Radiographic Evaluation of Marginal Bone Levels Around Platform-Switched Implants and Non-Platform-Switched Implants Immediately Loaded to Support Mandibular Overdenture

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ABSTRACT

Objective: This clinical study was conducted to assess the marginal bone level around two different types of implant abutment junctions which are the platform-switched connection and non-platform-switched connection used in cases of implants supporting mandibular overdentures following the immediate loading protocol.

Materials and Methods: Twelve completely edentulous male patients were randomly divided into two equal groups:

Group I: Each patient received two Legacy I Implants designed with internal bevel having 3.5mm implant platform diameter to which 3.5mm neck diameter healing collars were threaded creating a matching or non-platform switching mechanism at the implant abutment junction.

Group II: Each patient received two Screw Plant Implants designed with external bevel having 3.7mm implant platform diameter to which 3.5mm neck diameter healing collars were threaded creating platform switching mechanism at the implant abutment junction.

All implants were inserted bilaterally in the mandibular canine region following one stage surgical protocol. Ten days following the surgery all patients received mandibular overdentures and once patients were comfortable to the prosthesis, they were placed on a zero, six, and twelve months follow-up periods. Radiographic evaluation of peri-implant crestal bone height changes was taken using cone Beam Computed Tomography (CBCT).

Results: Both groups showed reduction in the crestal bone height however, Group II with platform-switched implant abutment junction showed less crestal bone resorption than Group I with non-platform-switched implant abutment junction.

Conclusion: Within the limitations of this study it could be concluded that the platform switching mechanism at the implant abutment junction preserves the crestal bone surrounding the implants that support mandibular overdentures.

KEYWORDS: Platform-switched implants, overdentures, bone height, cone beam computed tomography
INTRODUCTION

The peri-implant bone level has been used as one of the criteria to assess the success of dental implants.\textsuperscript{1-5} Traditionally, radiographic marginal bone loss of 1.5 mm during the first year followed by a radiographic marginal bone loss of less than 0.2 mm annually is an important parameter for the assessment of implant success.\textsuperscript{6}

The peri-implant bone remodeling occurs once the implant is exposed to the oral environment in a second surgical procedure or when the abutment is placed immediately after implant placement. The remodeling process involves marginal bone resorption that is affected by many factors such as quality and quantity of bone, insertion depths, arch region and surgical trauma. Additional factors are implant and abutment designs, implant’s surface structure, peri-implant inflammation and excessive loading conditions.\textsuperscript{7-16} When intense bone resorption occurs, esthetics and soft tissue architecture may be impaired.\textsuperscript{17,18} Moreover, bone loss usually begins in the crestal area of the cortical bone and can progress toward the apical region, jeopardizing the longevity of the implant and prosthesis.\textsuperscript{19}

An attempt to hinder this process has resulted in the development of the platform switching concept, which consists of using an abutment of smaller diameter connected to an implant of larger diameter. The platform switching effect was accidentally established in the late 1980s when different commercial dental implant manufacturers introduced implants of larger diameter before producing the corresponding abutments of the same measures. Contrary to what was expected, post-loading radiographic evaluations showed no changes in the crestal bone levels around those implants. This serendipitous finding led to the introduction of the concept of platform switching.\textsuperscript{20,21}

In platform switching it is possible to use abutments with a diameter smaller than the implant neck or body width, or alternatively an implant design can be used in which the neck diameter is increased with respect to the implant body width.\textsuperscript{22}

The use of platform-switched implants was suggested in anatomic sites where the recommended minimum distances between implants and adjacent units cannot be achieved.\textsuperscript{23} In a prospective study forty one pairs of platform-switched implants were placed at less than 3 mm of inter-implant distance. The radiographic evaluation showed that a platform-switched implant design can reduce the vertical and horizontal components of bone loss and may be used in atrophic sites.\textsuperscript{24} Baumgarten and coworkers\textsuperscript{25} suggested that the platform switching technique is useful when shorter implants are used, when implants are placed in esthetic zone, and when a larger implant is desirable but prosthetic space is limited.

