ~ 1.5-2 mm apically ~ to the first thread. In contrast, when smaller diameter components were placed on wider diameter platforms, the amount of crestal remodeling was reduced. Many platform switched restored implants exhibited no vertical loss in crestal bone height (24).

In a study carried to compare platform-switched and non platform-switched implants a significant difference was evident regarding periimplant bone levels at baseline and 1-year after insertion of final prostheses. Furthermore, the bone level decrease between baseline and 1-year follow-up was statistically less pronounced in the group with the platform-switched abutments. This radiographic observation suggests that the resulting postrestorative biologic process can be altered when the outer edge of the implant-abutment interface is horizontally repositioned inwardly and away from the outer edge of the implant platform (30).

Bone resorption can be activated by surgical trauma or bacterial infection, as well as by overloading at the bone-implant interface (31-34). Under functional forces, overloading of periimplant bone can be induced by a short coming in load transfer mechanisms, primarily due to improper occlusion, surgical placement and prosthesis and / or implant relation and design. Improper implant angulations and attachment position may induce interfacial shear stresses at the bone-implant interface. Related strain fields in bone tissue may stimulate biological bone resorption, jeopardizing implant effectiveness (33-36).

The purpose of this clinical trial was to study the influence of platform-switching on crestal bone changes at non submerged straight and inclined implants retaining mandibular overdentures.

MATERIALS AND METHODS

An overall, eight male patients, age range from 45-69 years, medium age 58.5 years, were included in this clinical investigation. All patients were chosen to be completely endentulous for more than 5 years. A patient was not admitted to the study if any of the following criteria existed: (1) alcohol or drug abuse. (2) health conditions that would preclude surgical procedures (such as uncontrolled diabetes). (3) any pathological conditions such as previous tumors, chronic bone disease or previous irradiations. (4) severe bruxism or clenching habits. (5) psychiatric disease. (6) abnormal ridge relationships. (7) narrow interarch space. Panoramic, lateral cephalometric and periapical films to the canine regions were performed to access the bone quality and height to accommodate a 13 mm length implants.

In is important to note that sufficient tissue depth (approximately 2 mm or more) must be present to accommodate an adequate biological width. In the absence of sufficient soft tissues, bone resorption will likely result, regardless of the implant geometry (37,38). This sometimes requires that the implant platform be placed below the bone crest to obtain adequate tissue depth.
Steps of complete denture construction were carried out for all patients until the try-in stage using lingualized occlusion concept (39,40). Duplication of the mandibular try-in was done into a stone cast. A transparent vacuum-pressed acrylic template was made on the duplicate cast to be used during surgery. Two holes were then drilled through the cingulum of the canine imprints. These holes are made wide enough to allow the free movement of the surgical drills. Lingual to these two holes, two stainless steel rods were fixed using molten wax so that one of them is placed parallel to the long axis of the canine and the other one making an angle varying from 15–20° with the first one. The angle is measured using a compass. These two rods were then fixed in their positions using an adhesive material (Fig. 1). Complete dentures were then flasked and processed. Dentures were checked intraorally for extension, retention and any occlusal adjustments.

Each patient was provided with two titanium endosteal root-form Screwplant implants [Spectra-System, Implant Direct LLC, CA]. Implants of 13 mm length and 3.7 mm diameter were chosen. The implants have an internal connection with 2 mm long hex and external bevel with 3.7 mm diameter platform. The body of the implant is tapered evenly down to facilitate insertion with least heat generation. The SBM [Soluble Blast Media of hydroxyapatite] textured surface extends over the entire endosseous portion of the implants. Mini-threads start 1 mm below the top of the implant and extend for 2-2.5 mm before transitioning into double-lead threads to the apex of the implant. Mini-threads reduce stress in the critical crestal bone region while double-lead threads reduce the number of turns required to seat the implant. Vertical cutting grooves extend half way up the implant from apex for self-tapping insertion.

All standard measurements for non-submerged protocol were followed (41,42). The anterior mandibular ridge was exposed and the mental foramina identified by a crestal incision. Implant sites preparation was completed aided by the prepared vacuum-pressed template. An effort was made to (1) decrease as much as possible heat generation (2) placing the implant at the level of the crest of the ridge or slightly below by 2 mm according to the thickness of the soft tissue (3) engaging the cortical bone of the mandibular inferior border to attain primary stability. Healing colars of 3-4 mm length and 3.5 mm diameter platform were connected preparing for the platform-switching mechanism. Patients were left for a week healing period. Mandibular complete dentures were then relieved opposite the area of the healing collars and relined using resilient soft liners. Dentures were delivered to the patients after ensuring absence of any occlusal discrepancies or overloading. Osseointegration of the fixtures was radiographically verified by panoramic and periapical x-ray films.

