CLINICAL ORAL IMPLANTS RESEARCH

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Esthetic assessment of immediately restored implants combined with GBR and free connective tissue graft

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Key words: connective tissue graft, esthetic assessment, immediate loading, single-tooth implants

Abstract

Aim: Esthetic assessment of immediately restored implants combined with GBR and free connective tissue (CT) graft

Methods: A case–control, retrospective study involving 34 patients treated with maxillary anterior single implants, immediately placed and restored. Clinical and esthetic results were analyzed using standard clinical examination and a comprehensive index, comprising pink esthetic and white esthetic scores (PES/WES). The height of the implant crown and the corresponding height of the contralateral tooth crown were measured to identify mucosal recessions. The distance from the mucosal margin to the implant shoulder (DIM) was measured on the master model.

Results: Thirty of 34 implants fulfilled the strict success criteria set for dental implants with regard to osseointegration. Success was defined as implants with bone loss not exceeding 1.5 mm during the first year and loosing not more than 0.2 for each successive year. The other four implants were stable but did not meet the bone loss criteria mentioned above and defined as survived implants. Mean PES/WES was 14.44 ± 2.34 (range: 9–20). Mean PES was 7.12 ± 1.89 (range: 1–10). The highest mean values were achieved for the variable of root convexity/soft tissue color and texture (1.71 ± 0.46) whereas the mesial papilla (1.09 ± 0.62) proved to be the least pleasing. The mean WES was 7.32 ± 1.25 (range: 5–10). The difference between IC and contralateral TC was 0.54 mm. The mean value for the facial DIM was 3.82 ± 0.87 mm.

Conclusions: An evaluation of soft and hard tissue augmentation in immediately restored immediate implant procedures was employed to obtain stable hard and soft tissues. The combined GBR and CT graft procedure achieved favorable peri-implant soft tissue condition and esthetic results. However, recession and incomplete papillas were frequently observed.

Advances in biomaterials technology and clinical methods over the past three decades have provided clinicians with efficient tools to improve treatment procedures. Accordingly, "osseointegration" has been redefined, influenced by contemporary patients' increasing expectations for reduced treatment time and improved comfort and esthetic outcomes.

The reduction of healing time by immediate implant placement into fresh extraction sockets has been previously described (Becker & Becker 1990; Becker et al. 1991; Tolman & Keller 1991; Gelb 1993; Polizzi et al. 2000; Gomez-Roman et al. 2001). Provided that suitable implant primary stability is achieved, survival rates are similar to these recorded using the conservative delayed techniques (Becker & Becker 1990; Becker et al. 1991; Tolman & Keller 1991; Gelb 1993; Polizzi et al. 2000; Gomez-Roman et al. 2001). Promising results in this field of research have led to further trials aiming to further shorten the healing period of maxillary multiunit implant reconstruction (Bergkvist et al. 2005; Degidi et al. 2005; Ibanez et al. 2005; Ostman et al. 2005), and for single-tooth implants, ultimately resulting in immediate implant retained provisional restoration (Ericcsson et al. 2000; Chausu et al. 2001; Cooper et al. 2001; Andersen et al. 2002). However, there has been a concern that recession of the marginal peri-implant mucosa may occur, which, in turn, may have an adverse effect on the final

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esthetic outcome (Grunder 2000; Norton 2004; Lindeboom et al. 2006). Several factors were claimed to influence the frequency and extent of marginal mucosal recession, including peri-implant soft tissue biotype (Kois 2004), connection of a provisional crown immediately following implant insertion (Wo¨hrle 1998; Jemt 1999) condition and thickness of the facial bone (Grunder et al. 2005), orofacial position of the implant shoulder (Buser et al. 2004; Evans & Chen 2008), and grafting of the facial peri-implant marginal defects with autogenous bone or bone substitutes (Zitzmann et al. 2001; Chen et al. 2005). In addition, an experimental study (Araujo & Lindhe 2005) showed that following tooth extraction the facial socket wall, which is composed almost entirely of bundle bone, may be susceptible to resorption in the vertical and horizontal planes. This crestal bone resorption may lead to recession of the facial marginal mucosa. It was suggested that disruption of the vascular supply to the facial bone by the elevation of surgical flaps might be an important contributory factor (Araujo & Lindhe 2005). It has also been claimed that to maintain the stability of the buccal soft tissue, the buccal plate of bone should be at least 2 mm thick (Spray et al. 2000). As in most cases suffering from bone loss and/or ridge deformations there is lack of soft tissue in addition to lack of bone, it is advisable to improve the soft tissue cover as early as possible, preferably at the time of hard tissue augmentation. Thin tissue biotype is considered a major risk factor for advanced midbuccal recession (Kan et al. 2011). It has been proposed that increasing the thickness of the facial mucosa by the addition of a connective tissue (CT) graft beneath the facial flap at the time of implant placement may reduce this risk for recession (Kan et al. 2005; Grunder 2011). Postextraction healing and healing from implant insertion coincide, as there is only one surgical phase. The standard protocol with 2–3 consecutive surgeries in the same site may result in more tissue damage, scarring, and loss. In addition, as the original gingiva may be preserved by the instant connection of a provisional restoration offering a mechanical support to the papilla and midfacial gingival tissue, the need for additional soft tissue surgery may be eliminated (Wo¨hrle 1998; Jemt 1999).

