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## Abstract

*Volume changes induced by three different soft tissue augmentation procedures were compared in 61 class III ridge defects, all possessing a width of two to three teeth. Four groups were formed. The first surgical group, CT, consisted of 28 ridge defects which were operated with a subepithelial connective tissue graft. Sixteen ridge defects were corrected by a modified connective tissue graft technique and constituted the second surgical group, mod. CT. Seventeen ridge defects were treated by the full thickness onlay graft and formed the third test group, OL. Twelve defects were not operated and defined the control group, CO. The volumetric change was assessed three months postsurgically relatively to the pre-operative dimension by taking impressions and fabricating dental casts. The defect size was measured in its horizontal and vertical dimension by utilizing a periodontal probe. Linear differences in each dimension were compared between the groups and analyzed by Kruskal-Wallis and Mann Whitney U test ($p < 0.05$). Results: The observation time for all surgical groups ranged between 3.4 to 3.7 months. The horizontal change of the gingival ridge level for the OL, CT, and CT mod. groups was + 1.3 mm (± 0.9), + 2.6 mm (± 1.4) and + 2.9 mm (± 1.5), respectively. In the vertical dimension the improvement of the gingival ridge level for the OL, CT, and mod. CT groups amounted to + 1.0 mm (± 0.7), + 1.8 mm (± 1.0) and + 2.0 mm (± 1.1). Vertical and horizontal gains were significantly larger in the CT and mod. CT group than in the OL group.*

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## Introduction

The localized alveolar ridge defect may be defined as a volumetric deficiency of soft and bone tissue with a limited extension, which is restricted to the alveolar process. These ridge defects are common in conjunction with single and multiple tooth loss. The prosthodontic treatment with fixed partial dentures of surgically uncorrected ridge defects is challenging and leads to several esthetic and functional problems (Seibert & Cohen 1987).

(1) The three-dimensional tissue loss reduces or eliminates the scalloping architecture of the gingival tissue and results in the loss of papillae, leading to dark, open interdental spaces. This results in not only esthetic and phonetic problems, but also in increased food impaction.
(2) The buccal prominence of the gingiva and alveolar mucosa is lost after a tooth extraction because the alveolar *jugae* resorb, resulting in esthetic problems with the prospective pontic contact. Larger ridge defects can only be masked by a removable partial denture if surgery can not be performed.
(3) Often an unpleasant looking gingival scar tissue is observed, instead of a physiological gingiva texture with its stippling. In the case of a too small keratinized gingiva band, a glossy and shiny alveolar mucosa is manifested.

These problems bothered at least a part of investigated patients during a recall examination. Their ridge defects were located in the visible area but remained surgically uncorrected and were nevertheless prosthetically treated with a fixed partial denture (Hawkins et al. 1991). Fourty-six percent of the patients were unsatisfied due to food impaction and 20% of the reexamined patients were not satisfied with the esthetic outcome. Consequently, it may be concluded that the prosthodontic therapy of an alveolar ridge defect is for at least a part of the patients necessary and represents a significant periodontal and prosthodontic challenge in order to obtain perfect mucogingival esthetics (Studer et al. 1996a).

A localized alveolar ridge defect can be either masked by prosthodontic tools or surgically corrected by soft tissue grafts during the prosthodontic pretreatment phase, especially if the defect size is limited. Different soft tissue augmentation procedures were presented in the periodontal literature (Abrams 1980; Coslet et al. 1980; Langer & Calagna 1980 & 1982; Garber & Rosenberg 1981; Seibert 1983a & 1983b). They were presented in form of several case reports with different modifications (Allen et al. 1985; Allen 1988; Hall 1989; Israelson & Plemons 1993; Miller 1986; Orth 1996; Palacci et al. 1995; Rosenberg 1989; Scharf & Tarnow 1992; Seibert & Cohen 1987; Seibert & Lindhe 1989; Seibert & Nyman 1990; Seibert 1991; Seibert & Salama 1996; Wang et al. 1993). However, only Allen et al. (1985) studied the volumetric effects of those soft tissue augmentation procedures. They applied *semi*-quantitative measurements by defining the severity of the ridge defect with a periodontal probe and compared the ridge augmentation performed with hydroxyapatite against the subepithelial connective tissue graft.

