CLINICAL AND RADIOGRAPHIC EVALUATION OF IMPLANT-TOOTH SUPPORTED FIXED PROSTHESIS WITH AND WITHOUT CANTILEVER DISTAL EXTENSION. A CONTROLLED SPLIT-MOUTH STUDY

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ABSTRACT

Aim of the study: The purposes of this study was to evaluate the clinical and radiographic outcomes of dental implants inserted in the edentulous space of posterior mandible and connected to natural teeth for supporting fixed bridge with and without cantilever extension.

Patients and methods: A total of 20 screw-shaped endosseous implants were inserted in systemically healthy ten patients with bilateral mandibular free-end saddles. Each patient received 1 implant in each side of the jaw bone placed either one tooth-width distal to the abutment teeth (control sides) or immediately distal to the abutment teeth (study sides). The final restorations received were tooth-implant supported fixed ceramo-metal fixed bridge with no distal cantilever extensions in the control sides or with distal cantilever extensions in the study sides. The following clinical parameters were used for assessment of both the natural tooth abutment and the peri-implant tissue: plaque index (PI), bleeding on probing (BOP), and pocket depth (PD). Clinical attachment level (CAL) was recorded for the natural tooth abutment only. A standardized periapical radiographs were taken with long-cone paralleling technique, scanned, stored and digitized in IBM computer for measuring of alveolar bone losses around implants and abutment teeth. Clinical parameters and radiographic measures were taken at implant loading (baseline), 6, 12, and 24 months.

Results: At the abutment teeth the mean BOP values at baseline were 0.27 and 0.28 for the control and cantilever sides respectively. These values showed non-significant increase after 6 months (0.38 and 0.50 respectively) and remained almost constant after 12 and 24 months. At the implants, BOP showed one fold increase at the cantilever side from 0.33 to 0.63 after 6 months and remained unchanged at 12 and 24 months of the assessment periods. The PI remained almost unchanged during the whole follow up periods. The mean PPD at abutment teeth of the cantilever sides showed non-significant increase in values than those of the control sides at 6, 12, and 24 months. At the implants, PPD remained almost unchanged over time for both control and cantilever sides. Marginal bone levels (MBL) of the implants at baseline were 1.49±0.18 and 1.46±0.16 mm for control and cantilever sides. High significant difference between cantilever and control MBL of the implant occurred at 24 months of loading (p < 0.001). Positive high significant correlations were noticed between marginal bone loss and PI of implants only at control sides after 12 and 24 months.

Conclusions: Cantilever implant-tooth supported fixed bridge produced more marginal bone loss at implants when compared to control side of implant-tooth supported fixed bridge. The MBL was not correlated to increased BOP, PI, and PD at the cantilever extension side. At the control side MBL was positively correlated to PI.
INTRODUCTION

In the last decade, the use of implant-supported fixed prosthesis has become a widely accepted therapy to solve such problems. This strategy was considered beneficial especially in Kennedy class I and II where removable partial dentures are usually disregarded by patients, and where traditional fixed cantilevered prostheses present increased biologic and technical problems (Hammerle et al 2000). However, a situation may arise where there are too few or an unfavorable distribution of remaining teeth in the jaw to serve as sole abutments for FPD (Laufer and Gross 1998). Also, anatomic limitations may require the placement of a single fixture whereas a minimum of two implants would otherwise be necessary to support prosthesis (Rangert et al 1991).

Although splinting an implant and a tooth is a rational alternative, dissimilar mobility patterns of the osseointegrated implants and natural teeth may complicate the biomechanical behavior of the entire system (Pesum 1997). Potential problems are abutment screw loosening, prosthesis fracture and intrusion of the natural tooth (Chang et al 2006). However, intrusion of the natural teeth is reported as a major clinical complication of such a design, with incidence ranging from 34 to 37% (Naert et al 2001, Carcial & Oesterle 1998). Teeth with healthy periodontal ligament show mobility upon displacement of the crown with a force of 1 N of 50-200μm (Weber et al 2006, Muhleman 1990). While osseointegrated implants demonstrate values of less than 16μm (Cohen and Orenotein 1994).

