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Coverage of localized gingival recessions: comparison of micro- and macrosurgical techniques

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Abstract
Background: In the presence of a thin and narrow zone of gingival tissue root recessions caused by trauma or inflammatory reactions seem to be a common feature of the buccal tissue morphology. The surgical coverage is mainly indicated for aesthetic reasons and may be accomplished with pedicled flaps in conjunction with or without the use of connective tissue grafts.
Aim: The purpose of the present study was to evaluate the degree of vascularization of connective tissue grafts by applying a microsurgical approach. In addition, the clinical outcome was followed for 1 year.
Material and Methods: The study population consisted of 10 patients with bilateral Class I and II recessions at maxillary canines. In split-mouth design, the defects were randomly selected for recession coverage either by a microsurgical (test) or macrosurgical (control) approach. Immediately after the surgical procedures, and after 3 and 7 days of healing, fluorescent angiograms were performed to evaluate graft vascularization. In addition, the clinical parameters were assessed before the surgical intervention, and 1, 3, 6 and 12 months postoperatively.
Results: The results of the angiographic evaluation at test sites revealed a vascularization of 8.9 ± 1.9% immediately after the procedure. After 3 days and after 7 days, the vascularization rose to 53.3 ± 10.5% and 84.8 ± 13.5%, respectively. The corresponding vascularization at control sites were 7.95 ± 1.8%/44.5 ± 5.7% and 64.0 ± 12.3%, respectively. All the differences between test and control sites were statistically significant. The clinical measurements revealed a mean recession coverage of 99.4 ± 1.7% for the test and 90.8 ± 12.1% for the control sites after the first month of healing. Again, this difference was statistically significant. The percentage of root coverage both test and control sites remained stable during the first year at 98% and 90%, respectively.
Conclusions: The present controlled clinical study has demonstrated that in root surface coverage, a microsurgical approach substantially improved the vascularization of the grafts and the percentages of root coverage compared with applying a conventional macroscopic approach.

Key words: fluorescence angiography; microsurgery; mucogingival surgery; periodontal plastic surgery; recession coverage; surgical microscope

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Alveolar bone and gingival recessions are predominantely found on the buccal root prominences, especially at premolar and canine sites, where bone dehiscences and fenestrations seem to be a common morphological feature (Larato 1970). Such anatomical variations have frequently been identified (Sangnes & Gjermo 1976, Rustogi et al. 1991, Löe et al. 1992) and their prevalence and severity appear to be age-dependent (Powell & McEniery 1981, Raetzke 1985). According to some assumptions the lesions may be classified into (1) traumatic injuries mainly owing to excessive and/or inadequate tooth brushing techniques and (2) inflammatory reactions of the gingiva as a result of plaque accumulation (Löe et al. 1992, Khocht et al. 1993, Serino et al. 1994, Joshipura et al. 1994) and combinations thereoff.

As aesthetic aspects represent an inseparable part of today's clinical practice, the surgical coverage of recessions is mainly indicated for aesthetic improvement rather than functional aspects (Bouchard et al. 2001). However, further indications for surgical coverage of exposed roots in association with dental hypersensitivity, root caries and in situations where e.g. a proper plaque control may be limited by an unfavourable contour of the gingival margin have also been described (Wennström 1996).

A recent systematic review (Roccuzzo et al. 2002) revealed that a variety of surgical techniques resulted in statistically significant coverage of gingival recessions and gain of clinical attachment levels (CALs). Hereby, the optimal treatment outcomes in percentage of root coverage were achieved by means of connective tissue grafts. Results varied between 64.6% (Bouchard et al. 1994) and 95.6% (Rosetti et al. 2000) of complete root coverage. On the other hand, the systematic review also yielded a marked variability for percentages of root coverage and percentages of subjects with complete coverage both between and within surgical techniques. The success of mucogingival surgical interventions may depend on several factors, such as e.g. (i) the bacterial contamination of the sites, (ii) local factors such as defect morphology, tooth position and tooth surface characteristics and (iii) the surgical technique per se (Kornman & Robertson 2000).

