Measurements of Soft Tissue Volume in Association with Single-Implant Restorations: A 1-Year Comparative Study after Abutment Connection Surgery

Kristina Henriksson, DDS;* Torsten Jemt, DDS, PhD†‡

ABSTRACT

Background: Patients with buccal defects due to tooth extraction seem to regain some of the contour at the time of abutment surgery and connection of single-implant crown restorations. It can then be assumed that different abutment systems could restore the buccal contour to different degrees.

Purpose: To measure changes in buccal tissue volume after placing restorations with single-implant crowns using two different abutment systems and to measure soft tissue change during the 1 year after single-implant treatment.

Materials and Methods: Eighteen patients were provided with single-implant restorations in the central incisor area. Nine patients in each group were treated with single-implant crowns supported by either CeraOne® abutments (Nobel Biocare AB, Göteborg, Sweden) or customized Procera® ceramic abutments (Nobel Biocare AB). Study casts were made before abutment connection, at crown placement, and after 1 year. After the casts were scanned, they were analyzed with a computer, using the model before abutment as a reference. In the area of the single implant, sagittal projections provided images of the models that allowed measurements between the contours at the different situations. Radiography and photography for measuring papillary volume were also performed.

Results: All patients exhibited increased "buccal volume" after abutment connection and crown placement ($p < .01$). A trend to greater increase was observed for the Procera group. Both groups also showed a reduction of buccal tissue 1 year later ($p < .05$–$.01$), leaving on average more volume in the Procera group. The papillae recovered spontaneously, and no relationship was observed between the presence of papilla and underlying bone support ($p > .05$).

Conclusions: The buccal tissue increased significantly after placement of the abutment cylinder and the implant crown. This increase of buccal contour was reduced after 1 year. Furthermore, no relationship was established between the presence of papillae and the distance between the contact point and the underlying bone crest.

KEY WORDS: aesthetics, custom abutments, mucosa adaptation, papilla, single implants, soft tissue

A common indication for single-implant restorations is a situation in which teeth adjacent to missing incisors are completely intact.[1] Experience gained to date with single-implant treatment in such situations indicates success rates that are comparable or higher than those of more conventional methods.[1–5]

The restoration of anterior gaps is aesthetically demanding with regard to surgery as well as to the final prosthodontic rehabilitation. This has led to the development of different types of grafting techniques for hard and soft tissue as well as to the development of several new implant components. One of the most challenging parts of this treatment is achieving an optimal contour of the buccal mucosa in the region of the single implant. Different types of surgical techniques involving procedures such as guided bone regeneration[6–10] and labial bone grafting[11–21] have been

*Consultant in prosthodontics, The Brånemark Clinic, Public Dental Health, Göteborg, Sweden; †chairman, The Brånemark Clinic, Public Dental Health, Göteborg, Sweden; ‡professor, Department of Prosthetic Dentistry/Dental Material Science, Göteborg, Sweden

Reprint requests: Dr. Torsten Jemt, The Brånemark Clinic, Public Dental Health, Medicinaregatan 12 C, S-413 90 Göteborg, Sweden; e-mail: torsten.jemt@vgregion.se

used to reshape the alveolar crest. Surgical techniques for grafting soft tissue to optimize the single-implant area have also been described.[22]

A recent trend in terms of the development of implant components is the introduction of customized abutments[23–26] to allow optimal support of veneering material as well as to better support the mucosa and thereby improve the emergence profile of the restoration. Measurements of buccal tissue volume after local bone grafting have recently been published in the report of a 3-year prospective study[21] of single-implant treatment in the central incisor region. It was observed that the local bone graft allowed the implant to be placed in a more optimal position, but it was also observed that the graft seemed to resorb to a significant degree during the follow-up period. An additional observation was that the buccal volume increased significantly as a result of abutment connection and subsequent crown placement. On the basis of this last observation, it was suggested that buccal tissue grafts done only to restore the crest aesthetically could be avoided because this could be achieved by merely connecting the implant and crown components. Should that approach be considered, the shape of the abutment components would probably become more important.