Platform-switched spheroflex abutments [Rhein 83 Srl, Italy] were requested from the company to have 3-4 mm cuff height and 3.5 mm platform. Restoring the 3.7 mm diameter collar (implant restorative platform) with the 3.5 mm prosthetic component medializes the implant / abutment junction.

Following the period of osseointegration, mandibular dentures were permanently relined and healing collars were removed. Spheroflex abutments are the only attachments with a mobile 2.5 mm diameter spheres,
that when taking into consideration the elasticity of the retentive caps, incline 7.5˚ in all directions. The prosthesis can even be inserted in a situation when there is a marked non-parallism. It is extremely difficult to unscrew the attachments if the proper tool for screwing is used and repeatedly tightened to permit good adaptation. Aided by its self-parallelizing spheres and the 0,7,14˚ directional rings (Fig. 2), direct picking-up was done intraorally. Holes are drilled opposite to the spheres in the relined mandibular dentures, protective disks were inserted below the spheres, picking-up was done using self-cured acrylic resin while the patient was closing in centric occlusion. Excess resin was refined and the prosthesis finished and polished. Adjustment of occlusion was performed using clinical remounting. All patients were instructed to follow strict oral hygiene measures after attaining their approval (Fig. 3).

Crestal bone levels around the implants, were assessed by evaluation of intraoral radiographs using long-cone paralleling technique(43), at 1 week, 6, 12, and 24 months follow-up visits.

For each patient, at each follow-up period, two standardized periapical radiographs were made for each implant using a special acrylic radiographic stent. Exposure time was 0.2 sec at 65 Kvp and 10 mA. Intraoral size 2 double film packets were used [EKTA speed, Kodak, USA]. One film was developed and interpreted to assure accurate projection geometry while the other film was stored in a refrigerator. All stored films were processed at the end of the study period at the same session using an automatic processor [Kodak, Eastman, USA]. All films were digitized using a drum scanner [Optrex Technology Corporation, Model photomarker 3 FDC]. DBS WIN Version II [Durr Dental Gm and CO KG, Germany] computer program was used to measure alveolar crestal bone heights both mesialy and distaly. All films were stored on the computer memory. On the distal and the mesial sides of the implant, the apical and coronal crestal bone intersects were marked. Calibrated measurements were conducted starting from the marked bone intersects to the apex of the implant. For both the mesial and distal side of each study implant site, the mean of the coronal and apical measurements was calculated. If one measurement was available, it was used as the value for the side (30). For further standardization of the measurements the apparent radiographic length of each implant was measured from IAJ to the apex and compared to the actual known length of the implant which was fixed on each successive image (Fig. 4,5). All data were gathered, tabulated and statistically analyzed.
RESULTS

Data were presented as means and standard deviations (SD) values. Paired t-test was used to compare between straight and inclined implants, to compare between crestal bone height at both the mesial and distal sides of the implant and to study the changes by time in each group. This significance level was set at P ≤ 0.05. Statistical analysis was performed with SPSS 16.0® [Statistical Package for Scientific Studies] for Windows.

With respect to both the straight and inclined implants, there was no statistical significant difference between the mean crestal bone heights of the mesial and distal sides through all time periods. Moreover, in the mesial side, there was no statistically significant difference between the mean crestal bone heights in the straight and inclined implants through all time periods. The same results were attained with respect to the distal side.

With respect to the mesial and distal sides of the straight implant, the crestal bone height was constant after 6 months. There was a statistically significant decrease in the mean crestal bone height changes throughout all other intervals.

The mean difference was 0.07 and 0.15 mm at the mesial side and 0.07 and 0.17 mm at the distal side after one year and two years, respectively [Table 1].

With respect to the mesial side of the inclined implants there was a statistically significant decrease in the mean bone height changes throughout all intervals, except from 12-24 months, no statistical significant difference was recorded [Table 2].

With respect to the distal side of the inclined implant, there was no statistically significant decrease in the mean bone height changes after 6 months, however, along the other time intervals a statistically significant decrease in the mean bone height changes was detected.