The aim of the present retrospective study was esthetic assessment of immediately restored implants combined with GBR and free CT graft.

To our knowledge, although such combined procedure has been described before, these esthetic assessments have never been implicated to asses this combined soft and hard tissue procedure.

Material and methods

Patient selection

A total of 34 patients who had been treated consecutively by the same senior author R.K (periodontist) during the years 2009–2013 with an immediate single implant in the esthetic zone of the anterior maxilla (central and lateral incisors, and cuspids) were included in this case–control retrospective study. All implants were restored according to the concept of immediate nonfunctional loading. The study was approved by the human ethics committee of Tel Aviv University, and patients signed an approved informed consent form. Patients were considered for the study on the basis of the following inclusion criteria:

1. Patients were at least 18 years old.
2. Extraction of a single tooth in the anterior esthetic zone of the upper jaw (incisors, lateral incisors, canine) was indicated; both neighboring teeth mesial and distal to the extraction site were present.
3. The alveolar process presented at least 5 mm of bone apical or palatal to the alveolus of the failing tooth to ensure primary implant stability.
4. Primary stability of the implant was 32 N cm or more.
5. After extraction, the width of the buccal plate was compromised (thinner than 1 mm, dehiscenced or fenestrated, or combination of 2 of those defects) due to previous periodontal disease, periapical pathologies or traumatic extraction, and commended an augmentation procedure.

Exclusion criteria were as follows:

1. Smokers of more than 10 cigarettes a day, and smokers of <10 cigarettes a day who had not committed to a smoking cessation protocol.
2. Poor plaque control or lack of oral hygiene compliance.
3. Active generalized periodontal disease.
4. Systemic disease involving the oral mucosa in the esthetic zone.
5. Para-functional habits such as bruxism.
6. Uncontrolled diabetes.
7. Acute infection (with the present of pus, fistula) around the failing tooth,
8. Failure to achieve primary stability of at least 32 N cm.

Fig. 1. Periapical X-ray tooth no. 21 is hopeless.

Surgical protocol

A thorough presurgical evaluation including clinical images, periodontal chart, smoking habits, periodontal diagnosis, and full-mouth periapical radiographs (Fig. 1). The morphology of the alveolar process at the implant site, the location of the incisive foramen and the root to be extracted as well as the presence of periapical pathologies were evaluated preoperatively using CT. Special attention was given to the trabecular pattern between the buccal and palatal plates and the existence of bony contour undercuts, and reason for extraction. Light smokers were committed to a smoking cessation protocol of 1 week before and at least 1 month after implant placement. Initial periodontal therapy including oral hygiene instructions and training until a Hygiene Index (HI) (O'Leary et al. 1972) of <10% was achieved. Scaling and root planning whenever indicated were carried out, followed by additional periodontal therapy aimed to reduce periodontal probing depth (PD) and bleeding on probing. A 1-min rinse with chlorhexedine solution 0.2% (Tarodent mouthwash; Taro Pharmaceutical Industries Ltd, Haifa, Israel) was used by the patients prior to surgery.

Premedication with 875 mg amoxicillin and clavulanic acid (Augmentin, GlaxoSmithKline, Brentford, UK) was given one hour before surgery. Penicillin-sensitive patients were premedicated with clindamycin HCL (Dalacin C; Pfizer NV/SA, Puurs, Belgium) 150 mg bid starting one hour before surgery. Antibiotic administration (Augmentin) was continued for 1 week (Dalacin 150 mg × 4 per day was utilized in penicillin-sensitive patients), and analgesic administration (Naproxen sodium 275 mg; Narocin, Teva Pharm Ind Ltd, Petah Tikva, Israel) was given for pain relief, and 0.2% chlorhexedine mouth rinse twice a day for 2 weeks.

All surgical procedures were performed and supervised by R.K. After the surgical site

