Effects of dental implants on hard and soft tissues

Tymstra, Nynke

IMPORTANT NOTE: You are advised to consult the publisher's version (publisher's PDF) if you wish to cite from it. Please check the document version below.

Document Version
Publisher's PDF, also known as Version of record

Publication date:
2010

Link to publication in University of Groningen/UMCG research database

Citation for published version (APA):
Chapter 7

An implant crown with a cantilever versus two implants with solitary implant crowns to restore a missing adjacent upper central and lateral incisor; a prospective comparative pilot study

This chapter is an edited version of the manuscript:

Tymstra N, Raghoebar G.M., Vissink A., Meijer H.J.A.
Dental implant treatment for two adjacent missing teeth in the maxillary aesthetic zone. A comparative pilot study.
Clin. Oral Impl. Res. (provisionally accepted for publication)
Abstract

**Aim** The purpose of this prospective comparative pilot study was to evaluate hard and soft peri-implant tissues in patients with a missing adjacent central and lateral upper incisor treated with either one implant and a implant crown with a cantilever or two implants with solitary implant crowns up to one year after functional loading.

**Material and methods** In the ‘implant-cantilever group’ 5 patients were treated with one dental implant in the region of the central incisor (NobelReplace Groovy Regular Platform). In the ‘implant-implant group’ 5 patients were treated with two adjacent dental implants: at the position of the central incisor (NobelReplace Groovy Regular Platform) and at the position of the lateral incisor (NobelReplace Groovy Narrow Platform). Implant survival, pocket probing depth, papilla index, marginal bone level and patient satisfaction were assessed during a one-year follow-up period.

**Results** No implants were lost during the one-year follow-up. Mean pocket probing values of the implants were comparable between the two groups. Papilla index scores in both groups were relatively low, pointing towards a compromised papilla. Marginal bone loss was minimal and comparable between the groups. Patient satisfaction was very high in both groups.

**Conclusions** There were no large differences in hard and soft tissue levels of patients with a missing central and lateral upper incisor and treated with either one implant and an implant crown with a cantilever or two implants with solitary implant crowns.
Introduction

Dental implants are more and more applied in the aesthetic zone, therefore, it is essential to be able to establish a predictable aesthetic result. According to the professionals’ opinion, dental implant crowns in the aesthetic zone are successful if a harmonious anatomical outcome has been established with the right dimensions of white and pink structures (Belser et al., 2004; Meijndert et al., 2007). On the other hand, regeneration of a soft tissue contour with intact interproximal papillae and a gingival outline that is harmonious with the gingival silhouette of the adjacent teeth appears to be one of the major challenges (den Hartog et al., 2008).

In case of a single-tooth replacement, the presence of interproximal papillae is determined predominantly by the attachment level of the neighbouring teeth (Kan et al., 2003; Grunder et al., 2005; Kourkouta et al., 2009), which favours the aesthetic outcome of single tooth replacements in case of periodontally unaffected neighbouring teeth. The advantage of having neighbouring teeth on both sides of a single-tooth replacement is not present if two adjacent teeth are missing, however. As a result the presence of a papilla between two implant crowns is predominantly dictated by the highest bone level between the implants (Kourkouta et al., 2009).

Inter-implant distance appears to be another important factor in the preservation of bone height between two adjacent implants and should be at least 3 mm. In case of an inter-implant distance of less than 3 mm, loss of the crestal bone height is to be expected. This is caused by the lateral component of the peri-implant bone loss around implants. Overlap of both resorption areas between the adjacent implants will eventually result in vertical reduction of the inter-implant bone crest level (Tarnow et al., 2000; Gastaldo et al., 2004; Kourkouta et al., 2009).

The reduced papilla height between two adjacent implants in comparison to single tooth replacement complicates the aesthetic outcome. Only a maximum of 3 mm of inter-implant soft tissue height should be expected instead of 3-5 mm of soft tissue height between an implant and a natural tooth (Gastaldo et al., 2004). To avoid black triangles and make sure that the distance between the contact point and the inter-implant bone crest is fully filled with soft tissue, the contact point of the two adjacent implant crowns should be positioned more apically resulting in a longer contact area. This technique is often used in case of compromised papilla presence, but interferes with the idea to manufacture harmonious anatomically shaped crowns.