The mean difference was 0.18 and 0.3 mm at the mesial side and 0.13 and 0.22 mm at the distal side after one and two year of follow-up, respectively [Table 2].
TABLE (1) The mean differences [MD], standard deviation [SD] values and results of paired t-test for the changes by time in mean crestal bone height of straight implant

<table>
<thead>
<tr>
<th>Side</th>
<th>Interval</th>
<th>MD</th>
<th>SD</th>
<th>P-value</th>
</tr>
</thead>
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<td>1 w – 6 m</td>
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<td></td>
<td>Not computed because the measurement was constant</td>
</tr>
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<td>Mesial</td>
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<td>0.05</td>
<td>0.025*</td>
</tr>
<tr>
<td></td>
<td>12 m – 24 m</td>
<td>0.08</td>
<td>0.04</td>
<td>0.004*</td>
</tr>
<tr>
<td></td>
<td>1 w – 12 m</td>
<td>0.07</td>
<td>0.05</td>
<td>0.025*</td>
</tr>
<tr>
<td></td>
<td>1 w – 24 m</td>
<td>0.15</td>
<td>0.05</td>
<td>0.001*</td>
</tr>
<tr>
<td></td>
<td>6 m – 24</td>
<td>0.15</td>
<td>0.05</td>
<td>0.001*</td>
</tr>
<tr>
<td>Distal</td>
<td>1 w – 6 m</td>
<td></td>
<td></td>
<td>Not computed because the measurement was constant</td>
</tr>
<tr>
<td></td>
<td>6 m – 12 m</td>
<td>0.07</td>
<td>0.05</td>
<td>0.025*</td>
</tr>
<tr>
<td></td>
<td>12 m – 24 m</td>
<td>0.1</td>
<td>0.04</td>
<td>0.018*</td>
</tr>
<tr>
<td></td>
<td>1 w – 12 m</td>
<td>0.07</td>
<td>0.05</td>
<td>0.025*</td>
</tr>
<tr>
<td></td>
<td>1 w – 24 m</td>
<td>0.17</td>
<td>0.05</td>
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<tr>
<td></td>
<td>6 m – 24 m</td>
<td>0.17</td>
<td>0.05</td>
<td>0.001*</td>
</tr>
</tbody>
</table>

*Significant at $P \leq 0.05$

TABLE (2) The mean differences [MD], standard deviation [SD] values and results of paired t-test for the changes by time in mean crestal bone height of inclined implant

<table>
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<tr>
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<th>MD</th>
<th>SD</th>
<th>P-value</th>
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<td>1 w – 6 m</td>
<td>0.07</td>
<td>0.05</td>
<td>0.025*</td>
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<tr>
<td>Mesial</td>
<td>6 m – 12 m</td>
<td>0.12</td>
<td>0.07</td>
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<td></td>
<td>12 m – 24 m</td>
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<td>0.12</td>
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<td></td>
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<td>&lt;0.001*</td>
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<tr>
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<td>0.08</td>
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<td>0.04</td>
<td>0.004*</td>
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<td>0.08</td>
<td>0.04</td>
<td>0.004*</td>
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<tr>
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<td>1 w – 12 m</td>
<td>0.13</td>
<td>0.05</td>
<td>0.001*</td>
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<tr>
<td></td>
<td>1 w – 24 m</td>
<td>0.22</td>
<td>0.08</td>
<td>0.001*</td>
</tr>
<tr>
<td></td>
<td>6 m – 24 m</td>
<td>0.17</td>
<td>0.05</td>
<td>0.001*</td>
</tr>
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*Significant at $P \leq 0.05$
Comparing the mean changes in crestal bone height of the mesial and distal sides related to each implant, it was detected that there was no statistically significant difference throughout all time intervals with respect to either the straight or inclined implants [Table 3].

Comparing the mean crestal bone height changes of both the straight and inclined implants at each side separately, it was found that in the mesial side, there was no statistically significant difference throughout all time intervals except for the period of 1 week – 12 months and 1 week – 24 months where the mean change in inclined implants showed statistically significant decrease in bone height than the straight implant. With respect to the distal side, there was no statistically significant difference throughout all time intervals (Table 4).

