Is there a correlation between vestibular depth and shrinkage of free gingival graft: A descriptive-correlational study

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Abstract

Background: The purpose of the present study was to evaluate the correlation of vestibular depth (VD) with Free Gingival Graft (FGG) dimensional shrinkage.

Methods: This study was a descriptive-correlational study which was performed on twenty patients with insufficient attached gingiva width (AGW). Under local anesthesia, a partial thickness bed with sub-marginal incision was created. An FGG was prepared from the palate and sutured to the prepared bed. Clinical parameters including VD, probing depth (PD), keratinized gingiva width (KGW), AGW, vertical graft dimension (VDG), horizontal graft dimension (HGD) and graft area (GA) were evaluated preoperatively and after one, three, and six months postoperatively. The distribution of data was normal. Repeated measures ANOVA, Repeated measures with covariance, Pearson correlation coefficient and linear regression were performed to analyze the data.

Results: One patient was excluded from the study, therefore, the obtained data of 19 remaining patients were analyzed. Six months after FGG surgery, AGW and KGW raised to 6.15±1.01 mm and 7.55±1.1 mm, which were statistically significant (p <0.001). The shrinkage rate of HGD, VGD, and GA were 13%, 34%, 42% respectively after 6 months. The VD was increased 2.05 mm compared to baseline which was statistically significant (p<0.01). Pearson correlation coefficient showed that there was a statistically significant correlation between VGD shrinkage (r=-0.614, p=0.005) and GA shrinkage (r=-0.476, p=0.039) with VD. The correlation of Horizontal shrinkage with VD was not statistically significant (r=0.065, p=0.792).

Conclusions: It was concluded that the shrinkage of FGG was influenced by VD and a negative moderate correlation was existed between VD and shrinkage of VGD and GA.

Trial registration: This study was retrospectively registered by Iranian Registry of Clinical Trials (IRCT) with the number: IRCT20101204005305N18. Registered 22 September 2019. https://irct.ir/trial/41736

Background

It is widely accepted that mucogingival problems often affect patients aesthetically and functionally (1, 2). However, existing literature has not documented minimal attached gingiva width to maintain periodontal health. An increase in attached gingiva width is required in cases of the inadequate attached gingiva, especially in orthodontic or prosthetic treatments, better plaque removal from the gingival margin, and aesthetic improvement (3-8).

FGG is the most common technique to increase keratinized and attached gingiva width (9, 10). Palatal mucosa is the most common site for FGG preparation, because of the close histologic resemblance to keratinized gingiva (11-13). The high predictability and stability for more than four years of newly formed keratinized tissue is one of the benefits of this method (14).
After FGG surgery, newly formed keratinized tissue shrinks an average of 30-45% during the first year. The shrinkage rate in the vertical dimension is higher than shrinkage rate in the horizontal dimension (15, 16). The success of gingival graft techniques is reduced by graft shrinkage (17). Graft preparation from the tuberosity area, graft with an appropriate thickness, using the graft on the denuded bone surface, application of atraumatic methods and graft fixation with minimal suture can all reduce graft shrinkage rate during the healing phase (1, 18-22).

Preoperative VD may be another factor affecting FGG shrinkage. Based on the recent literature review that we performed, there wasn’t any study about this topic. It has been shown that gingival recession and inadequate width of keratinized gingiva are commonly associated with shallow vestibular depth and high attached muscle fibers (23, 24). Shallow vestibular depth prevents the insertion of removable prosthesis as well as compromises oral health control procedures (25). It also compromises the apical stability of graft tissue due to the greater effects of muscle attachment, and eventually causes graft shrinkage in the vertical dimension within one year after surgery. In other hand, the vestibular depth also decreases within one year after surgery, because of graft shrinkage (26-32).

Due to the lack of documents in the literature regarding the effect of vestibular depth on the amount of FGG shrinkage, this study was conducted to investigate the correlation of VD with the postoperative FGG shrinkage.