The accurate measurement of volume changes induced by surgical procedures is of clinical interest. It quantifies dimensional effects of surgical methods, which allows the comparison of different surgical methods. In addition, long-term stability can be assessed. Based upon these known quantitative outcomes of each surgical method, a treatment planning of prosthetic reconstruction becomes more accurate. An optical measurement method in form of projection Moiré compared two different soft tissue augmentation procedures, which were applied for the correction of localized alveolar ridge defects. Results revealed that the subepithelial connective tissue graft technique produced more volumetric gain than the full thickness onlay graft technique after 3 months post surgically (Studer & Schärer 1994). However, these corrected ridge defects possessed an extension of one missing tooth, only.

Therefore, the purpose of the present study was the short-term assessment of the volumetric behavior of ridge defects with an extension of two to three missing teeth by applying different soft tissue procedures.

## Material and Methods

### Subjects

Patients were selected for this study utilizing the following criteria: (1) The presence of periodontal health without any obvious attachment loss and no probing pocket depths greater than 4 mm (CP-12, Hu-Friedy, D-69181 Leimen). Tooth loss never occurred due to periodontal disease. Reasons for tooth loss were trauma, congenital missing tooth and root fracture. (2) The presence of a high level of oral hygiene. This was manifested by a papillary bleeding index (PBI) ≤ 20 (Saxer et al. 1977). Further, two teeth which were located on each side of the ridge defect were not allowed to reveal any clinical gingivitis, which was assessed by the modified gingivitis index (Mombelli et al. 1987) and by the plaque index at four sites of each tooth (Silness & Löe 1964). The mean of these four teeth had to be smaller than 0.5. In addition, the tooth mobility of any of those teeth was not larger than grade 1 (Nyman & Lindhe 1989). (3) The patient showed an interest in dental esthetics. (4) The ridge defect had an extension of a multiple tooth width (Studer et al. 1996b) and was classified as a class III defect (Seibert 1983a).

The exclusion criteria were (1) patients with insufficient oral hygiene and/or periodontal diseases, (2) showing no esthetic interest, (3) the presence of any smoking habits, (4) the history or diagnosis of any disease affecting wound healing, and (5) the history or diagnosis of any hemorrhagic disease.

All patients were treated by post-doctoral students, senior lecturers and assistant professors in the Department of Fixed & Removable Prosthodontics & Dental Materials. In all cases the post-doctoral student, under supervision of the responsible assistant professor and/or chairman, was responsible for the accurate planning, case presentation, treatment and the correct incorporation of the prosthodontic work. The requirements of the Helsinki Declaration on informed consent were fulfilled by explaining the treatment plan to the patient during the case presentation, especially the planned soft tissue augmentation procedure, and the patient was asked for his/her consent. The surgical correction was performed by one dentist (S.St.). Patients which refused to have an additional surgery in form of the soft tissue augmentation were further excluded from the study. In these cases, the ridge defect was accepted as an esthetic compromise and was masked with prosthodontic tools. For the present study the control group was constituted by patients which fulfilled the inclusion criteria, but due to time reasons had to wait for the surgical ridge correction for at least three months.

### Measurement of the localized alveolar ridge defect

An impression was made of each ridge defect prior to and three months after surgical correction. A polyvinyl-siloxane material was mixed in a syringe (President Jet, regular body®; Coltene, Altstätten, Switzerland) and placed in a conventional metal tray (Type Rim-Lock®, Stoma; D-78576 Emmingen-Liptingen). A medium viscosity was chosen to reduce the risk of any tissue compression during impression making. The impression was poured not earlier than 12 hours with a vacuum-mixed (Type R3®; Degussa, D-Frankfurt) type IV special hard gypsum (Fuji Rock, GC Company, Japan) due to the viscoelasticity of the impression material.

The extension of the ridge defect was defined as distance between the buccal-proximal line angles of both adjacent teeth at the vertical level of the papilla tips. It was measured with an orthodontic caliber (Zürcher Model, Medidenta Zürich), having a division of one tenth of a millimeter. The result was rounded up to the next tenth of a millimeter.