The purpose of rehabilitation in the aesthetic zone should therefore be to maintain the bone around implants at an ideal level. Vertical and lateral bone loss around most implant systems
at the interface of implant and abutment is up to 1.5 mm and is due to chronic irritation from bacteria products out of this interface (Hermann et al., 1997; Tarnow et al., 2000; Cardaropoli et al., 2006). This means that bone around implants must be at least 1.5 mm wide at the approximal sides to be sure that the level of bone crest and thus the level of soft tissue will remain stable. If the two missing adjacent teeth are an upper central incisor and a lateral incisor, space is sometimes lacking to create enough distance between the implants and between the implants and their neighbouring teeth. Also utilisation of a smaller diameter implant in the region of the lateral incisor does not solve this problem. It is suggested that platform-switched implants, with less widespread lateral resorption could have an effect (Rodriguez-Ciurana et al., 2009). Another option in this region could be placing only one implant in the region of the central incisor and a prosthetic restoration consisting of an implant crown on this implant connected with a cantilever at the position of the lateral incisor. In this option bone crest height is not affected by the lateral resorption of the adjacent implant. In the literature, this option has not been evaluated so far. Therefore, the purpose of this prospective comparative pilot study was to evaluate hard and soft peri-implant tissue levels of patients with a missing central and lateral upper incisor treated with either one implant and a prosthetic restoration with a cantilever or two implants with solitary restorations up to one year after functional loading.

**Material and methods**

**Patient selection**

The patients selected for this study were referred to the Department of Oral and Maxillofacial Surgery (University Medical Center Groningen, University of Groningen, Groningen, the Netherlands) for implant therapy. To be included in this study, the patients should present with two missing adjacent teeth, being a central and lateral maxillary incisor. All patients had to be 18 years or older and were included in the study only after providing informed consent. The study was approved by the hospital medical ethical committee and written informed consent was obtained from all patients. Patients were selected on the basis of the following inclusion criteria:

- sufficient mesio-distal, bucco-lingual, and interocclusal space available for placement of two implant crowns with the right anatomical design
- sufficient bone available for placement of two dental implants with a minimum inter-
implant distance of at least 3 millimetres and a minimum tooth-implant distance of at least 1.5 millimetres (if required, a bone augmentation procedure was performed at least four months before implant placement)

- implant site free from infection

Exclusion criteria for this study were:

- presence of medical and general contraindications for the surgical procedures
- presence of active and uncontrolled periodontal disease
- bruxism
- smoking
- history of previous dental implant therapy in the same region
- history of local radiotherapy to the head and neck region

The study population was divided into two groups:

1) ’Implant-cantilever group’: 5 patients to treat with one dental implant in the region of the central incisor (NobelReplace Groovy Regular Platform; Nobel Biocare AB, Göteborg, Sweden); prosthetic restoration will consist of an implant crown connected with a cantilever at the position of the lateral incisor

2) ’Implant-implant group’: 5 patients to treat with two adjacent dental implants (NobelReplace Groovy Regular Platform at the position of the central incisor and NobelReplace Groovy Narrow Platform at the position of the lateral incisor); prosthetic restoration will consist of two single-tooth implant crowns.

Treatment allocation was performed using a balancing procedure to provide for an equal distribution of patients over the treatment groups with regard to whether a preoperative augmentation was performed.