While some authors (Pesum 1997, Uysal et al 1997) cautioned that the habit of combining implant with teeth should be avoided, others (Lindh et al 2001) considered tooth implant-supported FPD is considered a safe and predictable treatment when anatomic limitations prevent placement of more than one implant. In addition, the tooth implant supported FPDs were found to function in their biologic environment without affecting it adversely (Ranadi et al 1998). Moreover, it was not possible to demonstrate any higher risk of implant or prosthetic failure for tooth-implant-supported FPD compared with implant-supported FPD. From another standpoint, when patients demanded no more extensive use of implants for posterior quadrants, the incorporation of cantilevered prostheses over implants was considered. Mandibular posterior cantilever lengths of less than 15 mm, 15 to 20 mm (Beumer & Levis) or no greater than 20 mm (Naret et al 1992) have been suggested. Lindquist et al (1988) and White et al (1994) studied the effects of cantilever lengths on stress transferred to bone by the implant-supported prosthesis. Their findings revealed that cantilever length can influence forces delivered to the implants and bone and can directly affect marginal bone loss, these were supported by findings of Brosky et al (2003).

Cantilevers or crown with less favorable crown/implant ratios also increase the amount of stress to the implant. The primary vector of a compressive force on a unilateral cantilever portion of a fixed partial denture applies shear and tensile forces on the most distant abutment (Bidez & Misch 1992). The magnitude of load sustained by the implants is approximately proportional to the length of the cantilevers and varies as a result of implant number, spacing, and location (Rangert et al 1995). A clinical report by Lundquist et al (1988) correlated long cantilevers with increased crestal bone loss. In addition, cantilevers are known to cause more occurrences of prosthesis component failure, in particular, failure of prosthesis retaining screws (Mc Alarney and Stavropolos 2000).

The purposes of this study was to evaluate the clinical and radiographic outcomes of dental implants inserted in the edentulous space of posterior mandible and connected to natural teeth for supporting fixed bridge with and without cantilever extension.

PATIENTS AND METHODS:

Study design:

Ten patients were selected from those attending the out-patient clinic, Faculty of Dentistry, Mansoura University, seeking implant-tooth-supported restoration of bilaterally edentulous posterior mandibular free end
saddle. They were 6 males and 4 females with an age range of 20-65 years. All patients were systemically healthy, non-smokers, with no history of periodontal disease or previous treatment. A total of 20 screw-shaped endosseous implants (Tapered Screw Vent, TSV, USA) were inserted, each patient received 1 implant in each side of the jaw bone. Depending upon the ideal position to place an implant following clinical and radiographic examination, the free end saddle areas were randomly allocated to receive implants placed either one tooth-width distal to the abutment teeth (control sides) or immediately distal to the abutment teeth (study sides). The final restorations received were tooth-implant supported fixed ceramo-metal fixed bridge with no distal cantilever extensions in the control sides or with distal cantilever extensions in the study sides.

A preoperative radiographic examination was made including panoramic and intraoral periapical radiographs. Antibiotic prophylaxis with amoxicillin plus clavulanic acid (Augmentin 1 g, Galaxo Smith Kline Co., Egypt) was given one hour prior to surgery and was continued twice daily until the third postoperative day. Patients were asked to rinse the oral cavity with chlorhexidine digluconate 0.12% (Listermix,) for 1 minute prior to the surgery.

Surgery and implant insertions:

A two-stage surgical approach was performed according to a standard protocol described by Palmer et al (1999). All patients were operated under local anesthesia using mepivacaine HCl with levonordefrin 1:20,000 (Mopicaine, Alex Co. Egypt). Mid-crestal incision was employed through the periosteum down to bone. Full thickness mucoperiosteal flap was raised carefully to expose the entire extent of the edentulous ridge at the proposed area of implantation. The flap was elevated sufficiently using a mucoperiosteal elevator to reveal any bone concavities especially at the sites where perforation might occur. Implants were inserted following the standard protocol for osteotomy preparation using different drill sequences. In General, the final bone preparation site diameter was slightly smaller than the implant to produce compression of the surrounding bone on implant insertion, which improved the initial stability. In dense bone the site had to be more closely matching the size of the implant. Seventeen implants were of 13 mm length and 3.75 mm diameter, and 3 implants were of 10 mm length and 3.75 mm diameter. Finally, the mucoperiosteal flap was carefully closed with multiple interrupted black silk sutures (3-zero).