**Methods**

**Study design and population**

This was a descriptive-correlational study. Data was gathered before and after the surgical procedure and follow ups. The study population consisted of patients who referred periodically to the Department of Periodontics at the Faculty of Dentistry, Kerman University of Medical Sciences, with inadequate attached gingiva associated with single-rooted teeth of mandibular jaw (premolars, canines or incisors). The participants were entered in this study by non-probability sampling (convenience) method. All participants with inclusion criteria were entered the study.

The criteria for inclusion in the study were as follows: the need for gingival augmentation in single-rooted teeth of mandibular jaw considering KGW <2 mm, AGW <1 mm, no need for root coverage, need for prosthetic or orthodontic treatments, need for improvement of oral hygiene following mucogingival problems, no systemic diseases that contraindicated periodontal surgery, not using medications affecting on periodontium before surgery, no pregnancy, no smoking, no traumatic occlusion and acceptable oral hygiene (O’Leary plaque index less than 20%). The exclusion criteria in this study were as follows: poor oral hygiene during the study, need to use medication affecting the periodontium during follow-up period, incomplete follow-up data.

Prior to conducting this study, the procedure was fully explained to each patient, potential problems were identified, and then a consent form was signed by the participants. This study was approved by the
Pre-operative measurements:

KGM, AGM, PD, and VD were measured before surgery. The KGW [the mid-buccal distance from the gingival margin to the mucogingival junction (MGJ) of the tooth] was determined by a Michigan-O-Probe* with 0.5-mm accuracy using a Roll technique to determine MGJ and then, the mid-buccal AGW was calculated by subtracting the gingival probing depth (PD) from the KGW. All measurements were done by an experienced periodontist.

To determine the VD, alginate impression was prepared from the patient and special tray was made after casting. Then, after border molding, an alginate impression was taken again. After preparation of final cast, the deepest part of the vestibule was marked with a pencil and the distance of the mid-buccal gingival margin to the line marked in the vestibular depth was measured in millimeter (Fig.1).

Surgical procedure:

After prepping and draping, local anesthesia† was injected (2% lidocaine with 1/100,000 epinephrine) in recipient and donor sites. In the recipient bed, a partial-thickness incision was made using a 15c blade. The coronal incision was made sub-marginally at the MGJ, and two vertical incisions were created 10 mm apart and were extending apically as far as the vestiules allowed at a height of at least 9 mm, at both ends of the horizontal incision. The mesial and distal incisions were then connected apically. Sub-marginal and two vertical releasing incisions used to prepare recipient bed were butt-joint. After preparation of the bed, the remaining mucosa was not sutured on the apical periosteum. Any muscle fibers were removed with scissors creating an appropriate periosteal bed. Then, the FGG was prepared by using a mucotome‡ with a thickness of 1.5 mm and a dimension of 9 x 10 mm from the palatal area of the maxillary premolars and first molar with preserving the marginal gingiva at donor site (containing epithelium and a thin layer of underlying connective tissue). The reason for using the mucotome was to equalize the graft thickness. The graft donor site was covered with periodontal dressing§ after suturing with a 5-0 silk suture. The prepared FGG was adapted on the recipient bed and the lip or cheek adjacent to the graft was placed under tension to make certain that the grafts were free of movement during muscle traction. The graft stabilized with a 5-0 silk suture. Two interrupted sutures were applied in the coronal border to adapt the coronal margin of FGG to the left gingival margin and one vertical stabilizing suture with taking anchorage from the apical periosteum of recipient bed was used for graft fixation. Then, FGG in the recipient site was covered with periodontal dressing. All surgery procedures were performed by a periodontist.

After surgery, the patients were advised not to brush the treated sites within two postoperative weeks, and instructed to use a soft diet. Chlorhexidine mouthwash 0.2% was prescribed twice daily for 4 weeks and
ibuprofen 400 mg tablets were also prescribed every 6 hours as needed. After two weeks, dressing and sutures were removed, the surgical sites were washed with normal saline and plaque control was initiated by the patients.