Surgical and prosthetic procedures

All patients were treated at the same department (Oral and Maxillofacial Surgery, University Medical Center Groningen, University of Groningen, Groningen, the Netherlands) by one experienced oral-maxillofacial surgeon and two experienced prosthodontists. Preoperatively, diagnostic casts were made with a diagnostic arrangement representing the future restoration in the ideal prosthetic position. Next, this ideal prosthetic position was transformed into a surgical guide from transparent acrylic resin (Vertex Castapress; Vertex-Dental BV, Zeist, the
If it was clear that not enough bone was present to insert an implant with primary stability, a bone augmentation procedure was carried out with bone harvested from the retromolar region in a separate session. One day before implant placement, the patients began using a 0.2% chlorhexidine mouthwash (Corsodyl; GlaxoSmithKline, Utrecht, the Netherlands). One hour before implant surgery patient started taking antibiotics (amoxicillin 500 mg, 3 times daily for seven days). Under local anaesthesia (Ultracaine D-S Forte; Aventis Pharma Deutschland GmbH, Frankfurt am Main, Germany) the implants were placed, according to the procedure prescribed by the manufacturer, guided by the surgical guide. The implants used in this study were tapered and roughened to the top of the implants with a titanium oxide surface (TiUnite, Nobel Biocare AB, Göteborg, Sweden). A mucoperiosteal full-thickness flap was raised to provide a clear view on the surgery area. The shoulder of the implants was placed at a depth of 2-3 mm apical to the buccal and cervical aspect of the future clinical crown to provide soft tissue to develop an adequate emergence profile. The implants were placed with an insertion torque of at least 45 Ncm. If necessary the osseous crest was recontoured or slightly overcontoured to require a bone wall of at least 2 mm on the facial aspect of the implant. Furthermore, if part of the implant surface remained uncovered or if only a thin layer of labial bone was present, a local bone augmentation procedure was performed. For the simultaneous augmentation procedures an autogenous bone graft, collected during drilling or harvested intra-orally was combined with Geistlich Bio-Oss® (Geistlich Bio-Oss®, spongiosa granules (0.25-1.0 mm), Geistlich Pharma AG, Wolhusen, Switzerland) and overlaid with a Geistlich Bio-Gide® resorbable bilayer membrane (Geistlich Bio-Gide®, Geistlich Pharma AG, Wolhusen, Switzerland). The wound was closed primarily with sutures (Ethilon 5-0, Johnson & Johnson Health Care, Piscataway, NJ). For pain control, 600-mg ibuprofen (Brufen Bruis 600; Abott BV, Hoofddorp, the Netherlands) was prescribed, to be taken 3 times daily if needed. Following surgery, a temporary removable partial denture was adjusted not exerting pressure on the wound. Two weeks following implant surgery, the sutures were removed. Three months after implant placement, the implants were uncovered and a healing abutment (NobelRepace healing abutment, Nobel Biocare AB) was placed. One week after abutment connection, an open tray impression was made at implant level using an impression post (Impression Coping Implant Level Open Tray for NobelReplace, Nobel Biocare AB), a custom acrylic resin impression tray (Lightplast base plates; Dreve Dentamid GmbH, Unna, Germany) and a polyether impression material (Impregum Penta;
In the dental laboratory, a screw-retained provisional restoration was fabricated, consisting of a temporary abutment (NobelReplace temporary abutment Engaging; Nobel Biocare AB) against which veneering composite (Solidex; Shofu, Inc, Kyoto, Japan) was modelled. In the implant-cantilever group, the lateral incisor was modelled as a cantilever. A metal reinforcement was placed at the palatal side at the connection between the two composite crowns. The plaster cast was prepared in such a way that the lateral incisor could be overcontoured in the region of contact with the mucosa. In that way, the illusion was created that the cantilever crown emerged out of the mucosa. In the implant-implant group two solitary screw-retained provisional restorations were fabricated. The provisional crowns were contoured so that the peri-implant soft tissue was optimally supported. Extra care was given to the interproximal areas: the interproximal papillae were given enough space to regenerate. The cantilever crown was cleared of all contacts in occlusion. One week after the impression was made, healing abutments were removed and the provisional implant crowns were placed and torqued to 32 Ncm. For three months, the patients visited the prosthodontist once a month for examination. Three months later (six months following implant placement) another implant-level impression was made for the fabrication of the definitive restoration. In the dental laboratory, a soft tissue cast was prepared. First, a waxing of the definitive restoration was made on a temporary abutment (NobelReplace Temporary Abutment Engaging; Nobel Biocare AB). After that, the waxing was cut back to the desired form and scanned for fabrication of custom made zirconia abutments (Procera, Nobel Biocare AB). If the screw access hole was located at the mid-palatal side, the porcelain was added directly to the abutment to create a screw-retained crown. If the access hole was not located at the mid-palatal side, a custom made zirconia abutment was fabricated together with a full ceramic cement-retained restoration. Again, in the implant-cantilever group, the lateral incisor was modelled as a cantilever with a zirconia base connected to the central located restoration. The cantilever crown did not occlude with opposite teeth in the mandible. In the implant-implant group two solitary restorations were fabricated. Screw-retained restorations and zirconia abutments were torqued to 32 Ncm. Screw holes of screw-retained restorations were filled with a cotton pellet composite resin (Clearfil AP-x; Kuraray Medical, Inc, Okayama, Japan). Screw holes of abutments were filled with a cotton pellet alone. Cement-retained restorations were fastened with Fuji Plus cement (GC, Alsip, Illinois) (Figure 1).
Data collection

