Gingival dimensions after root coverage with free connective tissue grafts


Abstract. Traumatic injury in the presence of a thin and narrow zone of gingival tissue may lead to gingival recession. Especially in class I and II recessions, root coverage may be accomplished with connective tissue grafts. In order to prevent recurrent recession, altering gingival dimensions width and thickness might be of advantage. In the present study, dimensions of gingiva were measured for 1 year after root coverage with connective tissue grafts. The study population consisted of 18 patients with a total of 28 class I or II recessions. Gingival width and depth of the recession were measured with a caliper, and thickness of the marginal tissue with an ultrasonic device. Periodontal probing depth was determined with a pressure-controlled electronic probe. Mean (±sd) recession depth at baseline was 3.1±1.4 mm. After 12 months, coverage amounted to 74±30%. Width of gingiva rose from 2.1±1.0 mm to 3.2±1.4 mm, whereas thickness was increased from 0.8±0.3 mm to 1.5±0.7 mm, on average. No significant alteration of periodontal probing depth was observed but a mean gain of clinical attachment of 1.7±1.1 mm was ascertained. In a multiple regression analysis, recession depth and presence of the recession in the maxilla, but not tooth type significantly influenced relative root coverage (R²=0.34, p<0.01). Attachment gain after surgery depended on baseline attachment loss and was negatively influenced by smoking. The present results point to the possibility of doubling gingival thickness after root coverage with connective tissue grafts.

Key words: gingival recession; root coverage; connective tissue grafts; gingival thickness; ultrasonic method; smoking
Accepted for publication 5 September 1997

At least 2 distinct causes for facial or buccal root denudation called gingival recession have been claimed, namely (i) traumatic injuries mainly during excessive or inadequate tooth brushing and (ii) inflammatory reactions in the gingiva upon plaque accumulation (Löe et al. 1992, Khocht et al. 1993, Serino et al. 1994, Joshipura et al. 1994). Apart from case reports dealing with obvious gingival damage caused by tooth brushing (Axéll & Koch 1982), it has been shown that regularly and more vigorously brushing his or her teeth frequently leads to gingival laceration (Sandholm et al. 1982, Niemi et al. 1984) and increased bleeding tendency of the tissues (Abbas et al. 1990). Chronic trauma may be followed by gingival recession (Baker & Seymour 1976). However, whereas gingival erosion is also seen in the papilla region (Sandholm et al. 1982), recession is typically found on the buccal or facial root prominence. Especially at premolars and canines, bone dehiscences and fenestrations seem to be a normal feature of the periodontium at the buccal root prominence (Larato 1970). Thus, one of the most important factors increasing the risk for gingival recession may be a thin and delicate marginal tissue covering a non-vascularized root surface. In case of surgical coverage of denuded root surfaces it might therefore be desirable to increase the dimensions of the tissue, i.e. width and thickness, for preventive reasons. The aim of the present study was to follow the dimensions of the gingival unit for 12 months after root coverage procedures with connective tissue grafts.

Material and Methods
A total of 22 healthy subjects, 22–73 years of age, were consecutively recruited for the study. The 9 female and 13 male patients all desired treatment of one or several gingival recessions due to unfavourable esthetics or root hypersensitivity. Inclusion criteria were (i) no destructive periodontal disease, (ii) no medication, at present or in the past, affecting the periodontal tissues, and (iii) class I or II recessions (Miller 1985). 3 patients were current smokers. They were characterized by the number of consumed packs per day times the number of years smoking (puckyears). After
briefing on the procedures, patients gave their informed consent for participating in this one-year clinical study. Patients were informed about the probable cause of their gingival recession. Thereafter, they were instructed in proper oral hygiene measures employing a vertical rotatory technique. At least 2 prophylaxis sessions were performed in order to remove microbial deposits from the teeth and to check the patient's ability to maintain a proper oral hygiene.