**Postoperative measurements:**

Post-surgery measurements were consisted of PD, VD, KGW and AGW, HGD, VGD and GA. The HGD and VGD were measured in the midway of apico-coronal and mesio-distal dimensions of FGG (Fig. 2). The GA was calculated by multiplying its length and width. The shrinkage percentage of VGD and HGD and the GA shrinkage were calculated using the following Formulas. (see Formulas in the Supplementary Files).

The above measurements were repeated 1, 3 and 6 months after surgery.

**Statistical analysis**

Data were analyzed using SPSS 18 software. Kolmogorov-Simonov test was performed to analyze the normal distribution of the data. Given the normal distribution of the data, repeated measures ANOVA and Pearson correlation coefficient was used for data analysis. The influence of VD on variables was assessed using repeated measures with covariance. A simple linear regression was calculated to predict the percentage of vertical shrinkage based on VD. A p-value < 0.05 was considered statistically significant.

**Results**

One patient was excluded from the study because of failing to follow-up, therefore, this study was performed on 19 remaining patients (11 females and 8 males) with the mean age of 37 years. Postoperative healing of all cases was normal and no unexpected complication was recorded.

The results of this study showed that the KGW was 1.81±0.62 mm preoperatively, which increased to 8.5±1.26 mm, 8.02±1.25 mm and 7.55±1.1 mm, 1, 3 and 6 months after surgery, respectively. This increase was statistically significant at all times (P <0.001) (Table 1).

The mean and SD of PD in the mid-buccal of the teeth were 1.58±0.53 mm before surgery, which increased to 1.39±0.39 mm, 1.37±0.36 mm and 1.39±0.35 mm at 1, 3 and 6 months after surgery, respectively. The results showed no statistically significant difference in PD compared to pre-operation (P=0.1).

The AGW was 0.39±0.54 mm before surgery, which increased to 7.1±1.08 mm, 6.65±1.11 mm and 6.15±1.01 mm, 1, 3 and 6 months after surgery, respectively. The results showed a statistically significant increase in the AGW during different measurement steps compared to pre-operation (P <0.001) (Table 1).

The HGD was 10.18±1.16 mm at baseline, decreased to 9.36±1.09 mm, 9.15±1.14 mm and 8.92±1.18 mm, 1, 3 and 6 months after surgery, respectively. The highest descending changes were during the first
month after surgery. The results showed a statistically significant difference in the different measurement steps compared to baseline (P < 0.001) (Table 1). The VGD was 8.89±0.45 mm before surgery, changed to 6.65±0.85 mm, 6.28±0.82 mm and 5.89±0.77 mm, 1, 3 and 6 months after surgery, respectively. Overall, changes in the VGD had a descending trend over time, and most of the changes occurred during the first month after surgery. This change was statistically significant (P < 0.001) (Table 1). The GA at baseline, 1, 3 and 6 months after surgery was 90.71±12.21 mm², 62.80±21.91 mm², 57.98±12.09 mm², and 52.90±11.25 mm², respectively. Changes in graft area had a decreasing trend and were significantly reduced six months after surgery (P < 0.01) (Table 1). The results showed that the VD was 9.02±1.74 mm before surgery, which reached to 9.26±1.40 mm, 10.31±1.27 mm and 11.07±1.37 mm, 1, 3 and 6 months after surgery, respectively. This increase in VD was statistically significant (P < 0.001).