The aim of this study was to measure changes in buccal tissue volume after placing restorations with single-implant crowns using two different abutment systems and to measure the changes in soft tissue volume adjacent to the implant restorations during the first year of function.

MATERIALS AND METHODS

Patients and Clinical Procedures

A total of 18 patients (17 males and 1 female) who presented with the loss of a single upper central incisor owing to trauma were included in this study. The patients were divided into two groups. The first group was provided with single-implant crowns supported by CeraOne® abutments (Nobel Biocare AB, Göteborg, Sweden). The second group was treated with single crowns supported by customized Procera® ceramic abutments (Nobel Biocare AB). Both groups of patients had participated as subgroups in two earlier studies.[21,26]

The CeraOne group consisted of 9 male patients.[21] The patients had a mean age of 26.1 years (standard deviation [SD], 4.9) at the time of implant surgery, and their ages ranged from 21 to 36 years. All patients were healthy and were on no ongoing medication. There were no smokers in the group.

Prior to implant treatment, all patients in this group had buccal bone defects in the edentulous area, indicating a need for labial (horizontal) bone grafting to allow optimal implant placement. After clinical and radiographic examinations, treatment started with a bone-grafting procedure (described in detail elsewhere).[21] After the bone grafts healed, the patients received either Standard (7 patients) or Mk II (2 patients) Brånemark System® implants (Nobel Biocare AB) placed according to standard two-stage surgical protocol.[27] The implants were allowed to heal for an average of 8.1 months (SD, 2.2) prior to second-stage surgery, when a standard healing abutment was attached. The final impression was made directly at implant level (29072, Nobel Biocare AB) after appropriate soft tissue healing. Crown insertion took place at an average of 4.2 weeks (SD, 1.6) after second-stage surgery. The single-crown restorations were porcelain fused to metal crowns cemented on top of a CeraOne abutment.[21]

The Procera abutment group consisted of 8 male patients and 1 female patient. The mean age was 31.1 years (SD, 8.2), and ages ranged from 18 to 44 years.[26] All patients were healthy and were taking no medication, and there was one smoker in the group.

Each patient was provided with a Brånemark System Mk III implant (Nobel Biocare AB) placed according to standard two-stage surgical protocol.[27] The implants were allowed to heal for an average of 6.2 months (SD, 0.67). During second-stage surgery, standard healing abutments were attached to the implants.

Prosthodontic treatment started about 2 weeks after second-stage surgery. The final impression was made directly at implant level by means of an implant transfer coping (DCA 448). After the final impression and fabrication of the master cast, custom-made ceramic abutments were fabricated with Procera technology. This was performed by using a laser scanner to transfer data on the cast and the position of the implant into a computer.[21] A technician designed the abutment on the computer screen by using a special three-dimensional computer-aided design program. The designed abutment was fabricated in densely sintered pure aluminum oxide. The final crown restoration was made either by fabricating a Procera

all-ceramic crown[28] that was cemented onto the ceramic abutment (4 patients) or by fusing porcelain directly onto the ceramic abutment (5 patients). The four all-ceramic crowns were temporarily cemented (with Temp Bond NE™ combined with 50% Temp Bond Modifier, Kerr, Orange, CA, USA) to the abutments. Four weeks later the abutment screw was given a final tightening by means of the screw controller (29165, Nobel Biocare AB), to 32 Ncm. These crowns were finally cemented onto the Procera ceramic abutment with zinc phosphate cement. The remaining five patients received restorations that were designed with a screw access hole on the palatal surface of the crown. The abutment screws were tightened by hand at the time of insertion. The crowns were installed an average of 8.4 weeks (SD, 2.1) after second-stage surgery.

Registrations and Measurements

Clinical evaluation was performed at crown placement, after 2 weeks, and after 1 year. This involved assessment of the gingival condition around the implants, assessment of the stability of the implants and restorations, and registration of complications.

Impressions for study casts were made for all patients just prior to abutment connection, at the first follow-up appointment 2 weeks after crown placement, and after 1 year in function.