After a further 1–2 weeks, clinical examination at the recession site was carried out. The following parameters were assessed at 3 sites of the buccal aspect of the respective tooth. Gingival inflammation as well as supragingival plaque were estimated according to the gingival (GI) and plaque index (PI) systems (Löe 1967). The periodontal probing depth (PPD) was measured to the next 0.1 mm with an automatic, computerized probe (PeriProbe®, Vivacare, Schaan, Liechtenstein) with a ball-shaped tip diameter of 0.4 mm and a probing force of up to 0.45 N in 2 mm pockets and 0.25 N in 13 mm pockets (Quirynen et al. 1993). The following parameters were measured only at the buccal prominence of the tooth. After staining the glycofilm-rich lining mucosa with an aqueous solution of 10% potassium iodide and 5% iodine in order to enhance the contrast between the gingiva and the alveolar mucosa, the distance between the tip of the crown and the cemento-enamel junction (i.e., crown length) was assessed with a caliper to the next 0.1 mm. Gingival recession (GR) was calculated by subtracting crown length from the distance between the tip of the crown and the gingival margin. Width of gingiva (GW) was measured by subtracting the former measurement from the distance between the tip of the crown and the mucogingival border. Gingival thickness (GTH) at facial aspects was assessed atrametrically with an ultrasonic device (SDM®, Austenal Medizintechnik, Essen, Germany) to the next 0.1 mm (Eger et al. 1996). For this purpose, the edge of the transducer probe of the SDM® was placed at a midbuccal location at the level of the PPD. Finally, width of the recession (WR) was measured with a caliper as the distance between the mesial and distal intersections of the cemento-enamel junction and the gingival margin. From these measurements, further composite variables could be estimated. The clinical attachment level (CAL) was calculated as the sum of the attached gingiva (AG) was assumed to be GR minus PPD (negative values were possible). The location of the mucogingival border (MGB) relative to the cemento-enamel junction was calculated as the sum of GR and GW.

Root coverage was surgically accomplished with connective tissue grafts. In most cases a modification of the envelope technique (Raetzke 1985) was employed. After local anaesthesia with a 2% solution of lidocaine containing 0.001% adrenaline, a vertical access incision was made in the alveolar mucosa about one tooth distal to the recession site (Schäde & Matter-Grüttner 1993). The soft tissue around the recession was undermined with a small elevator both from the vertical incision as well as from the sulcus. The denuded root surface was then carefully scaled and planned, and conditioned with a saturated solution of tetracycline-HCl in physiological saline mainly in order to remove any smear layer. Thereafter, a free, 1.5–2 mm thick, connective tissue graft was harvested from the hard palate in the region between the 1st and 2nd molar. For this purpose, about 2 mm from the margin of the palatal mucosa, a 10 mm incision was made perpendicular to the alveolar bone. Therefore, a semilunar undermining incision was placed dissecting the main part of the lamina propria from a thin layer of connective tissue covered by epithelium. As the undermining incision reached the underlying bone, the connective tissue graft was carefully mobilized with an elevator and removed. The palatal site was sutured, and the connective tissue graft shoved through the vertical incision onto the root surface. Ideally, the main part of the graft was embedded by the surrounding tissues to ensure early re-vascularization. After compressing the tissue graft with a gauze swab for about 1 min, it was secured with a tissue sealant (Histoacryl®, Braun, Melsungen, Germany). Thereafter the vertical access incision was sutured. No periodontal pack was applied. In a 29-year old male, 6 recessions in the mandibular front teeth region were treated at 2 occasions with free connective tissue grafts and coronally advanced mucoperiosteal flaps (Langer & Langer 1985).

While no antibiotics were prescribed, all patients were instructed for proper homecare. They did not brush the surgical site for about 3 weeks and rinsed twice daily with a 0.1% solution of chlorhexidine digluconate during this time period. Thereafter progressive healing allowed carefully performed normal oral hygiene measures. Sutures were removed after 1 week. During the 1st postoperative month patients were seen weekly. Re-examinations were carried out 3, 6, 9 and 12 months postoperatively.