Based on the results of table 1, the effect size for KG, AG, HGD, VGD, and GA was high (effect size > 0.8). These results showed that augmentation of gingiva with FGG was a successful treatment. After adjusting the changes of these variables by VD, the effect sizes were reduced significantly, which indicates the influence of VD on the procedure's outcomes. After adjustment by VD, the changes in HGD and GA were not statistically significant (p=0.384 and p=0.399 respectively). But, the changes in VGD remained significant with lower effect size (P=0.001). The results of Pearson correlation showed that there was significant correlation between VGD shrinkage (r=-0.614, p=0.005) and GA shrinkage (r=-0.476, p=0.039) with VD. The correlation of Horizontal shrinkage with VD was not significant (r=0.065, p=0.792). A simple linear regression was calculated to predict the percentage of vertical shrinkage of FGG based on VD. A significant regression equation was found (f (1, 17) = 10.266, p=0.005), with an R²=0.340. The percentage of vertical shrinkage was equal to 56.91 – 2.55 (VD), when VD is measured in mm. The percentage of vertical shrinkage decreased by 2.55 percent for each mm increase of VD.

**Discussion**

The present study was carried out to assess the correlation of VD with the FGG shrinkage. In this study, the KGW and AGW increased significantly after surgery compared to baseline (P < 0.001). The amount of new KG and AG averaged 5.74 mm and 5.76 mm respectively. This amount of increase was in accordance with the results of McGuire's study.(33) In the McGuire's study, the results showed that the average increase of KGW was 3.65 mm in the control group (FGG). This amount was less than in our study, because of the different baseline widths of FGG in the two studies (4mm v 9 mm). Silva et al. reported 5.4 mm increase in KGW which was in accordance with our study (34).

The change in PD was not significant after surgery (P =0.10). This result was similar to the other related studies. (35, 36) The shrinkage of FGG was one of the variables which assessed in this study. The shrinkage of FGG in horizontal and vertical dimensions was statistically significant at months 1, 3, and 6 after surgery (P <0.001).

HGD shrinkage was 0.82 mm (8.05%) and 1.26 mm (12.3%) at 1 and 6 months after surgery. The greatest amount of shrinkage of HGD was occurred in the first month after surgery.
In Hatipoglu’s study, an average of 10.2% horizontal shrinkage was reported (37). In another study, Guncu et al. evaluated the effect of tissue adhesives on dimensional shrinkage of FGG. In this study, 14.25% horizontal shrinkage was shown in the control group (using suture for graft stabilization) at 3 months after surgery (38). The different amount of horizontal shrinkage of FGG in these three studies can be because of the different dimensions and thickness of FGG at the baseline. In Hatipoglu’s and Guncu’s studies, the baseline dimensions of FGGs were not equal and standard, and the thickness of FGG varied between 1 to 2 mm. In the present study, the primary dimensions of FGG were about 10×9 mm and the thickness of FGG was about 1.5 mm because of the use of mucotome.

In a study conducted by Silva et al., the mean horizontal graft shrinkage was 22% in non-smokers and 25% in smokers after three months, which was higher than our results (10.1%) (34). The primary horizontal dimension of prepared FGG in Silva’s study was about 14 mm and in our study was about 10 mm. This difference in amount of shrinkage may be partly related to different horizontal dimension of FGG. It can be concluded that if the primary horizontal dimension of FGG is greater, the horizontal shrinkage of FGG will be more. This is only a hypothesis and more studies will be needed to approve it.

In our study, the mean vertical graft shrinkage was 3 mm (33.74%) after six months. Mörmann et al. showed an average vertical graft shrinkage of 42.3% after 12 months postoperatively (39). In the study of Wei et al., the mean vertical graft shrinkage in the control group (FGG) was 16% six months after surgery (40). Hatipoglu et al. reported that the mean vertical graft shrinkage after 6 months was 24.8%.(12) The difference in baseline vertical dimension of FGGs, the thickness of FGGs and the type of suturing techniques may be the causes of these different results.