Measurement and analysis of the study casts have been described in detail by Jemt and Lekholm.[21] In brief the study casts were placed in an optical three-dimensional scanner (Atos, GOM International AG, Switzerland) to measure the contours of the models from the different clinical situations.[21] The scanner measured the surfaces of the models by projecting different fringe patterns onto the object; the patterns were recorded by two video cameras. The information from the two cameras was then translated into three-dimensional coordinates, with a calculated three-dimensional accuracy of 0.1 to 0.2 mm for this setup.

The measurements from the first study cast, made prior to the abutment surgery, were used as the reference for the other models.[21] The three-dimensional images of the other two models were then individually superimposed onto the reference model in the computer. On the computer screen a sagittal plane was placed through the edentulous area of the central incisor, presenting the tissue contour of the reference model in relation to the different follow-up models (Figure 1).

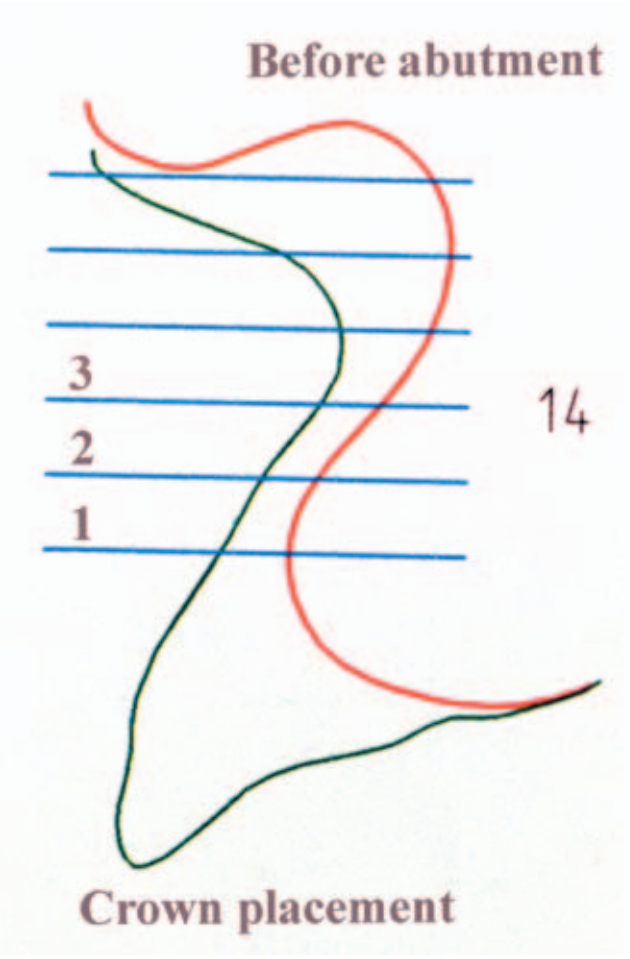

Figure 1 The model before abutment *(red line)* was used as the reference; the other models (crown placement, *blue line*) were measured in relation to the reference. In the area of the single implant, sagittal projections provided images of two models that allowed measurements between the contours of the casts in the coronal level *(level 1)* and in the more apical levels of the crest *(levels 2 to 3)*.

A horizontal reference line was then placed through the estimated gingiva/crown margin of the digital model at crown placement. Parallel lines were placed in the apical direction, with an interline distance of 2 mm, thereby creating sections of 2 mm–wide areas at various levels of the crest (see Figure 1). The area between the lines of the two models and the reference lines were then measured in square millimeters. These areas were referred to as ''volume,'' and changes between these areas were then compared throughout the study period to indicate changes in volume.

Clinical photography and impressions for study casts were done at the same follow-up appointments. The clinical photographs were used to analyze changes of soft tissue papillae adjacent to single-implant restorations by means of a papilla index[27] ranging from index

score 0 to index score 4. In brief, the papilla index measures the soft tissue volume in the embrasures by assessing the presence of tissue between a reference line between the teeth and the contact point of the crowns. Index score 0 denotes no soft tissue in this area; index score 1 denotes soft tissue reaching less than half the distance between the reference line and the contact point; index score 2 denotes more soft tissue than indicated by index score 1 but tissue not extending all the way to the contact point; index score 3 denotes tissue filling the entire embrasure; and index score 4 denotes a hyperplastic papilla.[27] Papillae were denoted as present when given an index score of 2 to 4 and absent when given an index score of 0 or 1.[29] Three of the mesial proximal areas and three of the distal proximal areas were excluded from measurements because of diastemata.