was anesthetized, mucoperiosteal flaps were elevated including intracrevicular incisions extending to the mid-facial aspect of at least both neighboring teeth, thereby fully reflecting papillae. This was followed by an atraumatic tooth extraction using periotomes (Hu-Friedy, Chicago, IL, USA) with an effort to maintain the integrity of the socket bonny walls. Granulation tissue was removed using a spoon curette and a 3-mm diamond bur (Strauss Company, Raanana, Israel). The drilling was conducted to the palatal wall, and care was taken to avoid any contact between the implant and the compromised buccal plate. The osteotomy was designed to achieve as much implant engagement with the bone apical to the extraction socket. Final drilling was performed using a drill measuring at least 1 mm in diameter less than the implant diameter, depending on the residual bone density. Final sitting of the implant was at least at 32 N cm, and this was performed using a torque-controlled ratchet (MIS Implants Technologies, Bar Lev, Israel). Screw-type bone level titanium implants with a platform switch design (Seven MIS Implants Technologies, Bar Lev, Israel) were used. Proper implant positioning was considered of pivotal importance with the neighboring teeth essentially being served as reference for optimal implant positioning. A minimum distance of 1 mm (measured with a periodontal probe) in M-D dimension between the implant shoulder and neighboring tooth was achieved in all the cases. In apico-coronal direction, the neck of the implant was flash with the palatal bone – 2, 3 mm apical to the cemento-enamel junction or to the crown cervical margin of the neighboring teeth if existed. In the orofacial dimension, an effort was made to place the buccal neck of the implant at least 2 mm palatal to the buccal contour of neighboring teeth. After adaptation of an appropriate abutment (0–25°, with 1–3 mm height gingival neck and torqued with 15 N cm (Anthogyr, torque-controlled ratchet-Botzer ergonomics, Tel Aviv, Israel), in all cases (not related to the socket configuration or defect morphology) allograft material 0.25–1 mm particle (FDBA-Raptos – Citagenics, Toronto, Canada) was applied in the residual gap and in excess above the buccal wall. A resorbable collagen membrane (Bio-Gide; Geistlisch Pharma AG, Wolhusen, Switzerland) was applied in an apron manner above the bone graft. At this stage, a free CT graft was harvested from the palate (Kan et al. 2005; Grunder 2011) and placed over the collagen membrane (Fig. 2). The buccal flap was coronally positioned after periosteal releasing incision and sutured to the palatal flap using Vicryl 4/0 sutures (Vicryl Rapid-Ethicon Johnson, Diegem, Belgium).

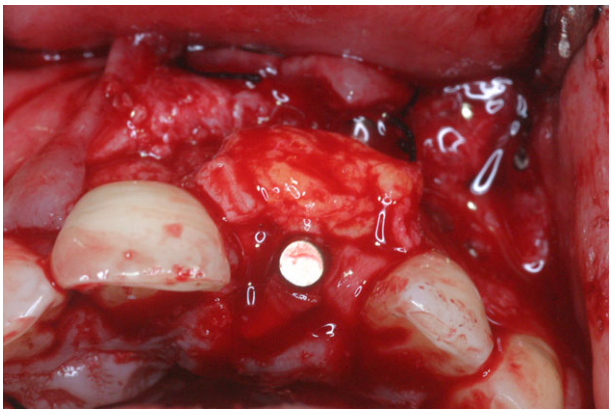

Fig. 2. Free connective tissue graft placed over Type 1 collagen membrane and allograft.

Fig. 3. Final X-ray at data collection.

Reconstructive treatment protocol

Abutment connection was followed by adaptation of a prefabricated nonfunctional acrylic temporary crown (no occlusal contacts in IC), and in protrusive and lateral movements. Six month after implant placement, after removal of the temporary crown and abutments, color-coded transfers (MIS Implants Technologies, Bar Lev, Israel) were adapted and radiographic verification of transfer adaptation was done. Impressions were taken using putty – wash one-step technique (Express, 3M. ESPE dental products, St. Paul, MN, USA) using the closed tray technique with metal stock trays. A master model with silicon image of the marginal gingiva was prepared, and interarch relations were recorded. At the following appointment, abutments were connected and the zirconia base was tried.

The permanent zirconia crown was cemented after occlusal adjustment, and glazing with temporary cement (Temp-Bond Kerr corporation, 1717 West Collins Avenue, Orange California, CA, USA).

Abutments were tightened to 35 N cm using a prosthetic ratchet (Anthogyr, torque-controlled ratchet-Botzer ergonomics). The implants were considered successful if they fulfilled the criteria of Alberktsson et al. (1986).

Clinical follow-up examination

Patients were clinically followed at 1, 2, 4 weeks and 3, 6, and 12 months postoperatively, and then annually. Patients have received personal oral hygiene programs and were seen and/or treated once every 3–6 months. Periodical maintenance visits were performed by dental hygienists supervised by RK and included plaque index and PD measurements and recordings. At the annual evaluation, the peri-implant hygiene was assessed using the HI (O'Leary et al. 1972) and gingival bleeding index (Ainamo & Bay 1975) consisting a dichotomous recording of the absence or presence of bleeding after probing of the gingival sulcus. Probing depth was measured using a light probing force (approximately 25 g) to the nearest mm using a periodontal probe (Hu-Friedy).

Radiographic evaluation

Postoperative periapical radiographs were performed immediately after implant placement, at the time of impression taking, at final crown installation, at the annual follow-up examinations and once again at the time of data collection during 2014 (Fig. 3). Standardized radiographs, with the film kept parallel (Schick technologies, Long Island, NY, USA), using plastic film holders and the X-ray beam kept perpendicular.