The most horizontal and vertical graft shrinkage were occurred during the first month after surgery (8.05%, 25.19% respectively) and the shrinkage of the vertical dimension was more than the horizontal dimension. This finding was in accordance with the other studies.(12, 34, 41) In the present study, the mean GA decreased by 42.2% during the follow-up period, which was statistically significant (P <0.001). Hatipoglu et al. obtained similar result and showed that graft shrinkage was 35.3% after six months.(12) The shrinkage of FGGs is a well-known clinical event that happens during graft healing in the first postoperative year and the width of new keratinized gingiva remains stable thereafter (41).

The most important variable which was evaluated in this study was VD. The results of the present study showed that the VD had increased 2.05 mm after 6 months and this change was statistically significant (P <0.01). In an old study which was carried out by Egli et al., the mean increase of VD was 2.3 mm after 12 months (30). In Egli’s study, the VD was measured from the incisal edge to the floor of the vestibular fold, minus the distance from the incisal edge to the gingival margin. This measurement may be encountered with some errors during realizing the floor of the vestibular fold. But in the present study, all VD measurements were done on the prepared casts to increase the precision.

The results of repeated measures with covariance structure, showed that after adjusting the changes of KG, AG, HGD, VGD, and GA by VD, the effect size of VGD was reduced from 0.993 to 0.303. Based on this finding, the VD which is determined by the level of muscle attachment is an effective factor on shrinkage
of VGD. Decrease of vertical dimension of FGG during this study may be in accordance to tendency of dissected muscular fibers to insert into their original sites. In cases with less VD, the muscular fibers are located more coronal and reattachment to them prevent apical stabilization of graft during healing phase. Adjustment of these variables by VD showed that the changes in HGD were not statistically significant. Considering the place of attachment and function of muscles in the mandible, it was expected that horizontal dimension of FGG was not influenced by VD. There was a significant correlation between VGD shrinkage ($r=0.614$, $p=0.005$) and GA shrinkage ($r=-0.476$, $p=0.039$) with VD by performing Pearson correlation coefficient. This correlation was moderate and negative. This means that there is a reverse correlation between the shrinkage of VGD and VD. The correlation between VGD shrinkage and VD was greater than the correlation of the GA shrinkage and VD, because of the impact of FGG horizontal dimension on calculating GA. The correlation of HGD shrinkage with VD was not significant ($r=0.065$, $p=0.792$). Based on the obtained results by doing a simple linear regression, the percentage of VGD shrinkage decreased by 2.55 percent for each mm increase of VD. Therefore, greater VD result in less shrinkage of VGD and vice versa.

In recent literature review, we did not find a similar study to compare the results. To assess the shrinkage of FGG, some factors such as preparation of recipient bed (partial thickness or denuded)(20), dimensions of FGG, thickness of FGG(42), performing of periosteal fenestration or not, the flap apical to the recipient bed, phenotype of periodontium(43), suturing techniques, type and size of suture(17, 44), preoperative VD and muscular forces may interfere in healing of graft and affect the final results(28). Therefore, doing a study with this wide range of confounders is very difficult, but considering these factors is necessary to design the future studies.

**Conclusions**

Based on the results of this study, the correlation of VD with FGG shrinkage was approved. A negative moderate correlation was observed between the VD and shrinkage of VGD and GA. It was concluded that people with less VD showed greater graft shrinkage compared to individuals with greater VD.

**List Of Abbreviations**

Free gingival graft (FGG)

Vestibular depth (VD)

Attached gingival width (AGW)

Probing depth (PD)

Keratinized gingival width (KGW)

Vertical graft dimension (VDG)
Horizontal graft dimension (HGD)

Graft area (GA)

Mucogingival junction (MGJ)

Standard deviation (SD)

**Declarations**

**Ethics approval and consent to participate:** This study was approved by the Kerman University of Medical Sciences with ethics code of IR.KMU.REC.1391.06. A written informed consent was obtained before surgical treatment.