Intraoral apical radiography was performed at the time of crown placement and after 1 year of function. One of the proximal sites was not possible to measure because the implant was placed very close to the tooth. The radiographs were analyzed with regard to presence of pathology, signs of mechanical complications, and marginal bone level changes in relation to the fixture/abutment junction (FAJ) (Figure 2, "FAJ" to "a"). Furthermore, for those areas with adjacent teeth in contact with the implant crown, the following distances were measured in relation to the FAJ indicated on the radiographs and shown in Figure 2:

1. The vertical distance from the level of the FAJ to the marginal bone level of the adjacent tooth ("FAJ" to "b")
2. The vertical distance from the level of the FAJ to the most apical level of the contact point ("FAJ" to "c")
3. The vertical distance between the most coronal point of the bone ("b") and the most apical level of the contact point ("c")
4. The horizontal distance between the implant and the adjacent tooth at the level of the FAJ ("i" to "t")

Statistics

Descriptive statistics and conventional life table analysis with regard to cumulative success rates (CSRs) have been used in the present study.

Changes of volumes between the different stages of treatment were tested by means of the Wilcoxon signed rank test. Changes of papilla volume (ie, present or not present) were tested by means of the chi-square test. Significant tests were two-tailed and were conducted at the 5% significance level.

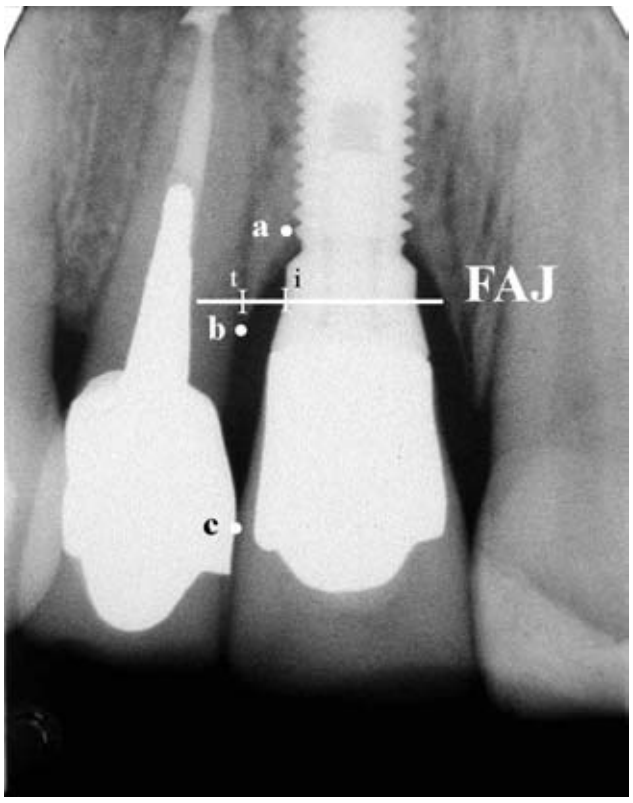

Figure 2 Radiograph showing the selected reference level (fixture/abutment junction [FAJ]) and the selected measuring points (see text).

RESULTS

All 18 patients showed up for all scheduled appointments. No complications were observed in relation to the bone grafting procedure or in connection with implant surgery protocols. All 18 implants were integrated and remained osseointegrated at the 1-year recall (100% CSR), all crowns remained stable during the follow-up period, and no complications were reported in relation to the crown restorations.

All patients exhibited increased buccal volume after abutment connection and crown placement; there was a trend of more increase for the Procera group (Table 1). The increase was significant for both groups ($p < .01$), and the increase in volume was more pronounced in the coronal area. Both groups showed a significant ($p < .05$–$.01$) reduction of buccal tissue 1 year later (see Table 1).