Follow-up and criteria for success

Radiographic distance from the implant shoulder to the coronal bone-to-implant contact

The mesial and distal alveolar bone crest to implant shoulder distance was digitally mea-

sured using computerized dental radiography based on parallel periapical X-rays (Schick technologies). Radiographic distortion was calculated by dividing the radiographic implant length by the actual one. Measurements were made at 12–48 month after the final crown adaptation, that is at the time of data collection. The value was calculated as the average of the obtained mesial and distal values. Successful implants were those with bone loss not exceeding 1.5 mm during the first year and loosing not more than 0.2 for each successive year (Alberktsson et al. 1986). The radiographic readings were performed by one experienced examiner not involved in the surgical or prosthetic treatment of the patient (E.M).

Esthetic assessment

Distance from the mucosal margin to the implant shoulder (DIM). At 7 month at the time of crown adaptation, the DIM was measured with a periodontal probe (Hu-Friedy) on the master model (type-4 stone and pink silicone imitation of the gingiva) after removal of the prefabricated new abutment and final crown to the nearest millimeter at four locations.

Cast analysis

Impressions were taken at 12 months after crown adaptation, and study models were produced using type IV stone. The casts were photographed with a standardized technique using a millimeter grid as reference. The mid-facial height of the implant crown (IC) and the corresponding height of the contralateral tooth crown (TC) were measured on these digital pictures using Image J (Image processing and analysis in Java) to identify potential changes in crown height or mucosal recessions. In cases in which the IC or the contralateral were longer, the measurement was adapted to a line traced along the incisal edge of the shorter crown.

Esthetic parameters of clinical outcome

All 34 patients were examined 12 month after the final crown was adapted. At these visits, a clinical examination and frontal photographs were taken (Canon EOS 650 D, Tokyo, Japan with a 100-mm Canon macro lens and a ring flash). The photograph was centered slightly superior to the occlusal plane, centered at the contact region of the centrals at the midline to facilitate the subsequent analysis, which is primarily based on symmetry (Fig. 4). Care was taken that the contralateral tooth was also completely and symmetrically represented.

Fig. 4. Final zirconia crown at 1 year (PES–WES score 20).

To comprehensively assess the esthetic outcome and performance, the technique described by Belser et al. (2009) was adopted. To objectively examine the esthetic outcome of the ICs at the 12-month examination, the respective casts and intraoral pictures were critically analyzed by three examiners (EM, NJ, and HN), not involved in the surgical procedure, according to two specific indices, pink esthetic score (PES) and the white esthetic score (WES) (Belser et al. 2009). The PES comprises the following variables: mesial papilla, distal papilla, curvature of the facial mucosa, level of the facial mucosa, () and root convexity/soft tissue color and texture at the facial aspect of the implant site.

The WES includes five variables: tooth form, tooth volume, tooth color including assessment of hue and value, tooth texture, and translucency – each with five parameters (Belser et al. 2009).

A score of 2, 1, or 0 is assigned to each parameter. Parameters were assessed by direct comparison with the natural, contralateral reference tooth, estimating the degree of match or eventual mismatch. In the case of an optimum duplication of the esthetically relevant features inherent to the control tooth, a maximum score of 10 is applied for each index. Hence, the highest possible combined PES/WES score was 20, which represents optimal match of the peri-implant soft tissue conditions and the clinical single-tooth IC compared to the respective features present at the contralateral natural tooth site. To facilitate the objective appreciation of some of the parameters, the examiners used the study casts. As per definition, the threshold of clinical acceptability was at a value of 6/10 for each index.

Statistical analysis

Statistical analysis was performed with the SPSS 20.0 statistical analysis software (SPSS Inc., Chicago, IL, USA). Student's *t*-test and the Mann–Whitney *U*-test were used to assess the differences between groups according to demographic and clinical variables. Due to the small sample size of the gingivitis and mild chronic periodontitis, periodontal diagnoses were grouped together into two groups' (i) Gingivitis and mild chronic periodontitis and (ii) advanced chronic and aggressive periodontitis. The Spearman nonparametric correlation coefficient test was used to test the correlation between age and outcome measures. The Wilcoxon signed-rank test with the Bonferroni correction for multiple comparisons was used to analyze the differences within the PES and WES parameters (five parameters in each group). The differences between the lengths of ICs and contra laterals were done using the paired *t*-test. P value <0.05 was accepted as significant.

Results

Thirty-four patients (14 males and 20 women) with age range 24–82 years (mean 52.68 ± 14.35 year) who had been treated consequently during the years 2009–2013 according to a strict protocol of simultaneous extraction, immediate implant placement, guided bone regeneration, and CT graft procedure were the study sample (Table 1).

Twenty-seven (79.4%) of the patients suffered from chronic advanced adult periodontitis or aggressive periodontitis, whereas 7 (20.6%) were diagnosed with gingivitis and/or mild adult chronic periodontitis. Eighteen teeth (53%) were extracted due to periodontal disease, 9 (26.5%) due to root fracture, 4 (11.7%) due to severe carious lesions, and 3 (8.8%) due to external root resorption. Intraoperative status of the buccal bony plate examined after extraction and debridement of soft tissue reflected that in 21 cases dehiscence's (15 dehiscence and six dehiscenced

and thin residual buccal plate) (62%) existed (Fig. 5), two fenestrations (6%) (Fig. 6), and in 11 cases (32%), the buccal plate was thinner than 1 mm (Fig. 7).