This platform switched connection shifts the perimeter of the implant-abutment junction inward towards the central axis (the middle of the implant), potentially improving the distribution of forces and placing the implant-abutment gap away from the peri-implant bone.\textsuperscript{26,27} It has been suggested that the inward shift of the implant-abutment gap may physically minimize the impact of the inflammatory cell infiltration in the peri implant tissues and diminish stress on the peri-implant bone in comparison with the conventional system.\textsuperscript{28,29} Therefore, this configuration has been related to microbiological and mechanical benefits that could limit crestal bone resorption.\textsuperscript{25,30-34}

Biomechanical studies of dental implants using finite elements analysis software are increasingly common.\textsuperscript{35-37} The behavior of reduced platform restorations was analyzed in the context of a finite elements study in three dimensions. The results showed a 10% decrease in all the prosthetic loading forces transmitted to the bone-implant interface.\textsuperscript{37} In similar two dimensions finite elements studies, some investigators reported 80% decrease in force transmitted to the cortical bone.\textsuperscript{35,36}

In addition to biomechanical studies, the concept of platform switching was extensively studied histologically. In histomorphometric studies on
RADIOGRAPHIC EVALUATION OF MARGINAL BONE LEVELS AROUND PLATFORM-SWITCHED DOGS

There was no significant difference in the marginal bone level around platform-switched and matched implants after 28 days of healing. In contrast, other studies reported significantly less bone loss around platform-switched implants after a loading period of two to six months.

Some investigators consider implant platform expansion to be of key importance for crestal bone stability. A multicenter study of 360 implants, compared expanded implant platforms versus cylindrical implants involving abutments of the same size, placed in 60 partially edentulous patients. The results showed less percentage of bone loss on employing the expanded implant platforms, with the preservation of bone up to 98.3% versus 66.1% after 12 months, and 97.2% versus 53.3% after two years. A long-term prospective study confirmed the advantageous features of platform-switched implants in preserving crestal bone levels.

Non-submerged straight and inclined platform switching implants retaining mandibular overdentures were examined to clarify its influence on crestal bone changes. It was found that this concept succeeded to keep the bone level almost stable within the first year of remodeling in both implant situations after prosthetic reconstruction. Another clinical study on immediately placed and immediately loaded implant reported no difference in bone level changes between platform switching and the external hexagon implant after 24 months.

The purpose of this clinical study is to assess the marginal bone level around the platform-switched and non-platform-switched implant abutment junctions used in cases of implants supporting mandibular overdentures following the immediate loading protocol.

MATERIALS AND METHODS

Patient Selection

An overall, twelve male patients with age ranging between 45 to 69 years, were included in this clinical investigation. All patients were chosen to be completely endentulous for more than one year and for no more than three years. The exclusion criteria included (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. Cone beam computed tomography was performed to assess the bone quantity and quality in the canine region. It revealed adequate bone width and height to accommodate implant with diameter 3.7mm and length not less than 10 mm. It also revealed bone density ranging from 850 to 1250Hu in all patients which is Division D2 according to Misch classification of bone.

Prosthetic Procedures

Complete dentures were fabricated for all patients prior to implant installation to assure ideal implant placement in harmony with osseous anatomy, denture esthetics and abutment connection. Primary impressions were taken using alginate (Alginmax, Major Prodotti, Dentari SPA, Moncalieri, Italy) in stock trays. Secondary impressions were taken using medium body rubber base (Swiss TEC, Coltene, Whaledent, Altstatten, Switzerland) in specially constructed special trays. Occlusion blocks were fabricated and maxillomandibular relationships were obtained using the conventional wax wafer technique. Casts were mounted on semi-adjustable articulator (Dentatus type ARH, AB Dentatus, Stockholm, Sweden). Setting up of teeth was done following esthetic tooth evaluation and modified lingualized occlusion scheme using modified cusped teeth (Vita-pan acrylic teeth, Vita Bad Sackingen-Germany). After approval of the try-in stage the waxed up denture was flanked and processed into high impact heat cure acrylic resin (Lucitone 199, Dentsply, York, PA-USA). Laboratory remounting was done before finishing the denture and occlusal discrepancies were adjusted.
Any necessary adjustments were carried out to eliminate occlusal interference and the denture was delivered to the patient. It was checked after twenty four and seventy two hours for any needed adjustment and to ensure that the patient was satisfied with esthetics, stability and retention of the denture. Following denture placement and patient adaptation, the mandibular denture was duplicated in clear acrylic resin and used as a surgical template. This assured that implants were installed beneath the planned position which was determined by ideal denture contour and esthetics.

