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Abstract

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Reference


DOI : 10.1111/clr.12743
PMID : 26773800
Soft tissue stability and volumetric changes after 5 years in pontic sites with or without soft tissue grafting: a retrospective cohort study

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Key words: connective tissue, crown, fixed partial denture, humans, pontic, soft tissue, volumetric analysis

Abstract
Objective: To evaluate volumetric changes (VC) of pontic sites with or without soft tissue grafting over 5 years.

Material and Methods: Twelve patients participating in a prospective clinical trial evaluating fixed dental prostheses (FDPs) were selected on the basis of having received a subepithelial connective tissue graft for soft volume augmentation in pontic sites (augmentation group [AG]). An additional 12 patients, belonging to the same study, that had not received soft tissue grafting were used as controls (control group [CG]). Casts made from dental impressions taken at prosthesis delivery (baseline [BL]) and at 5 years (5-FU) were digitized, and linear and volumetric measurements performed to assess the soft tissue pontic height (PH), abutment height (AH), (VC) and changes in tissue thickness (TT) on the buccal side of the pontics.

Results: There were no significant differences at BL between the two groups for linear measurements (P > 0.05). The changes in soft tissue pontic height (PHC) amounted to a loss in the height of 0.34 mm (SD 0.5) and 0.35 mm (0.2) for AG and CG, respectively. The mean VC amounted to a loss of 5.31 mm³ (±1.1) (AG) and 4.32 mm³ (±1.7) (CG). None of the changes between BL and 5-FU in volumetric and linear measurements, including TT and mean mesial and distal abutment height changes (mAHC and dAHC), reached statistically significant differences between AG and CG (P > 0.05). However the changes in linear measurements from BL to 5-FU were significant in all parameters for both groups (P < 0.01).

Conclusion: At an observational period of 5 years, pontic sites with or without grafting under FDPs demonstrated similar dimensional stability.

Clinical relevance: Pontic sites with or without grafting are volumetrically stable over 5 years.

Plastic periodontal procedures to augment soft tissue volume at pontic sites are well described in the dental literature (Esposito et al. 2012; Thoma et al. 2014). The techniques utilized to augment the tissue volume vary and include the use of biomaterials such as hydroxyapatite (Allen et al. 1985), free gingival grafts (Studer et al. 2000), connective tissue grafts (Akcali et al. 2015) and soft tissue allografts (Batista et al. 2001).

A recently published systematic review concluded that as a result of the heterogeneity of the publications evaluated, no meta-analysis could be performed (Thoma et al. 2014). The superiority of any of the aforementioned techniques is therefore unknown, and no long-term observational data are available. However, in all the publications evaluating soft tissue augmentation at localized alveolar ridge defects, the subepithelial connective tissue graft was the treatment of choice as a control group [CG] (gold standard).

Although there is no scientific evidence to indicate that the maintenance of soft tissue volume at pontic sites will improve the long-term success and survival rates of FDPs (Petursson et al. 2007), volume changes at the buccal aspect may have a negative impact on the esthetic appearance of FDPs. Moreover, the loss of contact between the pontic and the edentulous ridge may facilitate food impaction and reduce patient comfort (Dina et al. 2013).

The assessment of the soft tissue volume stability was in the past a challenging task...
because of the paucity of tools suitable to evaluate soft tissue changes. Recently, digital optical scanning and assessment methods have been applied with the aim of measuring volume changes of oral tissues over time (Thoma et al. 2010). Calibration studies demonstrated precision and reliability of these methods to assess soft tissue volume changes in a non-invasive way (Windisch et al. 2007). This method has successfully been used to assess the volume changes in the alveolar process in conjunction with soft and hard tissue augmentation in preclinical and clinical studies (Fickl et al. 2009; Schneider et al. 2011).

The aim of the present study was therefore to assess the long-term soft tissue changes between baseline (BL, prosthesis delivery) and the 5-year follow-up (5-FU) comparing pontic sites with and without previous soft tissue grafting in patients receiving tooth-borne fixed dental prostheses (FDPs).

Material and methods

Study design
The study was designed as a controlled clinical study. Ethic approval was obtained by the regional authorities (StV Nr. 01/03). Twelve patients that participated in a randomized controlled clinical trial evaluating zirconia frameworks for posterior 3-unit FDPs were selected on the basis of having received connective tissue grafting for soft tissue volume augmentation at the pontic sites (augmentation group [AG]). Twelve additional patients that participated in the same clinical trial and had not received any soft tissue augmentation procedures were randomly selected to serve as controls (CG).