The relevant details of the study group including, gender, smoking status, implant length, width, abutment type, and site of each implant are presented in Table 1. Implants diameter varied between 3.3 and 5 mm with (mean 3.73 ± 0.37 mm) and implant length varied between 13 and 16 mm (mean 15.53 ± 1.08 mm) (Table 1). At the time of data collection, no implants were lost, 30 of 34 (88%) implant were successful showing no more than 1.5 mm of bone loss for the first year and additional 0.2 mm for each successive year.

DIM values

The analysis demonstrated a mean value of 3.82 ± 0.87 mm (range between 2 and 5 mm) for the buccal DIM (Table 2).

Table 1. **Included patients and implants used**

	No	%
Gender		
Female	20	59
Male	14	41
Smokers		
<10 cigarettes per day	8	23.5
Nonsmokers	26	76.5
No. of implants	34	100
Implant length		
13 mm	5	15
16 mm	29	85
Implant platform		
3.3	10	30
3.75	17	50
4.2	6	17.5
5	1	2.5
Abutments		
Titanium	30	88
Zirconia	4	12
Implant site, maxilla		
Central incisor	12	35
Lateral incisor	13	38
Canine	9	27

Cast analyses

Implant crown and TC values performed over the 1-year study period showed a 0.54 mm (range 0–3 mm) ($P = 0.004$) difference between implant crown – IC and contralateral tooth crown – TC. (Table 2).

Esthetic parameters: PES/WES values at first year

Esthetic parameters 1 year after crown adaptation of the final restoration revealed a mean PES of 7.12 ± 1.89 (range: 1–10) and a mean WES of 7.32 ± 1.25 (range: 5–10) resulting a total PES–WES score of 14.44 ± 2.34 (Tables 2 and 3). The cumulative total PES/WES of the 34 cases shows that in 91.2% of the cases, good or acceptable esthetics was achieved (≥12).

Overall, the esthetic outcomes were favorable, as demonstrated in Table 2 within the five parameters of the PES index; the mesial papilla height had the lowest mean value of 1.09 and the level of facial mucosa a mean value of 1.26, whereas the root convexity/soft tissue color and texture at the facial aspect of the implant performed the best, with a mean value of 1.71 (Table 2). The differences between those values were significant.

Seventeen implants (50%) presented an optimal level of the facial mucosa recession of less than 1 mm was observed in nine implants (26.5%), and eight implants (23.5%) presented recession of 1 mm or more (Table 3). Among the five parameters of the WES index, surface texture with a mean values of 1.56 and tooth form 1.62 had the highest scores. The translucency scored 1.26, which was the lowest (Table 2).

Using the Mann–Whitney *U*-test, a significant association ($P = 0.048$) was found between the severity of the periodontal disease (advanced chronic and aggressive periodontitis group) and low scores of the PES total. Using the same test, no correlation was found between periodontal status and total WES ($P = 0.559$) and total PES/WES ($P = 0.066$) neither between the cause for extraction or smoking status and esthetic outcomes.

Using the Spearman test, no correlation was found between age and esthetic outcome ($P < 0.2$).

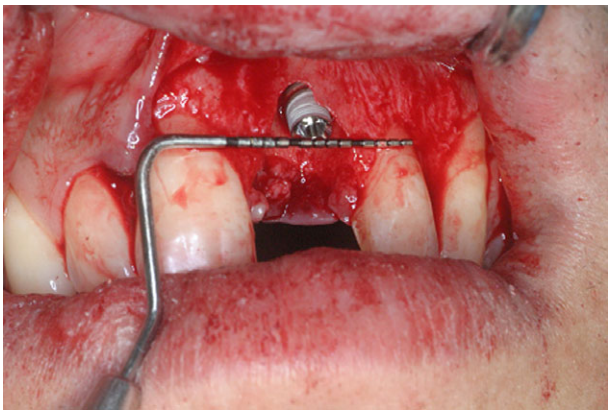

Fig. 5. Dehiscened and thin buccal plate.

Discussion

The cumulative survival rate of implants for the immediate tooth replacement procedure in the present study was 100% (34/34), whereas the success rate was 88% (30/34 implant) after a mean follow-up of 29 month (12–48 months). In the present study, success was defined as maximum 1.5 mm of marginal bone loss in the first year and not more than 0.2 mm of bone loss in each successive year; these results are comparable to the mean marginal bone loss observed in delayed loaded implants as well as immediately loaded implants after the first year (Kan et al. 2003a,b; De Kok et al. 2006; Andersson et al. 1995; Jemt & Pettersson 1993; Laney et al. 1994; Goodacre et al. 1999). Although in the present study the buccal bonny plate was compromised in all the cases, our data regarding success are comparable to the data reported when single implants were used to replace failing teeth in the esthetic zone with intact labial bony plate using the immediate provisionalization approach (Kan et al. 2003a, b; Barone et al. 2006). The present study shows that immediate implant placement for single-tooth replacement in the anterior maxilla is a successful treatment alternative presenting high predictability (Buser et al. 2004; Kan et al. 2005, 2011; Belser et al. 2009).