Study Implants

1- Legacy 1 Implant (Implant Direct LLC, USA, Canada). Implant dimensions are 10mm length and 3.7mm diameter designed with 3.5mm diameter platform having internal bevel (Fig.1).

2- Screw Plant Implant (Spectra-System, Implant Direct LLC, USA, Canada). Implant dimensions are 10mm length and 3.7mm diameter designed with 3.7mm diameter platform having external bevel (Fig.2).

The external bevel of the Screw Plant Implant widens the diameter of the implant platform in comparison to that of the Legacy1 Implants which has internal bevel with a narrower implant platform diameter (Fig1, 2).

Both implant systems have the same design and surface treatment including:

1- Internal Hex connection.
2- The body of both implant systems is tapered evenly down to facilitate insertion with least heat generation.
3- Mini-threads start 1 mm below the top of both implant systems 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.
4- Vertical cutting grooves extend half way up the implant from apex for self-tapping insertion.
5- SBM [Soluble Blast Media of hydroxylapatite] textured surface extends over the entire endosseous portion of the implants.

Surgical Procedures

Before the surgery the selected patients were randomly divided into two equal groups according to the type of implant they received.

Group I: Included six patients each received two Legacy I Implants with the previously mentioned criteria.

Group II: Included six patients each received two Screw plant Implants with the previously mentioned criteria.

Aided by the surgical guide, implants were installed in the canine region at equal distance from the mid line, parallel to each other and perpendicular to the occlusal plane. All implants were placed by the same oral surgeon following one stage surgical protocol. Healing collars were then threaded to the implants to be used as abutments.
Implant abutment junction

4.5mm Diameter healing collars which has 3.5mm neck diameter were threaded to the Legacy 1 Implants having 3.5mm implant platform diameter creating a matching or non-platform switching mechanism at the implant abutment junction (Fig. 3a,b).

3.5mm Diameter healing collars were threaded to the Screw Plant Implants having 3.7mm implant platform diameter creating a platform switching mechanism at the implant abutment junction due to decreased diameter of healing collars in relation to the implant neck diameter (Fig. 4a,b).

Overdenture insertion

Ten days following the surgery the mandibular denture base was relieved to accommodate the newly inserted healing collars. The complete over denture was then checked intra orally for complete seating. Self-cured acrylic resin (Lucitone 199; Dentsply) was injected in the relief areas made opposite to the abutments positions. The complete overdenture was inserted in the patient’s mouth and close-mouth technique was carried to ensure intimate adaptation. After hardening of the acrylic resin, the denture was finished and polished. Lingualized balanced occlusal scheme was verified clinically to ensure equal distribution of posterior occlusal contacts and no anterior contacts. The dentures were inserted, pressure indicating paste (Mizzy Inc.Cherry Hill,NJ) was utilized to identify any pressure areas and patients were instructed to follow strict oral hygiene measures.

Follow-Up Evaluation Schedule

Evaluation was scheduled at the denture insertion, six and twelve months following denture insertion. At these intervals, patients return for assessment of implant, prosthesis’ function and standardized evaluation of his oral health. Cone Beam Computed Tomography (CBCT) was used to identify peri-implant radioluencies and bone level around the implants of both sides.