In other surgical specialties, such as neurosurgery, plastic and eye surgery, treatment outcomes were significantly improved by applying minimally invasive techniques (Komatsu & Tamai 1968, Serafin 1980). The benefits of microsurgical approaches in periodontal therapy have also been described, although only in a few case reports (Shanelec & Tibbetts 1994, 1996, Tibbetts & Shanelec 1994, 1996, Burkhardt & Hürzeler 2000) and one prospective cohort study (Cortellini & Tonetti 2001). The latter clearly demonstrated improved treatment outcomes with the use of microsurgical techniques when compared with macrosurgically performed flap surgery.

It is the aim of the present clinical experiment to study the wound healing following mucogingival surgical interventions, microsurgically modified, in a randomized controlled clinical trial.

Material and Methods

Patient evaluation

A total of 10 subjects in the age range of 32–44 years from the patient pool of a specialist private periodontal practice, were consecutively recruited for the study. Six female and four male patients who all desired coverage of their gingival recessions for aesthetic reasons were admitted. Inclusion criteria were (1) good systemic health, (2) absence of periodontal diseases, (3) no medication intake affecting the periodontal tissues, (4) non-smokers and (5) presence of bilateral canine root denudations of Class I or II (Miller 1985).

After briefing on the procedures, the patients gave their informed consent for participating. They had to undergo three postsurgical angiographic appointments and several follow-up examinations during a 1-year study period.

Clinical procedure

Prior to the surgical procedures, the patients were informed about the probable cause of their gingival recessions and instructed in proper oral hygiene practices. They then were offered at least two prophylaxis sessions to remove microbial plaque from the teeth and to check the patient's ability to maintain adequate and complete oral hygiene.

After a baseline examination, the mucosa at the surgical sites was anaesthetized with 0.8–1.2 ml of a solution of 4% articain and 0.001% adrenalin (Ultracain® DS-forte, Aventis Pharma, Frankfurt, Germany). Subsequently, the root surfaces were scaled and planed with a curette or a rotating diamond with a grain of 40 and 15 μm (Perioset, Intensiv, Viganello, Switzerland).

The surgical procedure was performed according to the technique described by Harris (1992) using free connective tissue grafts covered by a double-pedicle papilla flap. The connective tissue was harvested from the hard palate in the region between the first premolar and the second molar applying a single incision technique (Lorenzana & Allen 2000). After harvesting the grafts, abundant fatty parts were removed, and the grafts were trimmed to a thickness of 1.5–2 mm.

To guarantee an optimal level of standardization in the surgical procedures, all patients were treated by the same routined surgeon. By the toss of a coin the sites were randomly assigned to either a micro-(test) or macrosurgical (control) approach. Both test (microsurgical) and control (macrosurgical) procedures were performed on the same day.

Macrosurgically treated recessions

The instruments used consisted of a disposable scalpel with a #15 blade (Swann-Morton Limited, Sheffield, UK), a surgical forceps, a surgical needle-holder and a scissor. For the fixation of the graft and the papillary suture, non-resorbable, pseudo-monofilament 4-0 sutures were chosen (Supramid, B. Braun Surgical GmbH, Melsungen, Germany). The wound closure at the palatal incision was performed with a monofilament Gore-Tex® suture CV-5 (W.L. Gore & Associates, Inc., Medical Products, Flagstaff, AZ, USA). The palatal graft harvesting as well as the buccal recession coverage was performed under normal vision without optical magnification aids.

Microsurgically treated recessions

The instruments used consisted of a microsurgical needle holder, a microsurgical anatomical forceps and a microsurgical scissor. The preparation of the split-thickness flap was performed with the microsurgical scalpel Sharptome® straight (Sharpoint®, Surgical Specialties Corporation, Reading, PA, USA), usually used in ophthalmology. The palatal harvesting of the free connective tissue graft was performed as for the macrosurgical approach using a #15 blade, fixed in a round scalpel handle for an easier rotating movement. For the closure of the papilla flap, a 9-0 polypropylene thread was used (Prolene®, Ethicon®, Norderstedt, Germany). The graft and the flap were adapted to the tooth with a vertical modified sling mattress suture and a 7-0 polyamid thread (Ethilon®, Ethicon®). The palatal incision was sutured as for the macrosurgical approach. The graft was harvested with a prism loupe (Carl Zeiss, Oberkochen, Germany) at five times magnification. The palatal closure was performed applying the same magnification. The recession coverage per se was performed under a surgical microscope OPMI® Pro magis at 15 times magnification (Carl Zeiss).