Data were collected starting pre-operatively (Tpre), directly after implant surgery (Tpost), directly (within a month) after placement of the definitive implant crown (T0) and one year after placement of the definitive restoration (T1).

The following parameters were assessed:
- implant loss during the entire evaluation period
- pocket probing depth at Tpre (only neighbouring teeth), T0 and T1: the depth was measured to the nearest millimetre at three locations around the implants and the neighbouring teeth (mid-buccally and at both approximal sides)
- papilla index according to Jemt (1997) at T1
- marginal bone level and bone crest level: two weeks after implant placement and one year after placement of the definitive restoration, intraoral radiographs were taken using a standardised paralleling technique (Figure 2) (2004). A computer-assisted calibration was carried out in the horizontal plane and, if necessary, in the vertical plane for each radiograph. In the horizontal plane the known dimension of the diameter of the implant

Figure 1.
Implant crown with a cantilever as lateral incisor; dental implant located at the central incisor.

Figure 2.
The linear measurements on an intraoral radiograph of a dental implant and neighbouring teeth from the implant-cantilever group: the marginal bone levels (MBL, and MBLt), the marginal bone level of the neighbouring tooth (MBT), the bone crest level between the implant and the cantilever (BCi) and the bone crest level between the implant and its adjacent tooth (BCit). See ‘Material and Methods’ for explanation.
was used to calibrate the radiograph. If the implant was slightly angulated, the radiograph was also calibrated in the vertical plane by using the known distance of several threads as calibration. This calibration ensured a correct measurement (Sewerin, 1990). The radiographs were analysed using computer software to perform linear measurements on the digital radiographs. The measurements were performed twice by one observer. The mean of these 2 measurements was used for analysis of the data. In the vertical plane, the following linear measurements were assessed to the nearest 0.1 mm: (1) the interface of the implant and the abutment was used as a reference line (line a) from which all distances were measured, (2) the first bone to implant level: the vertical distance between line a and the first bone to implant level, measured at the implant side facing the adjacent implant and at the implant side facing the neighbouring tooth, (3) the bone level of the neighbouring tooth: the vertical distance between line a and the first bone to tooth level, (4) the bone crest level: the vertical distance between line a and the most coronal bone peak of the inter-implant bone crest (implant-implant group) or between the implant and the cantilever (implant-cantilever group) and the most coronal bone peak of the bone crest between the implants and their neighbouring teeth (Figure 2).

- a subjective appreciation of the final result of the treatment was assessed with a modified patient questionnaire of the one used by Meijndert et al. (2007) The questionnaire comprised an overall satisfaction score (range 0-10), two questions concerning the implant-supported restoration and two questions concerning the peri-implant mucosa (possible score 0-4).

**Statistical analysis**

Because of the setting being a pilot study, statistical analysis has been restricted to means and standard deviation.

**Results**

Mean age in the implant-cantilever group was 33 years (range 20 to 43) and two males and three females were present in this group. A separate preoperative augmentation was performed in three patients of the implant-cantilever group. Mean age in the implant-implant group was 28 years (range 18 to 49) and four males and one female were present in this. Four patients of the implant-implant group had undergone a separate preoperative augmentation procedure. All ten
Table 1. Mean (SD) pocket probing depth values (mm) during the evaluation period.