Radiographic evaluation using Cone Beam Computed Tomography (CBCT)

Images were acquired using the Scanora 3D Imaging system (Scanora 3D, Sorredex-Finland) (voxel size 133um-350 um) which allows the recording of linear bone height of images. The personal computer utilized was an Intel Core Duo- 2.13 Mhz-3.25 Gbites-21 inches flat screen 9 Hewlett-Packard Pavilion Elite m9200t series (Hewlett-Packard Pavilion Elite m9200t series USA).
Image Analysis

Linear measurements for evaluation of crestal bone height:

Mesial and distal crestal bone levels were calculated from the reconstructed corrected sagittal views by drawing a line parallel to the implant serration extending from the crestal bone to the apical end of the implant (Fig.3a,4a). Similarly, buccal and lingual bone levels were calculated by using cross-sectional views (Fig.5). Average readings of the four sides at each interval were calculated and tabulated for statistical analysis.

Statistical analysis

The statistical analysis of data was done by using excel program and SPSS program (statistical package for social science) version 16 on windows xp. Mean ± SD for normally distributed quantitative data was performed.

The analysis of data was done to test statistical significant difference between groups for quantitative data normally distributed (mean ± SD).

Paired and unpaired student t-test was used to compare the two studied groups.

TABLE (I) Effect of time on crestal bone height surrounding the implants in both studied groups at different intervals of follow-up period.

<table>
<thead>
<tr>
<th>Period</th>
<th>Group I: Non-platform-Switched Implant Abutment Junction</th>
<th>Group II: Platform-Switched Implant Abutment Junction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (mm)</td>
<td>SD</td>
</tr>
<tr>
<td>At-insertion</td>
<td>9.16</td>
<td>0.52</td>
</tr>
<tr>
<td>At-6 months</td>
<td>8.69</td>
<td>0.52</td>
</tr>
<tr>
<td>At 12 months</td>
<td>7.97</td>
<td>0.54</td>
</tr>
<tr>
<td>0-6 months</td>
<td>15.57</td>
<td>&lt; 0.001**</td>
</tr>
<tr>
<td>6-12 months</td>
<td>12.84</td>
<td>&lt; 0.001**</td>
</tr>
<tr>
<td>0-12 months</td>
<td>15.53</td>
<td>&lt; 0.001**</td>
</tr>
</tbody>
</table>

* p value < 0.05: significant. ** p value < 0.01: highly significant. ns= P value >0.05: non-significant
Table II: Comparison between crestal bone height changes surrounding the implants in both studied groups at different intervals of follow-up period.

<table>
<thead>
<tr>
<th>Period</th>
<th>Group I: Non-platform-Switched Implant Abutment Junction</th>
<th>Group II: Platform-Switched Implant Abutment Junction</th>
<th>Unpaired t-test</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-6 months</td>
<td>Mean difference (mm)</td>
<td>0.47</td>
<td>0.07</td>
<td>0.36</td>
</tr>
<tr>
<td>6-12 months</td>
<td>Mean difference (mm)</td>
<td>0.71</td>
<td>0.14</td>
<td>0.25</td>
</tr>
<tr>
<td>0-12 months</td>
<td>Mean difference (mm)</td>
<td>1.19</td>
<td>0.19</td>
<td>0.61</td>
</tr>
</tbody>
</table>

* p value < 0.05: significant. ** p value < 0.01: highly significant. ns= P value >0.05: non-significant

FIG. (6) Comparison between crestal bone height changes surrounding the implants in the two studied groups at different intervals of follow-up period

There was statistically highly significant difference between the two studied groups in the decrease of crestal bone height surrounding the implants through all intervals of follow-up period where group I with non-platform-switched implant abutment junction showed more crestal bone resorption than group II with platform-switched implant abutment junction as shown in table II and Fig.6.