Second stage surgery for insertion of the transmucosal abutments was done after three months. After two weeks, the healing abutments were replaced with final abutments. Natural tooth adjacent to the edentulous space was prepared for full-crown. Impression and bite registration were taken, while final implant’s abutment preparation was done outside the patient’s mouth in the dental lab. Final fixed bridges, with and without distal cantilever, were temporary cemented (Figure 1).

Clinical parameters:

The following clinical parameters were used for assessment of both the natural tooth abutment and the peri-implant tissue: plaque index (PI), bleeding on probing (BOP), and pocket depth (PD). Clinical attachment level (CAL) was recorded for the natural tooth abutment only. All measurements were taken at 6 different sites (mesio-buccal, buccal, distobuccal, mesio-lingual, lingual, and distolingual) and the mean score was recorded for each parameter for a single patient. The measurements were taken at time of fixed bridge insertion (baseline), 6 months, 1, 1.5 and 2 years after fixed ridge insertion.

Radiographic evaluation:

A standardized periapical radiographs were taken with long-cone paralleling technique using customized film holders. The periapical films were conventionally processed and scanned using a black and white translucent scanner and stored in IBM computer. The radiographic images were magnified approximately 15X after digitizing the radiographs. Subsequently, lines and references points were marked on the screen. For determination of magnification errors due to x-ray exposure, the
implant dimensions in radiograph were compared with actual implant dimensions as recommended by Adell et al (1981). The ratio between implant dimensions in radiograph and actual implant dimensions was used to modify the apparent measurement of peri-implant bone resorption in radiograph to obtain the actual values.

The alveolar bone change was determined as recommended by Walter et al (2000), where the distance between implant first thread (point A) and first bone to implant contact (point B) was measured at the predetermined recall visits and any changes were recorded. Also in natural tooth abutment, the distance between the reference points at the cemento-enamel junction and marginal bone level was measured and recorded.

**Statistical analysis:**

The statistical analysis of data for significant differences between the control and study sides was done using Excel and SPSS (statistical package for social science version 10) programs. Data description was done in the form of mean ± standard deviation and frequency proportion. Analysis of data was done to test statistical significance between groups.

For quantitative data student t-test was used to compare between the 2 sides, and for qualitative non-parametric data, Mann-Whitney test was used to compare between the 2 sides and data were described in the form of the median and range (minimum – maximum). A p value <0.05 was considered significant.

![Clinical photograph of the prepared abutments (implants and teeth) and final fixed bridge. Left side showed cantilever bridge and right side represent the control side of this patient.](image-url)
RESULTS

All the ten patients had completed the study with no complications. All patients had stable prosthesis in place after 24 months of loading. No sensory disturbances were recorded and no increased tooth mobility was observed during the whole assessment period.

The results of clinical parameters showed non-significant differences when comparing the data with the baseline values. Figure 6, showed the mean BOP of both the abutment teeth and implants from the time of fixed bridge loading (baseline) throughout the different follow up periods at 6, 12, and 24 months. For the abutment teeth (A), the mean BOP values at baseline were 0.27 and 0.28 for the control and cantilever sides respectively. These values showed non-significant increase after 6 months (0.38 and 0.50 respectively) and remained almost constant after 12 and 24 months. At the implants (B), BOP of the peri-implant tissue showed one fold increase at the cantilever side from 0.33 to 0.63 after 6 months and remained unchanged at 12 and 24 months of the assessment periods. However the BOP at the control sides represented non-significant increase over time.