Papilla index scores in the CeraOne group ranged from 1 to 2 at the time of crown placement and from

Table 1 Mean Increase of ''Volume'' from Crown Placement and after 1 Year in Function

	Mean Area or "Volume" (mm^2)[†‡]			
	Procera Group		CeraOne Group	
Level of Crest below Crown Margin	At Crown Placement	After 1 Year	At Crown Placement	After 1 Year
Coronal 0–2 mm	2.54** (1.42)	1.86** (1.30)	1.90** (1.06)	1.39 (1.63)
2–4 mm	2.21** (1.34)	1.28** (0.91)	1.80** (0.74)	0.74 (1.49)
Apical 4–6 mm	2.19** (2.01)	0.39** (1.16)	1.34** (1.04)	0.07* (1.16)

[†]Measurements are given for different levels of the crest (see Figure 1) and are related to the reference at the time "before abutment connection."
[‡]Values in parentheses represent standard deviations.
*Statistical change in "volume" between two following observations, $p < .05$.
**Statistical change in "volume" between two following observations, $p < .01$.

1 to 3 at the follow-up appointments. The papilla index scores in the Procera group ranged from 1 to 3 at the time of crown placement and at the 1-year recall. An obvious increase of papilla volume was observed after 1 year in function (Table 2). The "presence" of papilla increased significantly ($p < .01$) during the follow-up period (Table 3).

No signs of pathology or mechanical complications were observed in the radiographs obtained during the study period. The mean marginal bone loss at the

Table 2 Distribution of Papilla Index Scores from Crown Placement to 1-Year Follow-Up

	Index Score*									
	0		1		2		3		4	
Registration	CP	1 Yr	CP	1 Yr	CP	1 Yr	CP	1 Yr	CP	1 Yr
Mesial	—	—	10	—	4	8	1	7	—	—
Distal	—	—	10	—	5	13	—	2	—	—

CP = crown placement.
*According to Jemt.[30]

Table 3 Presence and Absence of Papilla at Single-Tooth Implant Crown (Mesial and Distal) in Relation to Distance from Contact Point to Most Coronal Bone Level after 1 Year in Function

Distance (mm)	< 3	3	4	5	6	7	8	9	≥ 10
Total number of sites	3	2	6	4	6	4	2	0	3
At crown placement									
% present*	33	50	17	50	67	25	50	—	100
% absent[†]	67	50	83	50	33	75	50	—	0
After 1 year									
% present*	100	100	100	100	100	100	100	—	100
% absent[†]	0	0	0	0	0	0	0	—	0

*Jemt index scores 2 and 3, combined.[29,30]
[†]Jemt index scores 0 and 1, combined.[29,30]

Table 4 Mean Marginal Bone Loss from Crown Placement to 1-Year Follow-Up

	Marginal Bone Loss during First Year of Function (mm)			
	Procera Group		CeraOne Group*	
	Mean	SD	Mean	SD
Mesial	0.2	0.98	0.2	0.45
Distal	0.3	0.50	0.5	0.48
Change in Bone Level (mm)	Number of Sites			
+1.5 to > 0.0	3		3	
0.0	5		2	
>0.0 to <−0.5	7		5	
−0.5 to <−1.0	0		6	
−1.0 to <−1.5	3		1	
−1.5 to <−2.0	—		—	
−2.0 to <−2.5	1		—	

*One distal site was unreadable.

implants was 0.3 mm (SD, 0.63). Change of bone level at the implants ranged from an increase of 1.5 mm to a loss of 2.0 mm (Table 4).

Measured distances on the radiographs in relation to the FAJ are shown in Table 5. The most coronal level of the bone was at the tooth site ("b" in Figure 2) on all radiographs. From the measurements shown in Table 5, it can be observed that bone level was reduced at the implant site ("a" in Figure 2) as well as at the tooth side ("c" in Figure 2) after 1 year; the distance from bone ("b") to the contact point ("c") ranged from 2.0 mm to 11.0 mm after 1 year in function. No relationship could be observed ($p > .05$) between the papilla index score and the distance between bone crest and contact point after 1 year in function (see Table 3).