The severity of the ridge defect was assessed on the dental cast with a periodontal probe (PCP UNC 15, Hu Friedy, D-69181 Leimen) by measuring the defect size separately in the vertical and horizontal dimension (Studer et al. 1996b). The vertical component of the ridge defect was measured between the deepest point of the ridge defect to a line, which run through the adjacent papilla tips, named the papilla line (Fig. 1a & b). The horizontal component of the ridge defect was assessed between the deepest point of the ridge defect to the tooth arch curvature, which run through the adjacent gingival zeniths, or the buccal cemento-enamel junction, respectively (Fig. 2a & b). The papilla line and the tooth arch curvature defined in a semi-quantitative manner the esthetically ideal ridge form, which outlined the target volume for augmentation. Both lines were determined with a tin wire, having a circle round cross-section with a diameter of 1 mm, possessing no elasticity. In this manner, the ridge defect was semi-quantitatively determined prior to and three months after surgery. The measured results were rounded up to the next half millimeter.

The absolute gain in the vertical and horizontal dimension, expressed in millimeters, was calculated by subtracting the postoperative from the preoperative value. The relative gain in the vertical and horizontal dimension, expressed as a percentage,

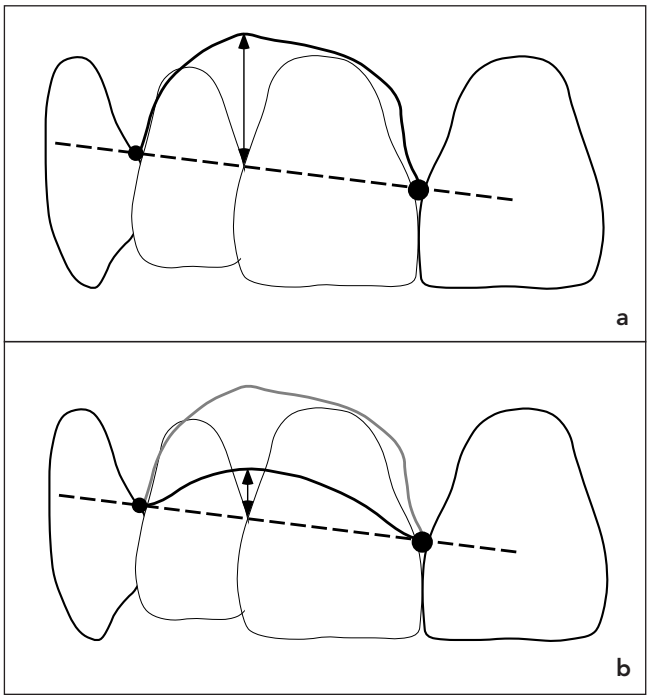


*Fig. 1 a) Front view of an alveolar ridge defect prior to surgery. The vertical component of the ridge defect was measured between the deepest point of the ridge defect to a line, which run through the adjacent papilla tips, named the papilla line. b) Semi-quantitative assessment of the corrected ridge defect in the difference between the pre- and postoperative measurement.*

was calculated as the absolute gain divided by the preoperative defect size times one hundred. The relative gain allowed a classification of each operation, separated into its vertical and horizontal dimension. Success was defined if at least 67% gain was reached, partial success if 33% to 66% gain was realized, and failure, if the gain was less than 33%.

## Surgical protocol

Prior to surgery every patient rinsed with 0.2% chlorhexidin solution (Hibitan®) for 30 seconds and was premedicated with 500 mg mefenaminacid (Ponstan 500®), an analgesic possessing an antiphlogistic component. In addition, an antibiotic was administered in form of 100 mg doxycycline (Vibramycin® 100 mg, Pfyzer).

The donor site for the soft tissue graft was limited to the hard palate between the area of the canine and the first molar. No grafts were harvested out of the tuberosity. The aim was to harvest "as much as possible" in order to obtain an optimal corrected ridge which allowed the achievement of an esthetic pontic. For every surgical step, the #15 blade was used. The bleeding in the palate was controlled by the use of local anesthesia (Ultracain forte 4%, Hoechst), compression with sterile gauzes, application of a liquid hemostatica in form of 13.3% ferricchloride (Adstringedent®, Ultradent Products, Salt Lake City, Utah), three to four single sutures (Ethibond 4-0, FS-2, Ethicon, Norderstedt, Hamburg) and a collagen material (Colla-Plug, Calcitek). The donor site was routinely covered in order to improve the patient's comfort by either a vacuum stent in conjunction with a soft relining material (Softliner®), seldom by a periodontal dressing (Coe-Pak®), or by an already existing orthodontic retainer plate or by a temporary plate.