Figure 7, demonstrated bar chart of the PI for both control and cantilever sides of the abutment teeth and implants. The PI remained almost unchanged during the whole follow up periods. The mean plaque scores for study sides (cantilever) showed no statistically significant difference with time and there was no statistically significant difference between the mean plaque scores in both the control and study sides. Figure 8, represented the PPD of both control and cantilever sides. At the abutment teeth, the mean baseline measurements were 1.55 and 1.62 mm respectively. The mean PPD of the cantilever sides showed more increase in values than those of the control sides at 6, 12, and 24 months, even this increase was statistically non-significant. At the implants, PPD of both control and cantilever sides remained almost unchanged over time when compared to baseline values.

Table 1 and 2 showed the means and standard deviations of marginal bone measurements at the implants and abutment teeth respectively. For the implants (Table 1), the mean baseline measurements were almost equal (1.49±0.18 and 1.46±0.16 mm respectively). These measurements increased to 1.86±0.21 and 1.98±0.16 mm after 6 months with no significant difference between the two values (p = 0.19). After 12 months statistically significant difference was observed between the two measurements (p = 0.01). At 24 months of loading, marginal bone measurements were 2.63±0.18 mm for the cantilever sides which was very highly statistically different when compared to measurements of the control sides (2.63±0.18 mm). For the abutment teeth (Table 2), non-significant differences were recorded when comparing the measurements of the control and cantilever sides at baseline, 6, 12, and 24 months observation periods.

Correlations between the amount of marginal bone loss (MBL) and the different clinical parameters (BOP, PI, and PPD) are shown in Tables 3 and 4. For the implants (Table 3), a highly significant positive correlation were detected between MBL of the control and PI after 12 and 24 months. However, non-significant positive and negative correlations could be shown between the MBL and all the clinical parameters. Table 4 showed non-significant correlation between the MBL and all the clinical parameters at the same follow up periods.
Fig. (3) Preoperative periapical x-ray of bilateral free-end saddle edentulous space.

Fig. (4) Periapical x-ray 6 months after loading of implant-tooth supported fixed bridge on both control (a) and cantilevered (b) sides.

Fig. (5) Periapical x-ray of the same case after 24 months of loading. No widening of periodontal space or alveolar bone loss could be detected at the natural-tooth abutments at the control (a) and cantilevered (b) sides. Crestal bone loss at implant necks are confined to the most coronal aspect of both implants.
Fig. (6) Bar chart of the bleeding on probing (BOP) of both abutment teeth (A) and implants (B) showing both cantilever and control values at baseline 6, 12, & 24 months.

Fig. (7) Bar chart of the plaque index (PI) of abutment teeth (A) and implants (B) showing both cantilever and control values at baseline 6, 12, & 24 months.

Fig. (8) Bar chart of the probing pocket depth (PPD) of abutment (A) teeth and implants (B) showing both cantilever and control values at baseline 6, 12, & 24 months.
Table (1) Marginal bone measurements at “implants” of both control and cantilever sides. Mean ± standard deviation in mm.

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>6 M</th>
<th>12 M</th>
<th>24 M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>1.49±0.18</td>
<td>1.86±0.21</td>
<td>2.04±0.17</td>
<td>2.15±0.23</td>
</tr>
<tr>
<td>Cantilever</td>
<td>1.46±0.16</td>
<td>1.98±0.16</td>
<td>2.36±0.18</td>
<td>2.63±0.18</td>
</tr>
<tr>
<td>(P)</td>
<td>0.71 (NS)</td>
<td>0.19 (NS)</td>
<td>0.01**</td>
<td>&lt;0.001***</td>
</tr>
</tbody>
</table>

NS non significant  **  high significant  ***  very high significant

Table (2) Marginal bone measurements at “abutment teeth” of both control and cantilever sides. Mean ± standard deviation in mm.