All primary variables were assessed in duplicate in order to estimate the reliability of the measurement. The second course of measurements was done immediately after the 1st in the same order. Replicate measurements were then averaged to enhance reliability (Fleiss 1986). To consider the reliability of the GI and PI assessments, weighted kappa was calculated (Fleiss 1981). Measurement error of the other variables was expressed as the standard deviation of differences divided by the square root of 2. Results are presented as mean and standard deviation. The unit for statistical consideration was the treated tooth.

Longitudinal alterations were tested by repeated measures analysis of variance or Friedman's test, where appropriate. The null hypothesis was rejected, if p < 0.05. Multiple linear regression analysis was applied in order to determine factors influencing important outcome variables, percentage of root coverage, attachment gain, and postoperative attachment alteration. A forward stepwise, interactive approach was chosen. Explanatory variables were entered, if p < 0.1 and removed at p < 0.15.

Results

Table 1 presents the distribution of all 32 recession sites treated with free connective tissue grafts. 53% recessions were located in the maxilla. A total of 4 connective tissue grafts (12.5%) in 4

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female, nonsmoking patients were lost within the first 3 days after surgery. The respective recession sites (2 at maxillary premolars, 1 at a maxillary front tooth and 1 at a mandibular molar) were excluded from the analysis. Thus, 28 recession sites in 18 patients, were followed for 1 year.

A high level of reliability of assessments was achieved and maintained. Based on 420 duplicate assessments, a weighted $\kappa$ of 0.89 was calculated for GI and 0.82 for PI scores. The standard deviation for single periodontal probing depth (PPD) measurements was 0.22 mm. The reliability of the following variables was calculated considering all 140 replicate assessments. The standard deviation for single measurements of gingival recession (GR) was 0.18 mm, for width of recession (WR) 0.08 mm, for gingival width (GW) 0.27 mm, and for gingival thickness (GTH) 0.13 mm.

In general, the level of oral hygiene was high during the study period. As is shown in Table 2, significant further decreases of the mean gingival (GI) and plaque index (PI) scores were observed after surgical root coverage. The mean GI decreased from 0.7 at baseline and after 3 months to 0.4 at the final examination. The mean PI dropped from 0.5 to 0.2 ($p<0.05$). The averaged PPD at mesial, buccal and distal sites was stable. At baseline, mean PPD (±standard deviation) was 2.25±0.38 mm and at 12 months 2.19±0.59 mm. When considering exclusively the respective recession sites, a small increase of (buccal) PPD from 1.64±0.49 mm at baseline to 1.97±0.72 mm 12 months after surgery was observed, on average (Table 3). This difference was not significant. At the outset, a mean GR of 3.05±1.37 mm was calculated (range 1.0–6.2 mm). This figure was reduced to 1.01±1.18 mm (0–3.3 mm), on average, while WR decreased from 3.7 to 1.6 mm after 1 year ($p<0.001$). Correspondingly, 73.9±30.1% coverage of recession depth and 52.1±49.0% coverage of recession width were achieved. However, only 11 recessions (39.3%) were completely covered. Simultaneously, GW increased from 2.1 to 3.7 mm and GTH from 0.8 to 1.6 mm after 3 months ($p<0.001$). At the 1-year follow-up, however, these figures dropped to 3.2 ($p<0.05$) and 1.5 mm, respectively.

Table 4 shows some composite variables calculated from the measurements. Thus, the clinical attachment level (CAL) at buccal sites significantly ($p<0.05$) decreased from 4.65 mm at baseline to about 3 mm after 1 year (mean gain 1.67±1.13 mm). Whereas before surgery, if at all, only a minimal zone of attached gingiva (AG) was present (at 11 recession sites PPD extended beyond the mucogingival border (MGB). In these cases a class II recession (Miller 1985) was diagnosed), the root coverage procedure resulted in the establishment of a significant band of AG after 3 months of 1.8±1.5 mm, on average. After 12 months, this figure dropped to 1.2±1.5 mm. Compared with the location at baseline, the MGB shifted about 1 mm into a more coronal position ($p<0.001$).