However, the main focus of this study was the esthetic outcome of this combined treatment approach. Three different methods were applied in an attempt to objectively assess the esthetic outcomes. First, evaluation by PES and WES (Belser et al. 2009) in which the minimal threshold for esthetic acceptability was set at six points of 10, for each one of the indices.

The overall present results were satisfying, with a mean total PES-WPS score of 14.44 ± 2.34. Our total PES–WES score is comparable the 14.7 ± 1.18 reported by Belser et al. (2009) evaluating 45 implants according to the concept of early implant placement placed (4–8 weeks postextraction) with augmentation of anterior maxillary teeth, and also to the data presented by Mangano et al. (2012) reporting a mean total PES/

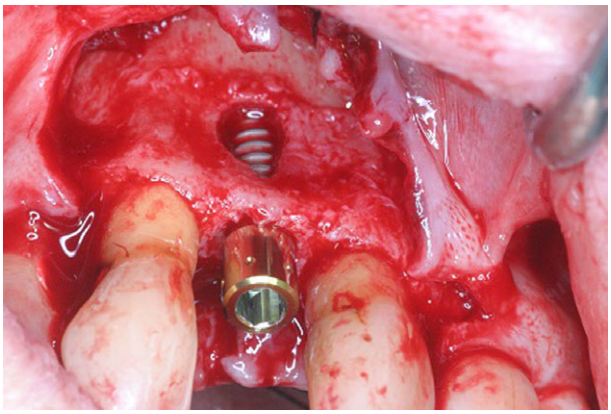

Fig. 6. Fenestration of the buccal bone.

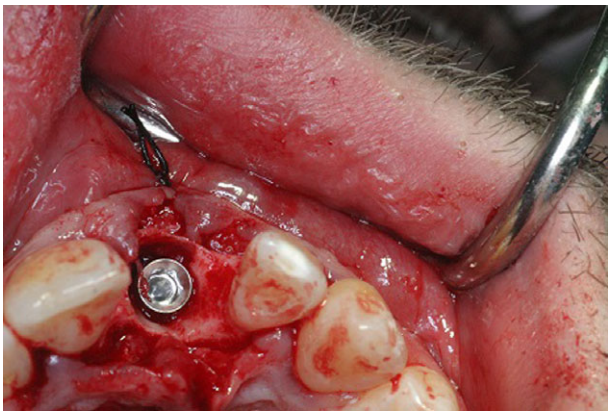

Fig. 7. Thin buccal plate (<1 mm width).

WES of 14.30 using 26 implants according to the concept of immediately loading of anterior maxillary teeth. On the other hand, our scores are lower than the 16.75 published by Buser et al. (2009, 2011) using the same guidelines to evaluate the esthetic outcome of early (8 weeks after tooth extraction) implants placed concomitantly with GBR, in 20 patients and followed for 3 years.

In the present study, the lower results may be explained by the fact that all the bony socket walls, involving the tooth to be extracted and replaced, were compromised in vertical and/or horizontal dimensions mainly due to previous periodontal disease.

The high score obtained for the combined root convexity/soft tissue color and texture (1.71) may be attributed to the combined procedure of GBR and CT grafts. This combination seems to have enhanced soft tissue morphology, successfully permitting an optimal emergence profile and texture of the buccal soft tissue. Of 34 cases, 24 scored 2 (70.6%) while the remaining 10 cases scored 1 (29.4%). Our data confirm those reported by Kan et al. (2009) that after CT grafting used for single immediate tooth replacement, the gingival level could be maintained regardless of the initial gingival biotype. Moreover if immediate placement is performed in patients with a thin biotype, there is a higher risk of soft tissue recession and underlying resorptive osseous remodeling, exposing the metal margin of the implant (Kois 2004). The use of GBR and CT grafts in all the cases in the present study intended to achieve favorable esthetics and to avoid recessions that will need a second soft tissue intervention during the first year (Cosyn et al. 2012).

The cumulative total PES/WES of the 34 cases shows that in 91.2% of the cases, good or acceptable esthetics was achieved (≥12). Using the modified PES score (Belser et al. 2009) produced a score of 7.12, which is comparable to data from other studies using the same modified PES score (Belser et al. 2009; Buser et al. 2011, 2013; Cosyn et al. 2012; Furze et al. 2012; Mangano et al. 2012).