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>6 M</th>
<th>12 M</th>
<th>24 M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>2.12±0.18</td>
<td>2.19±0.17</td>
<td>2.25±0.15</td>
<td>2.29±0.14</td>
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<tr>
<td>Cantilever</td>
<td>2.13±0.24</td>
<td>2.16±0.20</td>
<td>2.26±0.18</td>
<td>2.37±0.21</td>
</tr>
<tr>
<td>(P)</td>
<td>0.86 (NS)</td>
<td>0.67 (NS)</td>
<td>0.93 (NS)</td>
<td>0.33 (NS)</td>
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</tbody>
</table>

NS non significant  **  high significant  ***  very high significant

Table (3) Correlation between marginal bone loss and clinical parameters of the implants of “control” and “cantilever” sides at different assessment periods

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>6 Months</th>
<th>12 Months</th>
<th>24 Months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td></td>
<td>(r)</td>
<td>(p)</td>
<td>(r)</td>
</tr>
<tr>
<td>BOP</td>
<td>-0.11</td>
<td>0.75</td>
<td>+0.03</td>
<td>0.92</td>
</tr>
<tr>
<td>PI</td>
<td>-0.14</td>
<td>0.69</td>
<td>-0.12</td>
<td>0.72</td>
</tr>
<tr>
<td>PD</td>
<td>-0.15</td>
<td>0.67</td>
<td>-0.03</td>
<td>0.91</td>
</tr>
<tr>
<td>Cantilever</td>
<td></td>
<td>(r)</td>
<td>(p)</td>
<td>(r)</td>
</tr>
<tr>
<td>BOP</td>
<td>-0.21</td>
<td>0.54</td>
<td>+0.27</td>
<td>0.44</td>
</tr>
<tr>
<td>PI</td>
<td>-0.17</td>
<td>0.63</td>
<td>-0.24</td>
<td>0.40</td>
</tr>
<tr>
<td>PD</td>
<td>+0.34</td>
<td>0.33</td>
<td>-0.32</td>
<td>0.35</td>
</tr>
</tbody>
</table>

BOP bleeding on probing  PI plaque index  PD pocket depth  \(r\) correlation coefficient  \(p\) significant if < 0.05  **  highly significant

Table (4) Correlation between marginal bone loss and clinical parameters of the abutment teeth of “control” and “cantilever” sides at different assessment periods

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>6 Months</th>
<th>12 Months</th>
<th>24 Months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td></td>
<td>(r)</td>
<td>(p)</td>
<td>(r)</td>
</tr>
<tr>
<td>BOP</td>
<td>-0.50</td>
<td>0.13</td>
<td>+0.37</td>
<td>0.28</td>
</tr>
<tr>
<td>PI</td>
<td>-0.05</td>
<td>0.87</td>
<td>-0.13</td>
<td>0.70</td>
</tr>
<tr>
<td>PD</td>
<td>0.08</td>
<td>0.82</td>
<td>-0.09</td>
<td>0.80</td>
</tr>
<tr>
<td>Cantilever</td>
<td></td>
<td>(r)</td>
<td>(p)</td>
<td>(r)</td>
</tr>
<tr>
<td>BOP</td>
<td>+0.52</td>
<td>0.11</td>
<td>-0.38</td>
<td>0.27</td>
</tr>
<tr>
<td>PI</td>
<td>+0.37</td>
<td>0.29</td>
<td>+0.001</td>
<td>0.99</td>
</tr>
<tr>
<td>PD</td>
<td>+0.20</td>
<td>0.57</td>
<td>-0.60</td>
<td>0.06</td>
</tr>
</tbody>
</table>

BOP bleeding on probing  PI plaque index  PD pocket depth  \(r\) correlation coefficient  \(p\) significant if < 0.05
DISCUSSION

This present study compared the combined endosseous implants and natural teeth as abutments for a fixed prosthesis with and without cantilever extension in cases of free end saddles in partially edentulous mandibles. The complications encountered were associated with soft tissue and some minor prosthesis repair needs. All problems were transient in nature and were resolved without difficulty. All implants (100%) survived the 2-year follow up period compared to an average survival rate of 95.4% as reported in a systemic review by Lang et al (Lang et al 2004). The distribution of plaque free surfaces or small amount of plaque was essentially the same throughout the investigation for the implants whereas a slight improvement was on the tooth surface on both groups. Mucosal/gingival bleeding scorings revealed that although no bleeding was the predominant finding, a slight tendency toward increased bleeding could occur at both implant and abutment tooth in both sides.