Patients and prosthodontic procedures
Only patients in good general health were included in this study. Furthermore, the included patients had to be periodontally healthy with no clear sign of bruxism.

The pre-prosthetic as well as the prosthetic treatment for both types of FDPs was performed according to the standard techniques applied at the Clinic of Fixed and Removable Prosthodontics and Dental Material Science, University of Zurich. The abutment teeth were prepared according to the computer-assisted manufacturing (CAM) recommendations.

Surgical procedures
Following the insertion of a provisional prosthesis and a period of adaptation time, patients were recalled for the surgical augmentation procedure (Fig. 1a). In brief, crestal incisions were placed followed by partial thickness elevation of the vestibular flap (Fig. 1b). In addition, periosteal-releasing incisions were performed to assure tension-free closure. The pontic site was then measured, and a subepithelial connective tissue graft was harvested from the palate according to the pontic dimensions by means of a single-incision technique (Hurzeler & Weng 1999). Primary wound closure was achieved in the palate with the use of cross-mattress sutures. At the recipient site, the SCTG was fixed in the buccal aspect, and closure was achieved by horizontal mattress and single interrupted sutures (Fig. 1c). The pontic area of the provisional restorations was reduced to avoid compression of the tissues. Patients were recalled 1 week after the surgical appointment for suture removal. Tissue management was performed by gradually increasing the contact of the pontic areas with the soft tissues and began at 6–10 weeks after soft tissue grafting.

Fig. 1. (a) Pre-operative occlusal view before soft tissue grafting. (b) Crestal incision and split-thickness preparation of the buccal flap. (c) Connective tissue graft is fixed in the buccal aspect, and single interrupted sutures are used to close the site. (d) Three months post-connective tissue grafting. (e) Clinical image after connective tissue grafting and before tissue conditioning. (f) Clinical image after tissue conditioning was concluded with a provisional restoration. (g) Delivery of the final restoration (baseline, augmentation group [AG]). (h) Five-year follow-up (AG).
surgery (Fig. 1d, e). Final full-arch impressions were taken after tissue sculpturing was finalized, and tissues were deemed stable [Fig. 1f]. One experienced technician manufactured both ceramic and metal frameworks. Reconstructions were cemented with resin cement [Panavia 21 TC, Kuraray Co., Kurashiki, Japan] [Figs 1g and 2].

Further details regarding the prosthodontic procedures can be found in earlier publications reporting on the 5-year follow-up clinical outcomes [Sailer et al. 2006, 2007, 2009].

**Model fabrication**

Alginate impressions were taken at prosthesis delivery [BL] and at the 5-year follow-up [5-FU]. Dental stone casts were fabricated immediately after the impressions were obtained. A total of 24 pairs of models were obtained. Models were strictly evaluated for the presence of irregularities such as porous areas, undefined gingival margins, broken cusps or an undefined vestibule.

Following this examination, 21 pairs of casts [BL and 5-FU] were deemed appropriate for volumetric analysis [10 AG and 11 CG].

**STL image acquisition, matching of data and volume analysis**

Cast model was optically scanned with a desktop 3D scanner [Imetric 3D, Courgenay, Switzerland]. BL and 5-FU STL files of the models of the 21 patients were uploaded to image analysis software [SMOP, Swissmeda AG, Zürich, Switzerland]. To match the STL files, three clear and visible common references were selected in both the BL and 5-FU casts. After the selection of these references, the software automatically aligned these points together. This process was repeated until image superimposition was considered adequate by having the known unchanged areas superimposed [Fig 3]. A final adjustment was carried out using a “fine fit” command by which the software looks for the best fit between the two images using a series of mathematical algorithms.

**Image analysis**

If the pontic site had two pontic teeth, both pontic areas were evaluated separately, and the mean values were utilized. The following measurements were performed:

1. **Linear measurements**: A longitudinal slice that divided the pontic and abutment crowns mesiodistally into two equal parts was selected. A line coinciding with the axis of the crown was then drawn in the transversal images of the cuts. The apico-coronal height of the mesial and distal abutment crown [mAH and dAH] and the soft tissue pontic height [PH] at BL and at 5-FU were assessed by measuring the distance between two lines perpendicular to the axis of the tooth coinciding with the most prominent cusp and the gingival/pontic margin. To evaluate the changes in the soft tissue thickness [cTT], the distance from the two scanned surfaces was assessed at 1,3 and 5 mm below the mucosal margin at BL and at 5-FU [Fig 4].