DISCUSSION

The present study indicates that the tissue volume increases significantly at the buccal surface of a single-implant restoration after placement of the abutment and implant crown ($p < .01$). Both groups showed a significant increase of "volume," which first should be related to an adjustment of the flap in a buccal direction after connection of the space-demanding abutment cylinder. The tissue is then further forced to the buccal direction when the final crown is connected, which occasionally causes initial blanching in

Table 5 Measured Distances on Radiographs according to Reference Points in Figure 2

	Distance Measurement (mm ± SD)		
Distance Measured*	At Crown Placement	At 1 Year of Follow-Up	Difference
Bone level to implant (FAJ to a)	−1.0 ± 0.59	−1.3 ± 0.75	−0.3 ± 0.63
Bone level to tooth (FAJ to b)	3.4 ± 1.49	3.2 ± 1.38	−0.1 ± 0.71
			Range (mm)
Contact point to FAJ (FAJ to c)	—	8.6 ± 2.49	4.5–13.5
Contact point to bone crest (d)	—	5.9 ± 2.25	2.0–11.0
Contact point to bone, implant (a to c)	—	9.9 ± 2.78	4.5–16.5
Tooth to implant (i to t, mesial)	—	3.8 ± 0.93	2.5–4.5
Tooth to implant (i to t, distal)	—	2.0 ± 0.85	1.0–4.5

FAJ = fixture/abutment junction.
*The letters "a", "b", "c", "i", and "t" represent reference points marked in Figure 2.

Figure 3 Initial blanching in the soft tissue adjacent to the single-crown restoration at the time of placement.

the soft tissue adjacent to the single-crown restoration (Figure 3).

The initial hypothesis was that it could be expected that the Procera group would present more buccal volume because this group was provided with more space-demanding abutment/crown restorations. Accordingly the CeraOne group was provided with CeraOne abutments designed as cylinders of a dimension similar to that of the implant head whereas the Procera group had customized abutments that could be extended more to the buccal direction, outside the contour of the implant head. On average the buccal "volume" increased more in patients who had been provided with custom-made abutments (see Table 1) but did not reach a significant level in these patients ($p > .05$). Thus the initial hypothesis was not statistically supported by the results, but the observation of a clear trend of a more pronounced increase of buccal tissue for custom-made abutments may be statistically proven in larger patient groups.

It can be observed that buccal tissue volume changes significantly in the implant area during the first year of function. Accordingly it can be noticed that the contour of the buccal tissue "shrinks" significantly in both groups during the first year ($p < .05$–$.01$). Even though the previous grafting procedure had hardly any impact on the change of contour after crown installation in the CeraOne group, further resorption of the bone graft has been reported by many,[6–21] and this can play a role in the reduction of the buccal contour in this group during the first year after crown placement (see Table 1). In the CeraOne group, therefore, the buccal "shrinkage" could be related to both soft tissue resorption and a slow underlying resorption of the bone graft. However, in the Procera group the observed reduction of buccal contour should be more exclusively related to the reorganization of the mucosa. The initial trend of more buccal volume after crown placement in the Procera group remained also after 1 year, with still more increase of buccal volume when compared to the CeraOne group (see Table 1).

The observations in this study challenge the opinion that bone grafts should be used to aesthetically optimize the contour of the edentulous area in single-implant situations. It is common knowledge that the graft will resorb over time,[6–21] and it can therefore be questioned that from an aesthetic emergence profile point of view, the local bone graft may not be an optimal solution in a long-term perspective. This leaves the use of local buccal bone grafts in single-implant restoration to indications for optimizing the implant position whereas reshaping the crest from an aesthetic point of view probably might be handled by manipulation of the soft tissue, with comparable results.