<table>
<thead>
<tr>
<th>Implant</th>
<th>Side</th>
<th>Interval</th>
<th>Mesial</th>
<th>Distal</th>
<th>P-value</th>
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<td>0.05</td>
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<tr>
<td></td>
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</tr>
<tr>
<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td>6 m – 24 m</td>
<td>0.15</td>
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<td>0.17</td>
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<tr>
<td>Inclined</td>
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TABLE (3 ) The mean differences [MD], standard deviation [SD] values and results of paired t-test for the comparison between changes in bone height of the mesial and distal sides related to each implant.
DISCUSSION

An implant-retained mandibular overdenture (IOD) with two implants is a treatment option for edentulous patients. “The McGill consensus statement” recommended that the mandibular overdenture retained by 2 implants should be the first-choice standard of care for edentulous patients (44). Naert et al (45) reviewed prosthetic complications for 36 patients with mandibular overdentures retained by 2 implants. The findings were that the ball attachment group required 29 rubber rings or housings to be replaced; while in the bar attachment group 2 clips were replaced (46). While it is believed that a divergence or convergence of about 10 degrees is manageable, further misalignment will cause wear of the attachment (3). Some attachment manufacturers propose that attachments are capable of correcting the angulations of the abutment to 40 degrees (47). These claims have yet to be independently confirmed in a clinical setting.

Ball attachments, when used on abutments that are nonparallel and/or outside the path of insertion, may result in loss of retention of the prosthesis (3). A study by Walton et al (48) has shown that there are a higher number of repairs required when the lingual inclination of implants was greater than 6 degrees or if the facial inclination was less than 6.5 degrees. The lingual inclination was estimated to be greater than 6 degrees for the patient presented in this report. A bar may have been considered as an option to correct the angulation problem. However, financial limitations and concern for only hygiene access were contraindications to the use of a bar. Furthermore, a long-span bar between 2 narrow bodied implants may submit the framework or implants to excessive loads.

<table>
<thead>
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<th>Side</th>
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</table>

*Significant at P ≤ 0.05
A preliminary study \(^{(49)}\) demonstrated that, when substantial implant nonparallelism exists, some spherical attachment systems can allow predictable retention and seating of rigidly retained parallel retentive matrices. Attachments that are able to move freely on a retentive sphere can easily be made parallel by adjusting the position of the matrix with the aid of the paralleling device described in this article. Therefore, spherical attachments can be used successfully for restorative applications with nonparallel implants. Parallel implants with matrices not positioned parallel to each other, however, will not function properly. The amount of matrix divergence that a particular type of attachment can accommodate is related to the freedom of the matrix orientation available in the system. Attachments designs that do not permit ball-and-socket rotation within the matrix will not accommodate matrix divergence.

Several long-term clinical studies have shown a mean marginal bone loss around dental implants of 1.5 - 2 mm in the first year after prosthetic restoration and 0.1 – 0.2 mm annually hereafter \(^{(20-23)}\). Currently concepts to avoid bone remodeling around dental implants have been developed including surgical trauma, implant design, subcrestal positioning and platform-switching concept.

Surgical trauma due to heat generated during drilling, elevation of the periosteal flap and excessive pressure at the crestal region during implant placement may contribute to implant bone loss during the healing period. It was reported that bone loss due to periosteal elevation was restricted to the area just adjacent to the implant, even though a larger surface area of the bone was exposed during surgery. Early implant bone loss is in the form of horizontal saucerization. However, bone loss after osseous surgery in natural teeth is more vertical. Signs of bone loss from surgical trauma and periosteal reflection are not commonly observed at the implant stage II surgery in successfully osseointegrated implants. Thus, surgical trauma is unlikely to cause crestal bone loss \(^{(50)}\).

To increase the surface area for osseointegration, threaded implants are generally preferred to smooth cylindrical ones \(^{(51)}\). Depending on bone quality and surface treatments, thread geometry can significantly influence implant effectiveness, in terms of both initial stability and the biomechanical nature of the bone-implant interface after the healing process \(^{(52,53)}\).

The use of prosthetic abutments with reduced width in relation to the implant diameter (platform-switching) seems to have the greatest potential to limit the crestal bone resorption \(^{(30)}\). Accordingly, when crestal bone geometry was modeled by the platform-switching configurations and subcrestal positioning the best stress based performance for compact bone was obtained \(^{(54)}\). Reduced diameter components beginning with healing abutment must be used from the moment the implant is exposed to the oral environment, since the process of biological width formation begins immediately \(^{(50)}\).