Multiple linear regression analysis was applied in order to consider baseline factors jaw (maxilla, mandible), tooth type (molar/premolar, canine, incisor), smoking habits (packyears), GR,
WR, GW, GTH, AG, PPD, GI, PLI, as well as mean postoperative PLI, possibly influencing (i) relative root coverage, (ii) attachment gain, and (iii) postoperative alterations of attachment level. The respective models are presented in Table 5. Root coverage was mainly influenced by baseline GR. The deeper the recession, the poorer the 12-months' result: % coverage was better in maxillary teeth ($R^2=0.337$, $p<0.001$). No other variables were entered into this model. There was a strong influence of baseline attachment level, especially baseline GR, on attachment gain. Cigarette smoking had a negative effect ($R^2=0.418$, $p<0.001$). Attachment level alteration during the postoperative observation period was negatively influenced by the location of the recession in the maxilla and by cigarette smoking ($R^2=0.395$, $p<0.001$, Table 5). A representative case illustrating the surgical procedure and postoperative outcome is presented in Fig. 1.

**Discussion**

Although there is no strong scientific evidence, a large number of so-called predisposing factors may increase the risk of a given site or subject for developing gingival recession. These include, for instance, alveolar bone dehiscences (Löst 1984), tooth malpositioning (Kallestad & Uhlin 1992), orthodontic tooth movement (Foushee et al. 1985), a gingival phenotype with narrow and thin marginal tissue (Müller & Eger 1997), smokeless tobacco consumption (Hoge & Kirkham 1983, Robertson et al. 1990), cocaine abuse (Kapila & Kasahni 1997) or anorexia and bulimia nervosa (Scheutzel 1995).

One of the most important factors increasing the risk for gingival recession may be thin and delicate marginal tissue. Therefore, surgical procedures for root coverage should not only result in an increased width of the keratinized tissue but also thickness. In the present study, free connective tissue grafts from the palatal mucosa in the region between the 1st and 2nd molar were employed in a modification of the "envelope" technique (Raetzke 1985) in order to cover relatively shallow recession sites. Recently, it has been shown that this region provides appropriately thick mucosa for harvesting connective tissue grafts (Studer et al. 1997). When excluding the 4 immediate failures, about 74% of the recession depth and 53% of its width were covered after 1 year. This figure is somewhat smaller than the 80% coverage obtained by Raetzke (1985). The author reported on short-term results obtained for 12 relatively shallow recession sites in 10 patients. Total coverage was achieved at 42% sites as compared to 39% in the present material. In the present study, root surfaces had been conditioned with a saturated solution of tetracycline-HCl in order to remove the smear layer and to demineralize the dentin surface (Sterrett et al. 1997). No controlled clinical studies are available demonstrating a superior effect of tetracycline-conditioning of root surfaces as compared to procedures without root conditioning. However, its bacteriostatic effect and great substantivity (Bjorvatn et al. 1984) may actually enhance the potential for formation of a new connective tissue.
tissue attachment. Recently, Bouchard et al. (1997) showed similar results after root coverage with subepithelial connective tissue grafts employing either citric acid or tetracycline-HCl after 6 months. At present, based on human biopsy material, no or insufficient histological evidence is available to conclude on the quality of wound healing following this and similar procedures (Pasquinelli 1995). In the present study, mean gain of clinical attachment amounted to 1.67 mm after 12 months.

A large number of controlled clinical studies as well as case series have been published over the past 40 years employing different methods for root coverage. These studies have recently been reviewed extensively by Wennström (1996). Thus, root coverage achieved in the present study is comparable with the results of other authors, irrespective of the numerous surgical procedures described. However, for the first time it was demonstrated that, as a result of this root coverage procedure, not only a marked increase of the width of the keratinized tissue is to be expected but also its thickness. Thus, at baseline, GTH was about 0.8 mm, a figure within normal range (Eger et al. 1996). After surgery, GTH was as twice as thick, on average. Recently, Miller & Eger (1997) identified a rather small subpopulation among young healthy adults with wide and comparably thick gingiva at maxillary front teeth. Gingival appearance was associated with a quite quadratic shape of these teeth. At present, there is no information available with regard to a lowered risk for the development of GR in these individuals.