*Description of the surgical and control groups*

Three surgical groups were constituted, which were treated either with the technique of the full thickness onlay graft, the original subepithelial connective tissue graft or a modified version of the subepithelial connective tissue graft. Per defect the selection of the surgical method was at random. The control group consisted of multiple tooth defects, which remained surgically uncorrected during an observation time of more than three months, but they were not selected randomly.

The surgical methods are described elsewhere in details (Langer & Calagna 1980; Seibert 1983a; Studer et al. 1996b). Therefore, only a short summary shall describe each method.

*The full thickness onlay graft technique*

In the recipient site the de-epithelization was performed by removing about 1 mm of epithelium including a minimum amount of connective tissue, resulting in a bleeding recipient site. The adjacent papillae remained untouched. The onlay graft was prepared from the hard palate with a distance to the marginal gingiva of two to three millimeters. The graft consisted of epithelium, connective tissue and fatty tissue. Thin feather-like margins were cut off in order to obtain a butt joint margin. After the bleeding in the donor site was stopped, the onlay graft was sutured on top of the recipient site. The graft was sutured along all its four sides in order to avoid any movements which could be provoked by lip and cheek pull. Special care was given to the apical side of the graft which was sutured tightly to the underlying tissue in order to eliminate any hollow spaces.

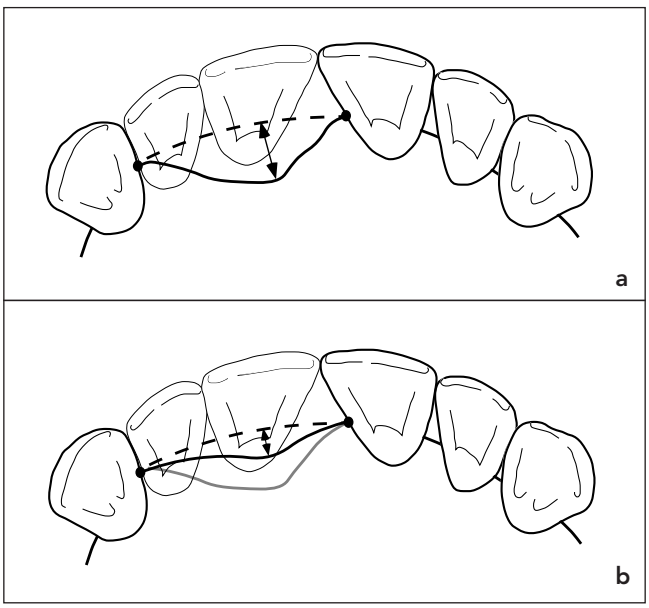


*Fig. 2 a) Palatal view of an alveolar ridge defect prior to surgery. The horizontal component of the ridge defect was assessed between the deepest point of the ridge defect to the tooth arch curvature, which run through the adjacent gingival zeniths, or the buccal cemento-enamel junction. b) Semi-quantitative assessment of the corrected ridge defect in the horizontal orientation after surgery. The horizontal gain was defined as the difference between the pre- and postoperative measurement.*

*The subepithelial connective tissue graft technique*
In the recipient site a partial thickness flap was elevated, strictly avoiding any perforation. If the flap tissue was thin, a full thickness flap was prepared at those sites to prevent any perforation, however, changing to a partial thickness flap beyond the mucogingival junction. The horizontal incision was performed on the palatal side of the ridge, having a distance of about 4 mm to the ridge crest. The vertical incisions were slightly divergent and ended always apical to the mucogingival junction. Both adjacent papillae were not included in the flap design. In the donor site, the graft was prepared in the hard palate with a distance to the gingival margin of two to three millimeters. First, a thin partial thickness flap was prepared, having a shape of a rectangle in order to uncover the connective tissue. Second, the connective tissue graft was harvested which included a small band of epithelium with one to two millimeter width. Therefore, the graft consisted of connective tissue, fatty tissue and that band of epithelium which was located on the tooth arch side. The graft was trimmed according to the shape of the recipient site. After the bleeding in the palate had stopped, the graft was sutured at its four edges with resorbable sutures to secure its position in the recipient site. Finally, the partial thickness flap was lengthened in order to suture the flap back in its original position without applying any tension: the submucosal layer was incised horizontally in the apical portion of the mucosal flap.