2. **Volumetric measurements**: The selected area used to evaluate the volume changes followed the mucosal margin of the pontic restoration, and it reached the mesial and distal line angles and extended apically 5–6 mm [Fig 5]. The software then calculated the volume change [VC] measured in mm$^3$, which corresponded to the volume enclosed between the two surfaces involved within the designed area. The software calculated as well the mean distance in mm between the two surfaces [MD].

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**Fig. 2.** (a) Control site at restoration delivery [baseline, control group [CG]]. (b) Five-year follow-up [CG].

**Fig. 3.** STL image superimposition of baseline and 5-year follow-up models and volumetric analysis. The colored area [blue] represents the area analyzed.
Statistical analysis

Descriptive statistics (means and standard deviations) of continuous variables and relative frequencies of discrete variables were computed for each system separately using a statistical software program (SPSS Version 20.0, IBM Corporation, New York, NY, USA). The Mann–Whitney test was used to disclose differences for continuous variables with respect to a factor with two levels. To express the influence of time, the differences between the 5-year values and the BL values were computed and analyzed with a Mann–Whitney test. The results of statistical tests with P-values smaller than 0.05 were interpreted as statistically significant.

Results

Twenty-one patients (10 females and 11 males) contributing to one FDP each were examined after a mean follow-up of 59 months (SD = 2.8 months). The mean age at the 5-year follow-up in the AG was 56.1 ± 12.2 years and 54.8 ± 10.7 for CG.

Patients in the AG healed uneventfully after the grating procedure and were restored with a total of 7 three-unit FDPs and 3 four-unit FDPs, whereas the CG was restored with 11 three-unit FDPs.

Baseline (BL) linear measurements

In the AG, the mean soft tissue pontic height at BL [PH] was 7.92 mm (±0.9), whereas in the CG this corresponded to 7.89 mm (±1.2).

The mean mAH was 7.54 mm (±1.4), and the mean dAH was 6.12 mm (±0.9) for AG, whereas in CG these values amounted to 8.07 mm (±1.0) for mAH and 6.61 mm (±0.7) for dAH.

There were no statistically significant differences between the two groups at BL for any of the parameters (P > 0.05) [Table 1].

Linear and volumetric changes between BL and 5-FU

The changes in linear measurements were calculated subtracting the 5-FU from BL values. The changes in pontic height [PHC] amounted to a loss in height of 0.34 mm (±0.5) and 0.35 mm (±0.2) for the AG and CG, respectively. In the AG, the mean abutment height changes [mAHC and dAHC] amounted to 0.36 mm (±0.3) and 0.37 mm (±0.3), whereas the CG exhibited a change of 0.15 mm (±0.2) and 0.22 mm (±0.3) for the respective values. The mean VC amounted to a loss of 5.31 mm³ (±1.1) [AG] and of 4.32 mm³ (±1.7) [CG]. The MD between the two surfaces within the designed area was 0.19 mm (±0.5) for the AG and 0.16 mm (±0.3) for the CG.

With regard to the changes in tissue thickness, the AG presented a change of 0.31 mm (±0.1) at 1 mm, 0.37 mm (±0.2) at 3 mm and 0.42 mm (±0.2) at 5 mm below the mucosal margin. The respective values for the CG were 0.35 mm (±0.2), 0.36 mm (±0.2) and 0.41 mm (±0.2) at the three levels.

No statistically significant differences were found between the two groups for any of the above-mentioned parameters (P > 0.05). However, there was a tendency indicating less tissue contraction for the CG in the mAHC (P = 0.08) [Table 2].

Although the differences were not significant between the groups, the changes between BL and 5-FU for linear measurements were analyzed separately for each system to investigate the influence of time in these variables. The changes between BL and 5-FU were significant for all linear measurements in both groups (P < 0.01).

Discussion

In the present investigation, minor changes were observed in both groups in terms of soft tissue changes between the insertion of the final reconstruction and the 5-year follow-up evaluation. Despite these changes being considered as minor clinically, the differences between BL and 5-FU still reached statistical
significance. With regard to tissue thickness, soft tissue pontic height, abutment height and facial pontic volume, no significant differences were found between AG and CG. Both groups seemed to demonstrate equal dimensional stability of the buccal tissues over 5 years.

Soft tissue grafting procedures have become routine interventions in mucogingival surgery to improve the resemblance between the reconstructed parts and the natural dentition (Cairo et al. 2008). Despite this, little is known about the long-term stability of sites augmented following soft tissue volume grafting procedures (Thoma et al. 2014).