DISCUSSION

In the last decade, promising results have been observed when non-submerged dental implants were subjected to immediate functional loads. The present study reported a survival rate of 100% after 12 months of follow up in both groups. The immediate loading protocol has psychological and functional advantages in eliminating second-stage surgery. It helps in reducing patient discomfort, reducing the treatment period and the additional costs of the procedure. 49-51

In most of the studies on immediate loading, good bone quality has been mentioned as an important prognostic factor for the success of the procedure. 52-55 It seems that planning for immediate loading of dental implants is facilitated by advanced imaging techniques. These techniques allow for selection of implant sites that have the highest Hounsfield values, which correlate with denser bone. 56 Therefore, pre-operative cone beam computed tomography was performed to assess the bone quality and quantity in the canine region. Furthermore, this computer assisted measurement technique was chosen in this study to determine the amount of marginal bone loss around the studied implants based on its reported accuracy and precision. 57

The amount of peri-implant bone loss has been found to be time related in the two groups. The results of this study document less bone resorption in platform-switched implants, as compared to non-platform-switched implant with a highly significant difference throughout the follow up period.
These findings are in agreement with some investigators who have reported less bone resorption in platform-switched implants in comparison to non-platform-switched implants.\textsuperscript{28,38,58,59}

Cappiello and colleagues\textsuperscript{28} found that the mean value of vertical bone loss for implants placed with platform switching was 0.95 mm whereas for implants placed without platform switching was 1.67 mm. The data reported in the present study revealed a mean marginal bone loss of 0.6±0.05 mm for platform switching implants and 1.19±0.19 mm for non-platform switching. Hurzeler et al.\textsuperscript{25} reported from a prospective clinical study, that mean bone level change from the baseline to 1-year follow-up was 0.12 mm +/- 0.40 mm for the platform switched group and 0.29 mm +/- 0.34 mm for the control group. They concluded that platform switching is an efficient way to avoid peri-implant bone loss.

However, the concept of platform switching was not fully understood, and several theories were suggested to explain this phenomenon. The biomechanical theory proposed that connecting the implant to a smaller-diameter abutment may limit bone resorption by shifting the stress-concentration zone away from the crestal bone-implant interface and directing the forces of occlusal loading along the axis of the implant.\textsuperscript{61,62} Another theory concerning the role of the inflammatory cell infiltrate at the Implant Abutment Junction (IAJ) supposed that the bone resorption at the IAJ was caused by an inflammatory cell infiltrate that formed a 1.5 mm semispherical zone around the IAJ.\textsuperscript{11} Regardless of the nature of the peri-implant inflammatory infiltrate, the physical repositioning of the IAJ away from the external outer edge of the implant and neighboring bone may limit bone resorption by containing the inflammatory cell infiltrate within the angle formed at the interface away from the adjacent crestal bone.\textsuperscript{6}

These findings are also supported by a recent animal study which recorded that the creation of discrepancy between the abutment and implant platform described as platform switching, seems to stabilize the circular collagen fibers at the implant platform level. Similar circular fiber orientation was found at the first implant thread bone level for regular implants without platform switching. This more coronal level of the circular fibers around platform switching can reduce crestal bone loss and can serve as a “mechanical retention factor” for periodontal fiber orientation.\textsuperscript{63}

In addition to these findings, some investigators consider implant platform expansion to be of key importance for crestal bone stability. Experimental histomorphometric studies have shown improvement in crestal bone levels in abutments with platform reduction, though statistical significance was not reached.\textsuperscript{26,44}

On the other hand, Enkling et al.\textsuperscript{64} performed a split-mouth trial of fifty platform-switched and matched implants placed in the posterior mandible under twelve months follow-up period. The radiographic examination included the measurement of the vertical and horizontal extents of marginal bone loss. The difference in both dimensions between the two groups was not statistically significant. Microbiologic samples were collected at different time points after implant insertion. The authors suggested that the extent of microbial colonization had a greater impact on the amount of peri-implant bone loss than the platform design.

Finally additional long-term studies are required to confirm that the platform-switched implant system has considerable potential to reduce crestal bone resorption.

**CONCLUSION**

Within the limitations of this study it could be concluded that the platform switching mechanism at the implant abutment junction seems to preserve the crestal bone surrounding the implants that support mandibular overdentures.
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