Postoperative angiography

For the postsurgical angiographies, sodium fluorescein was used as contrast medium. This medium has also been used as a dye for studying the flow of crevicular fluid and plaque formation (Hefferren et al. 1971, Cohen et al. 1972, Lang et al. 1972, Salkin et al.

1974), to examine the marginal integrity of fillings (Christen & Mitchell 1966) and to visualize the vascularization after mucogingival interventions (Mörmann & Lutz 1974, Mörmann et al. 1975, Mörmann & Ciancio 1977). Hence, the biocompatibility of these dies is well documented (Wessing & Eichelberg 1968), although rare side effects such as vertigo, nausea and vomitting have been reported after intravenous injection.

For a high-contrast angiogram, it is a prerequisite that the gingival vessels are perfused with a maximum concentration of fluorescein. To avoid an initial distribution of the contrast medium to a greater blood volume and perfusion area, 5 ml of 10%-solution of sodium fluorescein have been injected within 2–3 s, into the antecubital vein of the patients. As the total renal secretion of sodium fluorescein lasts for about 2 days, the consecutive angiograms were performed immediately after the surgery, and after 3 and 7 days.

In an angiogram of the gingiva neither the arterioles nor the venules are visible. For that reason, the angiogram is characterized by the filling phase of the capillaries. It is important to capture the first consecutive images of the high concentrated fluorescein burst. After approximately 20 s, the contrast medium passes through the vessel walls and spreads into the perivascular subepithelial tissue.

The machine to record the angiograms was built in duplicate and consisted of (1) two surgical microscopes OPMI® FR/1,25 m (Carl Zeiss), (2) two external 3CCD video cameras Sony DXC-930P (Sony Europe G.m.b.H., Cologne, Germany), (3) two xenon light sources (Carl Zeiss) and (4) two DVCPRO video recorders with timcode (Panasonic, Matsushita Electric Industrial Co., Ltd., Video Systems Division, Osaka, Japan). To reach a maximum of fluorescence a blue filter was inserted in the light beam of the xenon source. In this way, only a small range of the relevant light spectrum was transmitted containing the excitation maximum. To filter that range, a yellow blocking filter was added to the video recorder. Individually built bite forceps helped to reproduce the precise position for the three consecutive duplicate angiograms of each patient.

Clinical follow-up measurements

Clinical examinations at the recession sites were carried out before the surgical procedures and then after 1, 3, 6 and 12 months postoperatively. The following parameters were assessed at three sites of the buccal aspects of the respective teeth: gingival inflammation and supragingival plaque were estimated according to the criteria of the gingival (GI) and the plaque index (PII) systems (Löe 1967). The periodontal probing depth (PPD) was measured with a pressure standardized plastic periodontal probe (Vivacare TPS® probe, Ivoclar, Schaan, Liechtenstein). The following parameters were only measured at the buccal prominence of the tooth: The distance between the tip of the crown and the cemento-enamel junction (i.e. crown length) was assessed with calipers to the nearest 0.1 mm. Gingival recession (GR) was calculated by subtracting the crown length from the distance between the tip of the crown and the gingival margin. The CAL was calculated as the sum of GR and buccal PPD.

Data analysis

The percentage of vascularization was analysed on the standardized angiographic images in defined areas of the gingival surfaces. Evaluation squares with a side length corresponding to the extention of the horizontal surgical incision served as a basis for evaluation (Fig. 1). Corresponding angiograms were transferred to a personal computer and converted into 8-bit images. By the help of an image analysis software (Optimas®, Media Cybernetics®, Silver Spring, MD, USA) the defined squares were measured concerning percentages of vascularized and non-vascularized areas. Differences between micro- and macrosurgical angiograms were analysed by means of a *Student t-test* for paired observations for data obtained immediately after the surgical intervention and 3 and 7 days postoperatively. Likewise, the clinical parameters were analysed using paired *t*-test for dependent samples. Owing to the fact that previous reports (Cortellini & Tonetti 2001) established that microsurgically treated periodontal sites yielded outcomes which were at least as good as macrosurgically treated periodontal sites, the choice of one-sided statistical tests appeared to be justified.