*The modified subepithelial connective tissue graft technique*
The graft design of the modified technique was slightly different in comparison to the original method, described above . Half of the graft's width remained covered with epithelium, as it is the case with an onlay graft, whereas in the other half of the graft's width epithelium was removed leaving connective tissue and fatty tissue. Therefore, this graft represented a combined onlay - connective tissue graft. In the recipient site, the surgical steps remained the same as it was the case for the original subepithelial connective tissue technique. The combined onlay - connective tissue graft was adapted to the shape of the ridge defect. The onlay part of the graft was fixed on the palatal aspect of the recipient site. The connective tissue part of the graft was placed on the buccal aspect of the recipient site, correcting the ridge defect. The partial thickness flap was extended only to the buccal aspect of the onlay graft. This facilitated the fixation of the flap without applying any further tension and kept the mucogingival junction at the same level.

*Suture material*
Connective grafts, covered by a flap, were fixated in the recipient site with resorbable sutures having a thickness of 5-0 (Cat-Gut plain®, P-3; Vicryl rapid® P-3; Ethicon, Norderstedt, Hamburg). Onlay grafts and the repositioned flaps were positioned with resorbable and non-resorbable sutures (Cat-Gut plain®, P-3, 4-0; Vicryl rapid® P-3, 4-0; Prolene 6-0, P-3; Ethicon, Norderstedt, Hamburg).

*Medication after surgery*
Every patient rinsed with 0.2% chlorhexidin solution (Hibitan®) twice a day for thirty seconds during two weeks. 500 mg mefenaminacid (Ponstan 500®) was administered three times a day during at least four days in order to reduce the soft tissue swelling. 100 mg doxycycline (Vibramycin®, Pfyzer) was prescribed once a day during seven days. The sutures were removed after 7 to 10 days postsurgically and teeth were professionally cleaned (Prophybürstchen, Hawe, Gentillino, Lugano, Schweiz) with a prophylaxis paste (Cleanpolish®, Hawe, Gentillino, Lugano, Schweiz).
Recall sessions followed after one, two and three months post operative. These sessions included (1) periodontal examination by assessing plaque index, modified gingivitis index, probing pocket depth, tooth mobility and the width of the keratinized gingiva, (2) professional tooth cleaning (3) photographical documentation and (4) impression taking of the surgically corrected ridge defect.

*Prosthodontic treatment of the operated patients*
Every surgical corrected ridge defect was protected from chewing and soft tissue forces with either a fixed temporary bridge, consisting of a PMMA material, an orthodontic retainer plate or a removable temporary plate. Every temporary pontic tooth was reduced by at least one third in its length in order to avoid any local necrosis due to an inflammatory swelling of the augmented tissue during the first week of wound healing. The study protocol demanded an uncompressed augmented ridge during three months of observation which remained protected from chewing and soft tissue forces.

### Statistical analysis

Analysis were performed in three steps. (1) Preoperative differences between the four groups according to the defect's width, the vertical and horizontal defect size were evaluated using the Kruskal-Wallis test ($p < 0.05$). (2) Postoperative differences between the three surgical groups according to their vertical and horizontal defect size in millimeter and in percentage were examined with the Kruskal-Wallis test ($p < 0.05$). (3) The pairwise statistical testing of these postoperative differences was done by the Mann-Whitney U test ($p < 0.05$).

### Error of measurement

All measurements were triplicated and were performed by one operator (S.S.). The mean of these three measurements was used for further calculations. The ridge defects of ten pre- and postoperative dental stone casts were measured twice at different days. The difference between the first and second series of measurement was calculated. The means with standard deviation are given in Table I. For further calculations, always the first series of measurements was used.