This reorganization of the tissue can also be observed as a spontaneous recovery of the mucosa in the embrasure area (Figure 4; see also Figure 3), which thereby recreates the shape of the papilla (see Tables 2 and 3), in accordance with observations reported earlier.[30,31] However, the mechanism behind this regeneration is not clear. Tarnow and colleagues[32] measured the thickness of the soft tissue in interproximal sites before periodontal surgery in dentate patients. They related these measurements to visual observations of "presence" or "absence" of the papilla. A relationship between absence of the papilla and a mucosa thicker

Figure 4 Clinical photograph taken after 1 year in function.

than 6 to 7 mm was observed, but the reason for this relationship was unknown. [32] Choquet and colleagues [29] analyzed the presence of interproximal papillae adjacent to single-implant restorations in a cross-sectional retrospective study by combining data from radiographs and papillary volume measurements.[29,30] They interpreted their results as ''a clear shift of the presence or absence of papillae between 5 to 6 mm'' of thickness of the mucosa.[29] When Choquet and colleagues' criteria for the presence or absence of the papilla[29] are used, the present study cannot support these observations (see Table 3). Accordingly the present study found no relationship at all between the presence of papilla and bone support (see Table 3), thereby leaving the mechanism behind the presence or absence of the interproximal papilla still unknown, in accordance with the discussion by Tarnow and colleagues.[32]

CONCLUSIONS

This study indicated that an easy and cost-effective way of building buccal volume in the critical aesthetic area of single-implant restoration is to take advantage of customized abutments. Even though not statistically significant, the increase of buccal volume was more pronounced in the group that received customized abutments, and the created buccal contour seemed also to be more ''present'' after 1 year in function. The study's results support the assumption that an abutment profile that mimics the geometry of the natural tooth is a better solution than the traditional cylindrical standard abutment in regard to building tissue volume. Furthermore, without evidence of any relationship between the presence or absence of papillae volume and underlying bone support, the present study fails to support the assumption that it is important to have bone in order to recreate the interproximal papilla in single-implant treatment.

REFERENCES

1. Priest G. Single-tooth implants and their role in preserving remaining teeth: a 10-year survival study. Int J Oral Maxillofac Implants 1999; 14:181–188.
2. Priest GF. Failure rates of restorations for single-tooth replacement. Int J Prosthodont 1996; 9:38–45.
3. Creugers NHJ, van't Hof MA. An analysis of clinical studies on resin-bonded bridges. J Dent Res 1991; 70:146–149.
4. Creugers NHJ, Kayser AF, van't Hof MA. A meta-analysis of durability data on conventional fixed bridges. Community Dent Oral Epidemiol 1994; 22:448–452.
5. Pröbster B, Henrich GM. 11-year follow-up study of resin-bonded fixed partial dentures. Int J Prosthodont 1997; 10: 259–268.
6. Dahlin C, Linde A, Gottlow J, Nyman S. Healing of bone defects by guided tissue regeneration. Plast Reconstr Surg 1988; 81:672–676.
7. Dahlin C, Lekholm U, Linde A. Membrane-induced bone augmentation at titanium implants. A report on ten fixtures followed from 1 to 3 years after loading. Int J Periodontol Restorative Dent 1991; 11:273–281.
8. Buser D, Bragger U, Lang N, Nyman S. Regeneration and enlargement of jaw bone using guided tissue regeneration. Clin Oral Implants Res 1990; 1:22–32.
9. Cortellini P, Bartolucci E, Clauser C, Pini Prato GP. Localized ridge augmentation using tissue regeneration in humans. Clin Oral Implants Res 1993; 4:203–209.
10. Buser D, Dahlin C, Schenk RK, eds. Guided bone regeneration in implant dentistry. Chicago: Quintessence, 1994: 31–48.
11. Sinder-Pedersen S, Enemark H. Reconstruction of alveolar clefts with mandibular or iliac crest bone grafts: a comparative study. J Oral Maxillofac Surg 1990; 48:554–560.
12. Misch CM, Misch CE, Resnik RP, et al. Reconstruction of maxillary alveolar defects with mandibular symphysis grafts for dental implants: a preliminary procedural report. Int J Oral Maxillofac Implants 1992; 7:360–366.
13. Jensen J, Sinder-Pedersen S, Oliver AJ. Varying treatment strategies for reconstruction of maxillary atrophy with implants: results in 98 patients. J Oral Maxillofac Surg 1994; 52:210–216.
14. Friberg B. Bone augmentation at single-tooth implants using mandibular grafts: a one-stage surgical procedure. Int J Periodontics Restorative Dent 1995; 15:436–445.
15. Raghoeber G, Batenburg R, Vissink A, Reintsema H. Augmentation of localized defects of the anterior maxillary ridge with autogenous bone before insertion of implants. J Oral Maxillofac Surg 1996; 54:1180–1185.
16. Widmark G, Andersson B, Ivanoff C-J. Mandibular bone graft in the anterior maxilla for single-tooth implants. Int J Oral Maxillofac Surg 1997; 26:106–109.
17. Misch CM. Comparison of intraoral donor sites for onlay grafting prior to implant placement. J Oral Maxillofac Implants 1997; 6:767–776.
18. Chiapasco M, Abati S, Romeo E, Vogel G. Clinical outcome of autogenous bone blocks or guided bone regeneration with e-PTFE membranes for reconstruction of narrow edentulous ridges. Clin Oral Implants Res 1999; 10:278–288.
19. von Arx T, Kurt B. Implant placement and simultaneous ridge augmentation using autogenous bone and a micro titanium mesh: a prospective clinical study with 20 implants. Clin Oral Implants Res 1999; 10:24–33.