In a recent report comparing the 2-years’ outcome of treatment of GR by employing coronally advanced flaps with and without free connective tissue grafts, Wennström & Zucchelli (1996) achieved 99% and 97% root coverage, respectively, as well as remarkably stable conditions. These authors question, whether increased gingival dimensions (i.e., width and thickness) are significant factors for successful outcome of root coverage procedures. A significant mean increase of GW from 0.9 to 3.7 mm was noted after 2 years at sites treated with a free connective tissue graft, but only from 1.1 to 2.2 mm at sites treated without a connective tissue graft. While this difference was statistically significant, differences regarding all other parameters were found to be not. The authors conclude that changes of tooth brushing habits may be of greater importance than increased gingival thickness for long-term maintenance of the surgically established position of the soft tissue margin. However, GTH was actually not measured by the authors. Conceivably, not only GW but GTH as well considerably increased also at sites treated without connective tissue grafts (see, e.g., Fig. 1 in Wennström & Zucchelli (1996)). Thus it remains to be established whether increased thickness of the gingival tissue prevents to some extent occurrence or re-emerging GR.

Some of the variables followed in the present study remained rather stable after surgery. Thus, there was no significant alteration of the buccal PPD, residual recession (and therefore, CAL), or GTH. On the other hand, after surgery a shift of the MGB in a coronal direction occurred. Whereas the band of keratinized tissue was increased by 80% after root coverage, this figure was only 55% after 12 months. There is some evidence in the literature that the MGB is a rather stable landmark throughout life (Ainamo et al. 1981). Several authors actually had observed a shift of the border to its original location after apically repositioning (Ainamo et al. 1992) or coronal displacement of gingiva (Wennström & Zucchelli 1996). In the present study, the coronal shift of the MGB after surgery was significantly correlated with baseline GR (data not shown). Thus, it should in fact be interpreted as a regain of a more physiological or “genetically” defined (Wennström & Zucchelli 1996) location. Miller (1985) originally proposed a classification scheme of GR based on (i) on the involvement of the MGB, (ii) the level of the interproximal bone and (iii) the position of the tooth in the dental arch. In the present study, a class II recession was diagnosed in case of lack of any attached gingiva since a true extension of the recession beyond the MGB (i.e., lack of any keratinized tissue) was not seen. Even in advanced cases of GR a small band of (not attached) keratinized tissue is frequently found, however, the mucogingival border is undoubtedly involved.

Multivariate analyses of the present study (Table 5) clearly demonstrated that the chosen technique for surgical root coverage is appropriate only for shallow recessions in the 2-4 mm range. Best results were seen in the upper jaw. However, gain of clinical attachment depended on baseline CAL, especially recession depth. It is a trivial assumption and has been shown in numerous studies dealing with different therapies for inflammatory periodontal disease that, the smaller defect the smaller the therapeutical effect that can be expected (Cobb 1996). Interestingly, cigarette smoking was a significant factor negatively influencing attachment gain. Smoking is known an important factor interfering with healing processes following treatment of inflammatory periodontal lesions (Kinane & Radvar 1997). Miller (1987) found a 100% correlation between failure to obtain root coverage with soft tissue grafts and heavy smoking (more than 10 cigarettes per day). In the present study, 3 participants were smokers with 3, 7.5 and 14 packyears, respectively. Although root surfaces could be covered in these patients, no attachment gain was ascertained, thus giving rise to the assumption that only a deep pocket or “certain” had been created. This condition obviously occurred at the end of the observation period, since smoking also influenced attachment alterations after surgery.

In summary, the present study has clearly demonstrated that gingival dimensions can profoundly be altered by surgical root coverage employing free connective tissue grafts. Thus, gingival width as well as thickness can be increased without increasing periodontal probing depth. In addition, a postoperative shift of the mucogingival border into a more physiological location is possible. Smoking was identified a significant factor interfering with attachment gain. Further studies are necessary to establish a possible preventive effect of increased thickness of the marginal tissue.