<table>
<thead>
<tr>
<th>Location</th>
<th>Implant-Implant Group</th>
<th>Implant-Cantilever Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central incisor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proximal side facing adjacent tooth</td>
<td>2.0 (0.0) 1.0 (0.0) 2.0 (0.0) 2.0 (0.0)</td>
<td>2.2 (0.1) 2.2 (0.1) 2.2 (0.1) 2.2 (0.1)</td>
</tr>
<tr>
<td>Midbuccally</td>
<td>1.0 (0.0)</td>
<td>2.0 (0.0) 1.0 (0.0) 2.0 (0.0) 2.0 (0.0)</td>
</tr>
<tr>
<td>Proximal side facing adjacent implant</td>
<td>1.0 (0.0) 1.0 (0.0) 1.0 (0.0) 1.0 (0.0)</td>
<td>2.0 (0.0) 2.0 (0.0) 2.0 (0.0) 2.0 (0.0)</td>
</tr>
<tr>
<td>Proximal side facing no implant/adjacent lateral implant</td>
<td>1.0 (0.0) 1.0 (0.0) 1.0 (0.0) 1.0 (0.0)</td>
<td>2.0 (0.0) 2.0 (0.0) 2.0 (0.0) 2.0 (0.0)</td>
</tr>
<tr>
<td>Central implant</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proximal side facing adjacent tooth</td>
<td>2.0 (0.0) 2.0 (0.0) 2.0 (0.0) 2.0 (0.0)</td>
<td>2.2 (0.1) 2.2 (0.1) 2.2 (0.1) 2.2 (0.1)</td>
</tr>
<tr>
<td>Midbuccally</td>
<td>1.0 (0.0)</td>
<td>2.0 (0.0) 1.0 (0.0) 2.0 (0.0) 2.0 (0.0)</td>
</tr>
<tr>
<td>Proximal side facing adjacent implant</td>
<td>1.0 (0.0) 1.0 (0.0) 1.0 (0.0) 1.0 (0.0)</td>
<td>2.0 (0.0) 2.0 (0.0) 2.0 (0.0) 2.0 (0.0)</td>
</tr>
<tr>
<td>Proximal side facing no implant/adjacent lateral implant</td>
<td>1.0 (0.0) 1.0 (0.0) 1.0 (0.0) 1.0 (0.0)</td>
<td>2.0 (0.0) 2.0 (0.0) 2.0 (0.0) 2.0 (0.0)</td>
</tr>
<tr>
<td>Cuspid</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proximal side facing adjacent tooth</td>
<td>2.0 (0.0) 2.0 (0.0) 2.0 (0.0) 2.0 (0.0)</td>
<td>2.2 (0.1) 2.2 (0.1) 2.2 (0.1) 2.2 (0.1)</td>
</tr>
<tr>
<td>Midbuccally</td>
<td>1.0 (0.0)</td>
<td>2.0 (0.0) 1.0 (0.0) 2.0 (0.0) 2.0 (0.0)</td>
</tr>
<tr>
<td>Proximal side facing adjacent implant</td>
<td>1.0 (0.0) 1.0 (0.0) 1.0 (0.0) 1.0 (0.0)</td>
<td>2.0 (0.0) 2.0 (0.0) 2.0 (0.0) 2.0 (0.0)</td>
</tr>
<tr>
<td>Proximal side facing no implant/adjacent lateral implant</td>
<td>1.0 (0.0) 1.0 (0.0) 1.0 (0.0) 1.0 (0.0)</td>
<td>2.0 (0.0) 2.0 (0.0) 2.0 (0.0) 2.0 (0.0)</td>
</tr>
</tbody>
</table>

Abbreviations: Tpre = evaluation visit before implant surgery, T0 = evaluation visit directly after placement of definitive restoration, T1 = evaluation visit 1 year after placement of definitive restoration. n.a. = not applicable.
patients could be evaluated during the one-year evaluation period. No implants failed in both groups during the one-year follow-up. Mean pocket probing depths are listed in Table 1. Mean pocket probing values of the implants are comparable between the two groups; mean pocket probing depths are larger around the implants than around the natural neighbouring teeth. Papilla indices are listed in Table 2. Scores are relatively low, pointing towards a compromised papilla presence. The frequency distributions of the scores of both groups are comparable. Mean marginal bone level, bone crest level and changes during the evaluation period are listed in Table 3. Marginal bone loss occurs, resulting in similar results of both groups. The patients’ opinion is listed in Table 4. Patient satisfaction is comparable for both groups and is very high, with a mean overall satisfaction score of 8.8 for the implant-cantilever group and 9.2 for the implant-implant group.