20. Seibert J. Reconstruction of deformed partially edentulous ridges, using full thickness onlay grafts. II. Prosthetic/periodontal interrelationships. Compend Contin Educ Dent 1983; 4:549–562.
21. Jemt T, Lekholm U. Measurements of buccal tissue volumes at single implant restorations after local bone grafting in the maxilla. A 3-year clinical prospective study. Clin Implant Dent Relat Res 2003; 5:63–70.
22. Seibert J, Linde J. Esthetics in periodontal therapy. In: Lindhe J, Karring T, Lang NP, eds. Clinical periodontology and implant dentistry. 3rd Ed. Copenhagen: Munksgaard, 1997:647–81.
23. Jemt T. Customized titanium single-implant abutments: 2-year follow-up pilot study. Int J Prosthodont 1998; 11: 312–316.
24. Russell MM, Andersson M, Dahlmo K, Razzoog ME, Lang BR. A new computer-assisted method for fabrication of crowns and fixed partial dentures. Quintessence Int 1995; 26:757–763.
25. Persson M, Andersson M, Bergman B. The accuracy of high-precision digitizer for CAD/CAM of crowns. J Prosthet Dent 1995; 74:223–229.
26. Henriksson K, Jemt T. Evaluation of custom made Procera® ceramic abutments for single implant tooth replacement. A prospective 1-year follow-up study. Int J Prosthodont 2003; 16:626–630.
27. Adell R, Lekholm U, Brånemark P-I. Surgical procedure. In: Brånemark P-I, Zarb G, Albreksson T, eds. Tissue-integrated prostheses: osseointegration in clinical dentistry. Chicago: Quintessence, 1985:211–232.
28. Andersson M, Razzoog ME, Oden A, Hegenbarth EA, Lang BR. Procera: a new way to achieve an all-ceramic crown. Quintessence Int 1998; 29:285–296.
29. Choquet V, Hermans M, Adriaenssens P, Daelemans P, Tarnow D, Malevez C. Clinical and radiographic evaluation of the papilla level adjacent to single-tooth dental implants. A retrospective study in the maxillary anterior region. J Periodontol 2001; 72:1364–1371.
30. Jemt T. Regeneration of gingival papillae after single-implant treatment. Int J Periodontics Restorative Dent 1997; 17:327–333.
31. Jemt T. Restoring the gingival contour by means of provisional resin crowns after single-implant treatment. Int J Periodontics Restorative Dent 1999; 19:21–29.
32. Tarnow D, Magner A, Fletcher P. The effect of the distance from the contact point to the crest of bone on the presence or absence of the interproximal dental papilla. J Periodontol 1992; 63:995–996.