There appears to be one major consequence of the horizontal inward repositioning of the implant-abutment interface. As it has been shown, the IAJ is always encircled by an inflammatory cell infiltrate (0.75 mm above and below the IAJ). To protect the underlying bone from this inflammatory infiltrate and microbiologic invasion, 1 mm of healthy connective tissue is needed to establish a biologic seal comparable to natural teeth \(^{(24-28)}\). Thus, a close proximity of the IAJ to the bone, which is always established when implants are placed epicrestally, is eliminated by the bone resorption and establishment of the mentioned biologic seal. By repositioning the IAJ inward and away from the outer edge of the implant and adjacent bone (platform-switching), the overall effect of the inflammatory cell infiltrate on the surrounding tissue, as described by Ericsson et al \(^{(27)}\) may be reduced, thus decreasing the resorption effect of the inflammatory cell infiltrate on crestal bone. This can be explained by the enhanced distance, which is generated between bone and the inflammatory cell infiltrate by shifting the platform inwardly. Furthermore, by inward positioning of the abutment an approximately 90° step will be created compared with a 180° step when using the traditional
abutment design. The resulting confined area may have the consequence of restricting the inflammatory infiltrate to this restrained region and limiting the consequence to the adjacent tissues as it is mostly surrounded by nonbiologic material. This may result in a reduced inflammatory effect within the surrounding soft tissue and crestal bone.

The purpose of this clinical trial was to show the crestal bone height changes around the straight and inclined implants using a platform-switching protocol. It was found that this concept succeeded to keep the bone level almostly stable within the first year of remodeling in both implant situations after prosthetic reconstruction. This result was supported by a study carried by Huzeler et al. They compared between platform and non-platform implants. The mean bone level change from baseline to one year follow-up was 0.12 mm ± 0.4 mm for the platform-switched implants and 0.29 ± 0.34 mm, respectively for the non-platform switched implants. In this study, with respect to the inclined implants, the mean crestal bone change after the first year follow-up ranges from 0.13 – 0.18 mm, which was about half the changes reached by the previous study in the non-platform switched implants and approaching the values of the platform-switched ones. However, the straight implants, showed 0.07 mm crestal bone change after one year follow-up. This condition was less than the values recorded in the previous study. This observation could be attributed to the swiveling effect of the spheroflex attachment that dissipates a considerable amount of the load reaching the implant, decreasing the amount of the induced stress leading to less bone resorption.

Dealing with the second year follow-up the bony changes in both the straight and inclined implants was about 0.1 mm. This observation could be attributed to periimplant inflammatory condition that occur during the normal years of function. Schrotenboer et al. investigated the effect of microthreads and platform-switching on crestal bone stress levels, with finite element analysis. They showed that when the abutment diameter decreased from 5.0 to 4.5 mm and then to 4.0 mm, the microthread model showed a reduction of stress at the crestal bone level from 6.3% to 5.4% after vertical loading. Cappiello et al., in their clinical and radiographic prospective study, evaluated the bone loss around two-piece implants that were restored according to the platform-switching protocol. The data collected, showed that vertical bone loss for the test cases varied between 0.6 mm and 1.2 mm (mean: 0.95 +/- 0.32 mm), while for the control cases, bone loss was between 1.3 mm and 2.1 mm (mean: 1.67 +/- 0.37 mm).

Studying the stress-based performance of mesialy inclined and straight implants connected by a bar using finite element analysis revealed interesting results. The highest values of principle stress measured on cortical bone are computed in the case of inclined implants especially on the mesial crestal bone. In detail, compressive and tensile risk indicators relevant to the inclined implants are greater than those experienced for the straight ones. Cortical bone is least resistance to shear force, which is significantly increased by the bending overload provided by the spheroflex attachment. By the aid of their directional rings, the self parallizing attachments were made parallel during insertion and removal. However, during function, they induce tensile stresses slightly exceeding the cortical peak strength, but they are fully acceptable in a physiologic sense. Results proposed by Bozkaya et al., suggest that overloading of compact bone may occur in compression (due to the lateral components of occlusal load) and that overloading at the interface between cortical and trabecular bone can occur in tension (due to the vertical intrusive loading components). Being mesialy inclined by 15 -20°, the mesial crestal bone of the implant is preserved to a great extent when platform-switching concept was performed, however, it still shows a significantly different change than the mesial side of the straight one.
CONCLUSION

The concept of the platform-switching appears to limit crestal bone resorption in both straight and inclined implants and seems to preserve periimplant bone levels. However, a significant difference concerning the mesial periimplant bone height of the inclined implant compared to that of the straight one was still detected.

REFERENCES