## Results

Sixty one ridge defects with an extension of a multiple tooth width were surgically corrected in 56 patients. Twelve defects remained untreated and served as control. In five patients two ridge augmentation procedures were performed at different locations. The mean mesio-distal width of the ridge extension was

*Table I Difference between the first and second measurement of the ridge defect size in its vertical and horizontal dimension, as absolute and as relative error*

| | Absolute error (in mm) | | Relative error (in %) | |
|---|---|---|---|---|
| | Mean | Std.dev. | Mean | Std.dev. |
| Horizontal dimension | 0.2 | 0.3 | 3.1% | 5.9% |
| Vertical dimension | 0.0 | 0.2 | –1.0% | 5.6% |

*Table II Distribution of patients, ridge defects, mean mesio-distal width of ridge defects, and mean observation time after surgery*

| Surgical method | CT* graft | OL* graft | mod. CT* graft | Control group |
|---|---|---|---|---|
| Number of patients | 26 | 15 | 15 | 11 |
| Number of ridge defects | 28 | 17 | 16 | 12 |
| Mean width of ridge defect (± Std.dev.) | 18.4 ± 4.7 mm | 19.3 ± 2.8 mm | 18.3 ± 5.3 mm | 17.4 ± 3.9 mm |
| Mean observation time after surgery | 3.5 months | 3.7 months | 3.4 months | 6.6 months |

* CT, subepithelial connective tissue graft; OL: the full thickness onlay graft; mod. CT: modified connective tissue graft

*Table III Assessment of defect size in the horizontal (A) and vertical (B) orientation before and after surgery*

| Surgical method | CT* graft | OL* graft | mod. CT* graft | Control group |
|---|---|---|---|---|
| **A** Mean (± Std.dev.) of defect prior to surgery | 3.8 ± 1.7 | 3.6 ± 2.0 | 4.0 ± 1.5 | 4.5 ± 1.9 |
| Mean (± Std.dev.) of absolute gain after surgery | 2.6 ± 1.4 | 1.3 ± 0.9 | 2.8 ± 1.5 | 0.1 ± 0.3 |
| Mean (± Std.dev.) of relative gain after surgery | 68% ± 18 | 39% ± 30 | 67% ± 14 | 2.6% ± 5.8 |
| **B** Mean (± Std.dev.) of defect prior to surgery | 2.7 ± 1.2 | 2.9 ± 1.7 | 3.4 ± 1.3 | 4.1 ± 2.0 |
| Mean (± Std.dev.) of absolute gain after surgery | 1.8 ± 1.0 | 1.0 ± 0.8 | 2.0 ± 1.1 | 0.0 ± 0.2 |
| Mean (± Std.dev.) of relative gain after surgery | 70% ± 40 | 39% ± 33 | 59% ± 20 | -0.8% ± 5.5 |

*as in Table II

17.4 mm in the control group, 19.3 mm in the onlay group, 18.4 mm in the connective tissue group, and 18.3 mm in the modified connective tissue group. The postsurgical observation time was similar for all three surgical groups, i.e. 3.7 months for the onlay group, 3.5 months for the connective tissue group and 3.4 months for the modified connective tissue group (Tab. II).

The means of absolute and relative gain in the vertical and horizontal dimension for each surgical group are illustrated in Table IIIa & b. Table IVa & b summarizes the distribution of the successful, partially successful and failed ridge augmentation procedures, separated in the three surgical groups and in their vertical and horizontal dimensions.

## Discussion

The purpose of the present study was to assess the volumetric behavior of ridge defects having an extension of two to three missing teeth by applying different soft tissue procedures prior to definitive cementation of a fixed partial denture, or after three months postsurgically, respectively.