Zusammenfassung
Dimensionen der Gingiva nach Deckung der Wurzel mit einem Bindegewebstransplantat
18 Patients mit insgesamt 28 Klasse I und II Rezessionen. Die Breite und Tiefe der Rezession wurde mit einer Schuhlehrer, und die Dicke des marginalen Gewebes wurde mit einem Ultraschallgerät gemessen. Die parodontalen Sonderungstiefen wurde mit einer druckkontrollierten elektronischen Sonde bestimmt. Die mittlere (±d.l.) Rezessionstiefe betrug bei der Ausgangsuntersuchung 3.1±1.4 mm. Nach 12 Monaten betrug die Deckung 74±30%. Im Durchschnitt stieg die Breite der Gingiva von 2.1±1.0 mm auf 3.2±1.4 mm an, während sich die Dicke von 0.8±0.3 mm auf 1.5±0.7 mm vergrößerte. Es wurde keine signifikante Veränderung der parodontalen Sonderungstiefen beobachtet, aber es wurde ein mittlerer klinischer Attachmentgewinn von 1.7±1.1 mm nachgewiesen. Durch eine multiple Regressionsanalyse zeigte sich, daß die Rezessionstiefe und Anwesenheit der Rezession im Oberkiefer aber nicht der Zahnyp die relative Wurzeldeckung signifikant beeinflußt (R²=0.34, p<0.01). Der Attachmentgewinn nach der Chirurgie hing von der Ausgangstiefe und dem Verlust ab und wurde durch Rauchen negativ beeinflußt. Die vorliegenden Ergebnisse zeigen die Möglichkeit auf, nach der Wurzeldeckung mit Bindegebetransplantaten die Gingivadücke zu verdoppeln.

Résumé

Dimensions de la gencives après recouvrement de la racine avec des greffes libres de tissu conjonctif

Une lésion traumatique en présence d’une zone mince et étroite de tissu gingival peut aboutir à une récession gingivale. Spécialement dans les récessions de classe I et II, le recouvrement de la racine peut être accompli avec des greffes de tissu conjonctif. Pour prévenir une récidive de la récession, il peut être avantageux de modifier les dimensions gingivales, largeur et épaisseur. Dans la présente étude, les dimensions gingivales ont été suivies pendant 1 an après le recouvrement de la racine avec greffes de tissu conjonctif. La population étudiée était composée de 18 patients avec un total de 28 récessions de classe I et II. La largeur et la profondeur de la récession ont été mesurées à l’aide d’un com- pas, et l’épaisseur du tissu marginal avec un appareil à ultra-sons. La profondeur du sondage parodontal a été déterminée avec une sonde à pression réglable électronique. La moyenne (±écart-type) de la profondeur de la récession au début était 3.1±1.4 mm. Après 12 mois, le recouvrement atteignait 74±30%. La largeur de la gencive augmentait de 2.1±1.0 mm à 3.2±1.4 mm, tandis que l’épaisseur augmentait de 0.8±0.3 mm à 1.5±0.7 mm. En moyenne. Aucune modification significative de la profondeur de sondage parodontal n’a été observée, mais un gain moyen d’attache clinique de 1.7±1.1 mm a été constaté avec certitude. Dans une analyse de régression multiple, la profondeur de la récession et la présence de récession au maxillaire supérieur, mais pas le type de dent, avaient une influence significative sur le recouvrement relatif de la racine (R²=0.34, p<0.01). Le gain d’attache après l’opération dépendait de la perte d’attache initiale et le fait de fumer avait une influence négative. Les présents résultats semblent indiquer la possibilité de doubler l’épaisseur gingivale après le recouvrement de la racine avec des greffes de tissu conjonctif.

References


Address:

Hans-Peter Müller  
Department of Operative Dentistry and Periodontology  
University of Heidelberg  
Im Neuenheimer Feld 400  
D-69120 Heidelberg  
Germany
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