**Consent for publication:** Not applicable

**Availability of data and materials:** The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

**Competing interests:** The authors declare that they have no competing interests

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**Authors' contributions:** Mohammad Mohammadi conceived the ideas; Moein Saeedi & Mohadeseh Arab Solghar collected the data; Hadi Ranjbar analyzed the data; Mahsa Jalali wrote the article.

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**FOOTNOTES**

* Hu-Friedy, USA

† Darou Pakhsh Company, Tehran, Iran

‡ PR4, DEPPELER, Swiss

• Coe-Pak, GC, Japan

|| SUPA medical devices, IRAN

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Tables
Table 1 - Changes in Clinical parameters (Mean±SD) during six months follow up. The results of repeated measures ANOVA (model 1) and the results of repeated measures with covariance (model 2)

| Clinical parameters | Baseline Mean ± SD | 1 month Mean ± SD | 3 months Mean ± SD | 6 months Mean ± SD | *Model 1 F (3, 54) = | **Model 2 F (3, 51) = |
|---------------------|--------------------|--------------------|--------------------|--------------------|------------------------|------------------------|
| Keratinized gingiva width (mm) | 1.81±0.62 | 8.5±1.26 | 8.02±1.25 | 7.55±1.1 | 857.451, p<0.001, Eta=0.979 | 14.014, p<0.001, Eta=0.425 |
| Attached gingiva width (mm) | 0.39±0.54 | 7.1±1.08 | 6.65±1.11 | 6.15±1.01 | 713.908, p<0.001, Eta=0.975 | 10.056, p<0.001, Eta=0.372 |
| Horizontal graft dimension (mm) | 10.18±1.16 | 9.36±1.09 | 9.15±1.14 | 8.92±1.18 | 83.446, p<0.001, Eta=0.823 | 0.962, p=0.384, Eta=0.054 |
| Vertical graft dimension (mm) | 8.89±0.45 | 6.65±0.85 | 6.28±0.82 | 5.89±0.77 | 252.290, p<0.001, Eta=0.933 | 7.403, p=0.001, Eta=0.303 |
| Graft area (mm²) | 90.71±12.21 | 62.80±12.91 | 57.98±12.09 | 52.90±11.25 | 322.235, p<0.001, Eta=0.947 | 0.917, p=0.399, Eta=0.051 |

*Crude Model
**Adjusted for VD

Table 2 - Effect of baseline vestibular depth on the width of keratinized and attached gingiva 6 months after Surgery
| Clinical parameter | Vestibular depth | P Value |
|--------------------|------------------|---------|
|                    | < 9mm            | ≥ 9mm   |
| Attached gingiva   |                  |         |
| width              |                  |         |
| 1 month            | Mean ±           |         |
|                    | 6.50±0.82        | 8.14±0.55 | <0.001 |
| SD(mm)             |                  |         |
| 3 months           | Mean ±           |         |
|                    | 6.04±0.91        | 7.71±0.39 | <0.001 |
| SD(mm)             |                  |         |
| 6 months           | Mean ±           |         |
|                    | 5.62±0.88        | 7.07±0.34 | 0.001  |
| Keratinized gingiva|                  |         |
| width              |                  |         |
| 1 month            | Mean ±           |         |
|                    | 7.83±0.98        | 9.64±0.80 | 0.001  |
| SD(mm)             |                  |         |
| 3 months           | Mean ±           |         |
|                    | 7.33±0.93        | 9.21±0.69 | <0.001 |
| SD(mm)             |                  |         |
| 6 months           | Mean ±           |         |
|                    | 6.95±0.89        | 8.57±0.53 | P <0.01 |

**Figures**
Figure 1

Preoperative vestibular depth. (A) Vestibular depth 6 months after operation. (B)

Figure 2

Preparation of recipient site (A) Graft placement on recipient site (B) Vertical graft dimension one month after operation (C) Vertical graft dimension Three months after operation (D) Horizontal graft dimension Three months after operation (E) Free gingival graft after six month (F)

Supplementary Files

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- Formulas.pdf