In the present study the variable of main interest was the bone response to implant loads reflected in the change of marginal bone height with time in both sides. With the difficulties in randomizing the distribution of the two prosthesis designs within the individual patients, it was deemed important to control for any systemic differences in factors that could confound the results. Bone density, inflammation in the pre-implant mucosa and implant loading were considered to be influential on the outcome of the change in marginal bone height with time. However, this variable displayed low values in general throughout the study and showed no difference between the implants in the different prosthesis designs. The load transmitted to the bone via the implants in the different prosthesis designs was presumably also an important constituent to influence the results. The change in marginal bone level was chosen as the primary response variable. The overall mean bone loss was within accepted limits and of similar magnitude as in recently published reports. However the mean bone loss for the implant in study sides was exceeding the annual 0.2 mm limit in the success criteria used and was significantly larger compared to the corresponding value for the implant in the control sides. There was, on all levels of analysis, a tendency for fixed partial dentures with cantilever extensions to have a greater mean peri-implant bone loss and show a higher frequency of implant with ≥1 mm of bone loss than fixed partial dentures without cantilevers. In the present study, highly significant bone loss occurred at implants of cantilever side when compared to control sides after 12 and 24 months (p ≤ 0.01).

Findings from in vitro studies revealed that higher stress concentrations developed at implants that support cantilever units than at implants without such elements (Block et al 2002, Lang et al 2004). It was further observed that the enhanced stress occurred mainly at the bone crest adjacent to the distal surface of the implant that was facing the cantilever extension and was dependent on the length of cantilever segment (McAlarney & Stvropoulos 1996). Barbier and Schepers (1997) reported from an animal study that the presence of cantilevers in a fixed partial denture might stimulate bone remodeling and result in an increased density of the trabecular bone and a thickening of the cortical layer of the adjacent ridge. The hypothesis that excessive, non-axial load inflicted on an implant-tooth supported fixed partial denture may have a detrimental effect on the peri-implant bone was to some extent supported by data from experimental studies in the monkey by Lisdor et al (Schlumberger et al 1998, Lsidor 1996) It was reported that while biofilms present on the implant surface caused overt soft tissue inflammation and marginal bone loss, overload induced by non-axial, interrupted forces resulted in loss of osseointegration, rather than reduction in the height of marginal bone (Steflik et al 1982).

In the present study and in the study by Gross et al (1997) and Jan et al (2004), the tooth and the implant were joined by completely rigid connectors. No change in tooth mobility or any signs of intrusion of the abutment teeth were seen in either of both sides. In contrast, Zeev et al (2005), also rigidly connecting teeth and implants, reported tooth intrusion in two cases. However, in a
newly published retrospective study (Weber & Sukoty 2007), the clinical results from over 3,000 prostheses on implants and teeth with rigid connection reported that only 0.3 % of the abutment teeth showed signs of intrusion.

Although the clinical studies referred to indicate that cantilever extensions might not jeopardize the stability of the peri-implant bone level in a full arch fixed partial denture, it is not properly documented whether in a fixed partial denture, supported by few implants, the load exerted on the cantilever extension may cause undue bone loss. In a clinical study by Romeo et al (2003), it was reported that after an average of 3-years in function, the amount of bone loss that had occurred at the implant closest to the cantilever extension in fixed partial denture was correlated to the extension of the cantilever segment. In the recent study, statistically significant differences were found in bone level change between implant-tooth-supported partial denture with cantilever extension and without cantilever extension after 24 months of loading. The marginal bone loss at the cantilever extension sides was not correlated to the increased measurements of BOP, PI, and PD. While at the control sides, the marginal bone loss was positively correlated to PI after 12 and 24 months of loading. This meant that the bone changes at the cantilever side were stress-related rather than due to accumulation of plaque.

REFERENCES