The low scores of the mesial papilla (1.09 ± 0.62) and the level of facial mucosa (1.26 ± 0.83) were affected by the marginal bone loss of the neighboring teeth (Ryser et al. 2005). Our data of 23.5% regarding buccal soft tissue recessions (more than 1 mm) are lower than those reporting 30–40% using immediate implant placement technique (Chen et al. 2007; Kan et al. 2007a,b; Evans & Chen 2008; Lindeboom et al. 2006) and much higher than the 5% reported by Buser et al. (2009, 2011) using a staged approach. Thus in almost 1 of 4 cases of the cases, a notable recession of more than 1 mm existed a fact raising the question if a staged approach may achieve better results in compromised buccal bonny cases like in the present case study.

The findings of the present study shows that only partial compensation of the buccal bone deficiencies was achieved by the use of a combined GBR and CT graft procedure.

Another two additional methods were used to evaluate the esthetic outcomes in the present study. The second evaluation method was based on DIM values on the facial gingival aspect of the implant at the time of crown placement. The assessed mean DIM value of 3.82 ± 0.87 mm confirmed that the technique permitted the formation of a normal mucosa of the facial aspect (Kan et al. 2003a,b). DIM data were comparable to that presented by Buser et al. (2009), 12 months after early implant placement with simultaneous GBR for single-tooth extraction.

The third method of esthetic assessment was the measurement of IC vs. the contralateral tooth on study casts. The comparison of these values at 12 months showed a significant difference of 0.54 mm between IC and TC. In a study (Kan et al. 2007a,b) of immediate implant placement in the presence of defects in the facial bone of varying size, recession of the mid-facial mucosa of 1.5 mm or more was reported in 34.8% of sites. Similarly, the defects were grafted with autogenous bone chips or DBBM combined with a resorbable collagen membrane (Kan et al. 2007a,b). In the present study, a relatively lower ratio of >1 mm recession cases were noticed (23.5% of cases presented a recession of more than 1 mm), a fact that may be attributed to the CT additive effect. The cumulative data of the present study and Kan's study reflect the difficulty in compensating buccal bone deficiencies using GBR and GBR with CT grafts.

In contrast, one study of delayed placement after GBR with autogenous bone chips combined with DBBM and resorbable collagen membrane reported a relatively low incidence of recession after 3 years, 1 of 20 sites (5%) demonstrated mid-facial recession in the range of 0.5–1 mm (Buser et al. 2011).