The pontic site appears to be the ideal model to evaluate the stability of soft tissue grafts over time as it rules out other aspects that may have an influence on the preservation of tissue such as peri-implant bone levels, soft tissue recession and gingival inflammation.

The findings of this study relate to those published earlier by Allen et al. (Allen et al. 1985). In that study, soft tissue changes were evaluated 36 months after grafting with connective tissue grafts and hydroxyapatite. A visual inspection of the 14 sites grafted with the fibrous connective tissue reported high stability of the areas; however, no standardized clinical measurements were performed.

A recently published randomized controlled clinical trial compared pontic sites grafted with either SCTGs or palatal vascularized interpositional periosteal connective tissue graft [VIPCG] (Akcali et al. 2015). The outcomes demonstrated a contour change in labial distance between BL and the 6-month follow-up of 1.2 mm for VIPCG sites and 0.6 mm for SCTG sites. In addition, a loss of the initial volume [gained at BL] was reported, amounting to 47% at 6 months for SCTG sites and to 6.4% for VIPCG sites.

The findings of the latter study are difficult to compare with the findings obtained in the present study. The focus of the present investigation was the long-term stability of the augmented sites starting at the day of cementation [BL]. The initial volume gain and a potential volume loss between the grafting and cementation of the reconstruction were therefore not recorded.

The reported volume loss reached 5.31 mm³ for AG and 4.32 mm³ for CG. This was considered as a minor change. However, bearing in mind that an initial value for the volume gain is lacking, this parameter appears to be difficult to judge. In a pilot study, five patients were evaluated contributing to five edentulous sites and followed for 5 months after soft tissue augmentation (Gonzalez-Martín et al. 2014). In that study, the volume gain after connective tissue grafting in pontic sites was analyzed utilizing image analysis software for STL model superimposition. Five months post-surgery, a mean soft tissue volume increase of 35 mm³ (ranging from 12.80 to 52.59 mm³) was reported. Other methods such as the Moir system have been utilized to assess volume augmentation at pontic sites (Studer et al. 2000). Pontic sites augmented with SCTG or free gingival grafts were evaluated for volume changes. The twelve patients that received SCTG reported a gain in volume of 159 mm³ at the 3.5-month follow-up.

Regarding the linear measurements in the present study, AG showed a tendency for a greater loss of mucosal height in the mesial abutments. The values for the distal abutments were also higher for the AG. Although mucosal recession may be an expected phenomenon in patients with FDPs, the values in this study were all below 0.5 mm, which may not be of clinical relevance. Other linear parameters that represent a more homogeneous variable of the area evaluated such as MD or PH showed high similarities between both groups.

Unfortunately, the present study cannot be compared with other investigations that have analyzed volume changes at implant sites over time (Sanz Martin et al. 2015). This is mainly because of the heterogeneity found in the study models as the buccal peri-implant tissue may be influenced by parameters such as the peri-implant marginal bone levels or prosthesis design.

It must be taken into consideration that the data presented were obtained in a retrospective manner and some important variables such as graft dimensions could not be assessed. Moreover, the impressions were made of alginate, which may introduce accuracy issues. In fact, one pair of casts was excluded because of model artifacts that did not allow for STL matching, and two pairs were excluded because of minor tooth drifting that made accurate matching more challenging.

However, the data introduced were obtained by the use of a reliable method to superimpose digital STL files of the models obtained at BL and SFU to compare tissue height changes in the pontic and abutments of three- and four-unit FDPs. The manufacturer of the optical scanner reports accuracy values to be <20µm over complete arch scanners. The accuracy of the optical method evaluated has been tested and shown to be very high with differences between test and control measurements never exceeding 1.5%. The reproducibility of these values has been shown to have very low coefficients of variation ranging from 0.05 to 0.5%, indicating excellent reproducibility (Windisch et al. 2007).

Conclusions

From the data analyzed, it can be concluded that minor changes occurred in the pontic areas grafted with a SCTG from the day of cementation to the 5-year follow-up visit. No significant differences were found with the control (non-grafted) sites in terms of linear and volumetric measurements.

Acknowledgements and conflicts of interests: This study was funded by the Clinic of Fixed and Removable Prosthodontics and Dental Material Science, School for Dental Medicine, University of Zurich, Zurich, Switzerland. The authors report no conflict of interest for this study.

References


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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.