The preoperative defect size did not differ statistically from each other in all four groups, either in the vertical dimension (P–Value=0.1053) or in the horizontal dimension (P=0.6406), as well as for the extension of the defect size (P=0.4246). The observation time was similar for all three surgical groups and ranged between 3.4 to 3.7 months. This allows the conclusion, that the three surgical groups and the non-operated group possessed the same presurgical conditions in relation to ridge extension and defect size in its vertical and horizontal dimension. Therefore, differences between these groups which were determined after surgery were not related to presurgically already existing differences. The postoperative differences between the three surgical groups were statistically significantly different according to their vertical gains (P=0.0111) and to their horizontal gains (P=0.0017). The dimensional gains for the three surgical groups as a percentage were again statistically significantly different for the vertical direction (P=0.0232) and for the horizontal direction (P=0.0006). The pairwise statistical testing of these postoperative differences revealed that the onlay group obtained significant smaller gains in comparison to the connective tissue group in their vertical (P–Value=0.0186) and horizontal dimension (P–Value=0.0019). The same was observed in the pairwise comparison between the onlay group and the modified connective tissue group for the vertical (P– Value=0.0042) and horizontal dimension (P–Value=0.0042). The comparison between the connective tissue and the modified connective tissue group showed no significant differences in relation to the vertical (P–Value=0.4568) and horizontal gain (P=0.6694). Therefore, both connective tissue methods showed better results than the onlay method. Surprisingly, this was the case not only in the horizontal dimension, but also in the vertical dimension, although the latter method is described in the literature as the method of choice for the correction of vertical ridge defects (Seibert 1983a). Similar results were obtained for the surgical correction of ridge defects with an extension of a single tooth. The subepithelial connective tissue graft technique delivered significantly more volumetric gain three months postoperative than the full thickness onlay graft technique, which was assessed quantitatively by a projection Moiré method (Studer & Schärer 1994). There-

*Table IV Distribution of successes, partial successes and failures in the horizontal (A) and vertical (B) orientation*

| Surgical method | CT* graft | OL* graft | mod. CT* graft |
|---|---|---|---|
| Number of sites | 28 (100%) | 17 (100%) | 16 (100%) |
| **A** Number of successes | 18 (64%) | 2 (12%) | 10 (62.5%) |
| Number of partial successes | 9 (32%) | 9 (53%) | 6 (37.5%) |
| Number of failures | 1 (4%) | 6 (35%) | 0 (0%) |
| **B** Number of successes | 14 (50%) | 4 (24%) | 9 (56%) |
| Number of partial successes | 12 (43%) | 6 (35%) | 5 (31%) |
| Number of failures | 2 (7%) | 7 (41%) | 2 (13%) |

* as in Table II

fore, it may be concluded that the connective tissue method gives more favorable results than the onlay graft technique which are independent of the defect size.
For the present study a simple measurement method was applied, which allowed a fast and easy assessment of ridge defects prior to and after surgery. In addition, this method did not demand expensive equipments. The drawback of this method lies in its limited precision, which was manifested in a relative error of measurement in the horizontal dimension of 3.1 (± 5.9%) and in the vertical dimension of -1.0% (± 5.6%), respectively. Another limitation may be the fact that the location of the defect size assessment do not necessarily remain at the same location between the pre- and postoperative measurement. Consequently, this measurement method may be defined as a semiquantitative one. The alternative for the assessment of 3-D volume differences could be the projection Moiré technique (Studer et al. 1993). This method offers volume assessments with sufficient accuracy. However, it is time-consuming and demands significant computer equipments (Studer et al. 1997). It would be of interest to measure this present dataset with the Moiré projection method and compare its results with the present study, possibly establishing the presented method as a fast control method.
It must be critically commented that the aim of the ridge augmentation procedure was to augment "as much as possible". The exact graft volume which was placed in the recipient site was protocolled, but not applied for this measurement method due to its limited accuracy. The known graft volume would possibly give more accurate information about the efficacy of different surgical procedures, if the volumetric outcome is quantitively assessed, e.g. by projection Moiré.
The postsurgical observation time was similar for all three surgical groups, i.e. 3.7 months for the onlay group, 3.5 months for the connective tissue group and 3.4 months for the modified connective tissue group (Tab. II).
The postoperative assessment after $3^1/_2$ months was performed due to empirical experiences. There are no evidence-based data available which study the volumetric behavior of augmented ridges after surgery. The major amount of shrinkage occurs during the first month, which is followed by a minor volume loss during the following one to three months (Seibert & Lindhe 1989). In addition, there are no results published, which assessed the volumetric stability underneath the pontic area after cementation of a bridge work.

## Conclusions

1. With the limitation of the applied measurement method, class III ridge defects with an extension of multiple teeth were more favorably corrected by two different connective tissue graft techniques than by the full thickness onlay graft technique when evaluated 3.5 months postsurgically.
2. The onlay technique revealed more failures than the two connective tissue techniques.
3. Therefore, if a volumetric problem at the mucogingival complex has to be corrected in those defined defect sizes, the connective tissue technique should be favoured.