**Discussion**

Reporting no implant failures of a study group with solitary implant crowns in the aesthetic region, conventional healing and a follow-up period of at least one year is not uncommon. Palmer et al. (1997), Jemt & Lekholm (2003), Cardaropoli et al. (2006) and Zarone et al. (2006) all reported a 100% survival rate. In general, survival rates are very high of implants this region (den Hartog et al., 2008). However, never has been reported on implant survival rates of
implants supporting a crown with a cantilever. It must be noted that the cantilever crown was cleared from all contacts in occlusion, but the cantilever could be loaded during biting and thus exerting moment forces on the implant.

Mean pocket probing values around the implants of both groups were comparable; the presence of a cantilever and possible moment forces on the implant apparently has no or a negligible negative effect on the pocket probing depth. Mean pocket probing depths were larger around the implants than around the natural neighbouring teeth. The observed values and difference between implants and natural teeth is in agreement with other studies (Bragger et al., 1997; Hultin et al., 2000; Meijndert et al., 2008). This is due to the biological width being different around natural teeth compared with implants (Cochran et al., 1997), which might result in a stronger resistance to probing in a gingival sulcus around natural teeth when compared with a mucosal seal around implants (Ericsson & Lindhe, 1993). Another factor which might influence the probing depth is the difference between the marginal bone height of the implants and the neighbouring teeth. The more coronally positioned marginal bone level of the teeth predominantly determines the interproximal soft-tissue level, resulting in deeper pockets on the proximal side of the implants with a more apically positioning of the marginal bone level.

Papilla indices are listed in Table 2. Scores were relatively low, pointing towards a compromised papilla presence. There were no large differences in the frequency distribution of the scores between the groups. Scores were the same for the presence of the papilla between the implant crown and the cantilever and the papilla between the two implant neighbouring implant crowns. And in both groups the inter-implant papillae scored worse compared to papillae between an implant and a natural tooth. In case of two missing adjacent teeth, the bone condition in most cases is compromised. Due to resorption, the characteristic interdental bone peak is missing which causes an underdevelopment of the papilla in that region (Tarnow et al., 1992).

Mean marginal bone level, bone crest level and changes during the evaluation period are listed in Table 3. There were no large differences between the groups. A marginal bone loss occurs of 0.9 mm to 1.8 mm mesially and distally of the implants in the period from placement of the implants to one year after placement of the definitive crowns. Marginal bone level was at placement of the implants more or less at the level of the top of the implant. This phenomenon of resorption of bone in the vicinity of the microgap has been described as a result of a chronic irritant, such as bacteria, coming from the implant-abutment interface. A resorption of 1.5 to
Table 3. Mean (SD) bone level and bone changes during the evaluation period in mm.

<table>
<thead>
<tr>
<th>Location</th>
<th>Implant-Cantilever</th>
<th>Implant-Implant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tpost*</td>
<td>T1*</td>
</tr>
<tr>
<td>Central incisor</td>
<td>Marginal bone level facing the adjacent central implant</td>
<td>1.6 (0.8)</td>
</tr>
<tr>
<td>Bone crest</td>
<td>Bone crest level between central incisor and central implant</td>
<td>2.2 (0.6)</td>
</tr>
<tr>
<td>Central implant</td>
<td>Marginal bone level facing the adjacent central incisor</td>
<td>0.0 (0.0)</td>
</tr>
<tr>
<td></td>
<td>Marginal bone level facing no implant/ lateral implant</td>
<td>-0.1 (0.1)</td>
</tr>
<tr>
<td>Bone crest</td>
<td>Bone crest level between central implant and no implant/ lateral implant</td>
<td>1.2 (0.9)</td>
</tr>
<tr>
<td>No implant/ lateral implant</td>
<td>Marginal bone level facing the adjacent central implant</td>
<td>n.a.</td>
</tr>
<tr>
<td></td>
<td>Marginal bone level facing the adjacent cuspid</td>
<td>n.a.</td>
</tr>
<tr>
<td>Bone crest</td>
<td>Bone crest level between no implant/ lateral implant and cuspid</td>
<td>1.3 (1.7)</td>
</tr>
<tr>
<td>Cuspid</td>
<td>Marginal bone level facing the adjacent no implant/ lateral implant</td>
<td>1.3 (1.8)</td>
</tr>
</tbody>
</table>