Table 2. **Detailed PES and WES of All 34 included implants – GBR and CTG**

	Implant	Pink esthetics (PES)*						White esthetics (WES)*									Distance from mucosal margin to implant shoulder (DIM)			
N	Site	Mesial papilla	Distal papilla	Curvature of facial mucosa	Level of facial mucosa†	Root convexity, soft tissue color and texture	Total PES	Tooth form	Tooth volume/ outline	Color (hue/ value)	Surface texture	Translucency and characterization	Total WES	Total PES + WES	Crown_ length (mm)	Contralateral_ length (mm)	Buccal	Mesial	Distal	Palatal
1	23	0	2	2	2	2	8	2	2	1	1	1	7	15	8.9	8.8	5	9	8	6
2	22	1	1	2	0	2	6	2	1	2	2	1	8	14	11.2	9.0	4	6	6	5
3	12	1	1	1	1	2	6	1	1	2	2	1	7	13	10.4	10.0	4	7	6	5
4	23	0	1	1	2	2	6	2	2	1	1	1	7	13	12.3	11.8	3	6	5	5
5	21	2	2	2	2	2	10	2	2	2	2	2	10	20	10	10.0	4	6	6	5
6	11	1	2	1	2	2	8	2	2	1	1	1	7	15	10	10.0	4	6	6	5
7	22	1	1	1	2	1	6	1	1	1	1	1	5	11	9.8	8.9	5	6	5	5
8	22	1	1	1	1	1	5	1	1	1	2	2	7	12	8.5	8.5	5	8	7	5
9	21	1	2	1	1	2	7	1	1	1	2	2	7	14	10	9.5	4	7	6	4
10	11	1	2	1	1	1	6	1	1	1	2	1	6	12	9.8	9.1	3	6	6	4
11	21	1	2	2	2	2	9	2	2	1	2	1	8	17	9.3	10.0	3	5	5	3
12	12	2	2	2	0	2	8	2	1	2	2	1	8	16	8.8	7.1	4	7	6	5
13	22	1	2	1	2	1	7	2	1	2	1	1	7	14	9.1	8.8	5	8	7	5
14	13	2	1	1	1	2	7	1	1	1	1	1	5	12	10.6	10.0	3	5	4	3
15	12	1	1	2	2	2	8	2	2	1	1	1	7	15	8.8	11.8	3	5	4	3
16	23	1	1	1	2	1	6	2	2	2	1	1	8	14	10.5	10.0	2	4	4	3
17	12	0	0	0	0	1	1	1	2	2	2	1	8	9	10.7	9.0	3	5	4	3
18	23	2	2	2	2	2	10	2	2	1	1	1	7	17	9	9.1	4	6	5	3
19	11	0	2	1	0	2	5	1	1	1	2	1	6	11	11.5	10.0	4	6	5	4
20	21	1	2	1	0	1	5	2	1	2	2	2	9	14	11	9.0	5	7	6	3
21	21	1	1	2	2	2	8	2	2	1	2	1	8	16	9.5	10.0	4	5	4	3
22	21	1	2	2	0	2	7	1	1	2	2	1	7	14	11.2	10.0	2	4	3	3
23	22	1	2	2	2	2	9	2	2	1	1	0	6	15	9.6	10.0	4	6	5	4
24	22	2	2	2	2	2	10	2	2	2	2	1	9	19	9.2	9.0	3	4	4	3
25	22	1	2	2	1	2	8	2	1	1	2	1	7	15	9	7.6	4	6	6	4
26	21	1	2	1	0	2	6	1	0	2	2	2	7	13	12.8	11.0	5	3	5	5
27	21	1	2	2	2	2	9	1	1	1	2	2	7	16	9.6	9.4	4	6	6	5
28	21	0	2	1	1	2	6	1	1	1	1	2	6	12	9.4	9.5	3	6	5	4
29	12	1	1	2	2	2	8	2	1	2	2	2	9	17	10.4	10.0	5	7	6	6
30	12	2	2	1	0	1	6	1	1	2	2	2	8	14	8.4	7.2	5	8	6	5
31	13	1	1	2	1	1	6	2	2	2	2	2	10	16	10.1	9.1	4	6	6	4
32	23	2	2	2	2	2	10	2	2	2	1	1	8	18	9.1	8.9	4	6	5	4
33	13	2	1	2	2	2	9	2	2	0	0	1	5	14	10.3	10.0	3	6	7	4
34	23	1	1	2	1	1	6	2	2	2	1	1	8	14	10.7	10.1	3	6	5	3
	Average	**1.09**	**1.6**	**1.5**	**1.26**	**1.71**	**7.1**	**1.62**	**1.44**	**1.44**	**1.56**	**1.26**	**7.3**	**14.44**	**9.95**	9.41	**3.82**	**6**	**5**	**4.15**
	Standard deviation	**0.62**	**0.6**	**0.56**	**0.83**	**0.46**	**1.9**	**0.49**	**0.56**	**0.56**	**0.56**	**0.51**	**1.3**	**2.34**	**1.04**	0.9	**0.87**	**1.26**	**1**	**0.96**
	Median	**1**	**2**	**2**	**1.5**	**2**	**7**	**2**	**1**	**1**	**2**	**1**	**7**	**14**	**9.9**	**9.515**	**4**	**6**	**6**	**4**
	Minimum	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	**5**	**9**	**8.4**	**7.08**	**2**	**3**	**3**	**3**
	Maximum	**2**	**2**	**2**	**2**	**2**	**10**	**2**	**2**	**2**	**2**	**2**	**10**	**20**	**12.8**	**11.8**	**5**	**9**	**8**	**6**
	Difference (in mm)														**0.54**					

*Belser et al. (2009).
†0, identical vertical level; 1, slight discrepancy up to 1 mm; 2, major discrepancy more than 1 mm.

Table 3. **Scores assessment for single PES/WES variables 1 year**

	1-year assessment, *N* (%)			
	0	1	2	Average
Mesial papilla	5 (14.7)	21 (61.7)	8 (23.5)	1.09
Distal papilla	1 (2.9)	13 (38.2)	19 (55.8)	1.56
Curvature of facial mucosa	1 (2.9)	15 (65.2)	19 (55.8)	1.50
Level of facial mucosa	8 (23.5)	9 (26.5)	17 (50)	1.26
Root convexity/soft tissue colour/texture	0 (0.0)	10 (29.4)	25 (73.5)	1.71
PES (mean ± SD)		**7.12 ± 1.89**		
Tooth form	0 (0.0)	13 (38.2)	21 (61.7)	1.62
Tooth volume/outline	1 (2.9)	17 (50)	16 (47)	1.44
Tooth colour (hue/value)	1 (2.9)	17 (50)	16 (47)	1.44
Surface texture	1 (2.9)	13 (38.2)	20 (58.8)	1.56
Translucency	1 (2.9)	23 (67.6)	10 (29.4)	1.26
WES (mean ± SD)		**7.32 ± 1.25**		
Total PES–WES		**14.44 ± 2.34**		

The surgical technique applied is the present study is characterized by the use of non-cross-linked collagen membranes in combination with mineralized allograft granules (FDBA). The FDBA granules offer good volume stability for the buccal bone augmentation because of their low substitution rate (Kolerman et al. 2013).

The non-cross-linked collagen membrane was used because the use of a bioabsorbable membrane decreases the risk for membrane infection if a soft tissue dehiscence occurs postoperatively (Buser et al. 1996; Stavropoulos et al. 2004).

In the present study, a hard and soft tissue augmentation concomitantly with immediate implant placement was employed in order to obtain stable hard and soft tissue. The results imply that the combined GBR and CT graft procedure may only partially compensate for buccal bone deficiencies.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Table S1. CONSORT 2010 checklist of information to include when reporting a randomised trial.