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## Zusammenfassung

61 Klasse-III-Kammdefekte mit einer Ausdehnung von zwei bis drei Zähnen wurden mit drei verschiedenen Weichgewebeaugmentationen korrigiert und ihre Volumenänderungen verglichen. Vier Gruppen wurden gebildet. Die erste chirurgische Gruppe, CT, bestand aus 28 Kammdefekten, die mit einem subepithelialen Bindegewebe-Transplantat operiert wurden. Sechzehn Defekte wurden mit einem modifizierten subepithelialen Bindegewebe-Transplantat korrigiert und bildeten die zweite chirurgische Gruppe, mod. CT. Siebzehn Defekte wurden mit dem freien Onlay-Transplantat behandelt und bildeten die dritte chirurgische Gruppe, OL. Zwölf Defekte wurden nicht operiert und definierten die Kontrollgruppe, CO. Das Ausmass des Kammdefektes wurde drei Monate nach dem Eingriff in Relation zur präoperativen Situation anhand von Gipsmodellen bestimmt. Die Defektgrösse wurde in der horizontalen und vertikalen Dimension mittels Parodontalsonde gemessen. Lineare Differenzen in jeder Dimension wurden zwischen den Gruppen verglichen und mit dem Kruskal-Wallis und Mann-Whitney-U-Test analysiert ($p < 0,05$). Die mittlere Beobachtungszeit für alle chirurgischen Gruppen schwankte zwischen 3,4 und 3,7 Monaten. Der horizontale Gewinn des gingivalen Kammniveaus für die Gruppen OL, CT und CT mod. war +1,3 mm (±0,9 S.D.), + 2,6 mm (±1,4) und + 2,9 mm (±1,5). In der vertikalen Dimension resultierte eine Verbesserung des gingivalen Kammniveaus für die Gruppen OL, CT und mod. CT von + 1,0 mm (±0,7), +1,8 mm (±1,0) und +2,0 mm (±1,1). Die vertikalen und horizontalen Gewinne waren in der CT- und mod. CT-Gruppe signifikant grösser als in der OL-Gruppe.

## Résumé

Cette étude a comparé au niveau de 61 lésions de crête alvéolaire de classe III, d'une étendue de deux à trois dents, les changements de volume tissulaire suite à la mise en œuvre de trois techniques chirurgicales destinées à augmenter la quantité de tissu mous. Quatre groupes ont été formés. Dans le premier groupe (CT) 28 lésions de crête alvéolaire ont été traitées par une greffe de tissu conjonctif subépithéliale. 16 autres lésions corrigées à l'aide d'une technique de greffe de tissu conjonctif modifiée constituaient le deuxième groupe (CT mod.). 17 lésions de crête traitées avec des greffes d'épaisseur complète (type «onlay») formaient le troisième groupe test (OL). Douze lésions qui n'ont pas été traitées constituaient le groupe de contrôle (CO). Les changements de volume par rapport aux dimensions préopératoires ont été évalués trois mois après l'intervention chirurgicale, en utilisant une technique d'empreintes et de modèles en plâtre. La taille de la lésion a été déterminée en mesurant ses dimensions verticale et horizontale à l'aide d'une sonde parodontale. Les différences linéaires pour chaque dimension ont été comparées entre les groupes et analysées par les tests de Kruskal-Wallis et de Mann-Whitney U ($p < 0,05$). Résultats: le temps d'observation pour tous les groupes chirurgicaux était compris entre 3,4 et 3,7 mois. Les changements horizontaux du niveau de la crête muqueuse des groupes OL, CT et CT mod. étaient de +1,3 mm (±0,9), + 2,6 mm (±1,4) et +2,9 mm (±1,5), respectivement. Pour ce qui est de la dimension verticale, l'augmentation du niveau muqueux pour les groupes OL, CT et CT mod. totalisait +1,0 mm (±0,7), +1,8 mm (±1,0) et +2,0 mm (±1,1). Les gains verticaux et horizontaux étaient significativement plus importants pour les groupes CT et CT mod. que pour le groupe OL.

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