* Negative values indicate a level apical to the microgap and positive values indicate a level coronal to the microgap.
† Negative values indicate bone resorption and positive values indicate bone gain.
Abbreviations: Tpost = evaluation visit directly after implant surgery, T1 = evaluation visit 1 year after placement of definitive restoration, n.a. = not applicable.
2.0 mm has been reported (Hermann et al., 1997; Tarnow et al., 2000). On the other hand, the mean marginal bone loss at the side of the implants facing the cantilever tended to be slightly larger in comparison to the other approximal implant sides of the implant-cantilever group and the implant-implant group. Mean bone crest resorption distally of the central implant in the implant-cantilever group was comparable with the mean inter-implant bone crest resorption between the central implant and the lateral implant in the implant-implant group. Mean bone crest resorption distally of the central implant in the implant-cantilever group is 1.1 mm. Mean bone crest resorption between the central implant and the lateral implant in the implant-implant group is 1.4 mm. Although the inter-implant distance is more than 3.0 mm, there could still be an effect of a lateral resorption area. Rather large standard deviations were observed for the mean changes in marginal bone level and crestal bone level. Similar observations were reported in other studies (Tarnow et al., 2000; Palmer et al., 2000; Steveling et al., 2001; Tawil & Younan, 2003; Meijndert et al., 2008). The large standard deviations suggest a considerable variability in changes in marginal gingival level and marginal bone level between individual patients, making a reliable prediction of the expected changes in hard and soft peri-implant tissues for an individual patient rather difficult. Variations in the distance from contact point

<table>
<thead>
<tr>
<th>Score**</th>
<th>Mean (SD)</th>
<th>Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall score (range 0-10)</td>
<td>8.8 (0.8)</td>
<td>9.2 (0.8)</td>
</tr>
</tbody>
</table>

* Implant crown and mucosa score: score 0 = completely dissatisfied, 1 = dissatisfied, 2 = neutral, 3 = satisfied, 4 = completely satisfied.
** Overall score: score 0 = completely dissatisfied to score 10 = completely satisfied.
to approximal crestal bone and variations in the level of the marginal approximal bone of the adjacent might be the basis of the variation in individual changes of the approximal peri-implant tissues (Tarnow et al., 1992; Kan et al., 2003; Grunder et al., 2005).

The patients’ opinion is listed in Table 4. Patient satisfaction was very high, without differences between the groups. It appears from the papilla index scores that presence of papillae, especially between the implant crown and cantilever and the adjacent implant crowns, is compromised. This disagreement has been described before by Meijndert et al. (2007) Also in this study patients were less critical than one might expect.

More patients in the study groups are needed, based on a power analysis, to confirm the findings of this pilot study with a thorough statistical analysis.

Conclusions

This one-year prospective comparative pilot study demonstrated that no large differences in hard and soft tissue levels has to be expected between patients with a missing central and lateral upper incisor treated with either one implant and an implant crown with a cantilever or two implants with solitary implant crowns. The clinical significance of these findings points towards a prosthodontic solution in which patients with a missing central and lateral upper incisor can be treated with only one implant restored with an implant crown and cantilever.

Acknowledgements

The investigators express their gratitude to Mr. J. de Vries (Biomedical Engineering, University Medical Center Groningen) for his valuable help in developing the software for the radiographic measurements.
References