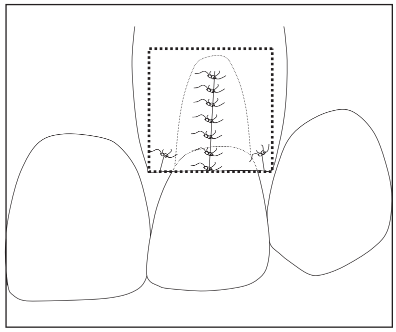

Fig. 1. Evaluation square with a side length corresponding to the extention of the horizontal surgical incision serving as a basis for the angiographic evaluation.

Table 1. Initial depth of all recessions (right and left sides)

	Test sites (mm)	Control sites (mm)
Patient #1	3.3	3.1
Patient #2	3.9	4.5
Patient #3	3.8	3.1
Patient #4	4.5	4.1
Patient #5	2.8	3.0
Patient #6	4.2	4.3
Patient #7	5.2	5.6
Patient #8	4.3	4.5
Patient #9	3.8	4.4
Patient #10	4.6	4.0
Mean depth of recession	**4.04** $\pm$ 0.68	**4.06** $\pm$ 0.81

No statistically significant difference between test and control sites.

Results

Because of relocation, only eight of the originally 10 patients could be followed for 1 year. Table 1 presents the presurgical extent of all recessions treated in all 10 patients. On average 4.04 ± 0.68 and 4.06 ± 0.81 mm were observed at the test and control sites, respectively. No statistically significant difference was found between the two homologous sites.

In general, the level of oral hygiene was high during the study period. In the test sites, 90% of the surfaces scored PII = 0 at baseline, while 100% of the control sites were plaque-free. This resulted in 90% of both the test and control sites scoring GI = 0 at baseline. The remaining 10% of the sites were given a score GI = 1. No bleeding on probing was present at either test or control sites for any observation period. During the observation period, very low PII and GI scores were encountered in both test and control sites. At 1 month, however, only 70% of both the test and control sites were plaque-free with 84% of the test and 75% of the control sites remaining completely clinically free of inflammation. Again, the remaining percentages scored only GI = 1.

The proportion of plaque-free sites and consequently, sites free of inflammation increased to 87% and 100%, respectively at 6 and 12 months examinations.

The mean operation time was 51 ± 5 min. for the macrosurgical and 72 ± 8 min. for the microsurgical treated sites. This difference was highly significant ($p < 0.01$).

Fluorescence angiography (wound healing)

The results from the evaluation of vascularization as revealed in the predetermined evaluation square are depicted as percentage in a box plot (Fig. 2). Immediately after the surgical interventions, a mean of 8.9 ± 1.9% and 8.0 ± 1.8% of the square were vascularized at the test and control sites, respectively. The difference in vascularization of 0.9% between the two procedures was statistically significant ($p = 0.02$). After 3 days of healing, a statistically highly significant difference in the vascularization between test and control sites was observed ($p < 0.01$). The microsurgical sites yielded a mean vascularization of 53.3 ± 10.5%, while the macrosurgical sites were vascularized to 44.5 ± 5.7%.

After 1 week of healing, the highly significant difference in vascularization between the test and control sites remained ($p < 0.01$) (Fig. 3). Microsurgically treated sites were vascularized to 84.8 ± 13.5%, while the vascularization of the macrosurgically treated sites was 63.9 ± 12.3%.

Clinical outcomes

One month following micro- or macrosurgical coverage of the recessions, 95.2–100% of the root dehiscences were covered in the test and 75.5–100% in the control sites, respectively (Table 2). This corresponded to an average coverage of 99.4 ± 1.7% for the microsurgical and 90.8 ± 12.1% for the macrosurgical sites, respectively. This difference was statistically significant in the one-sided test situation ($p < 0.05$).

At 3 months, the root coverage ranged from 92.8% to 100% and from 77.8% to 100% at the test and control sites, respectively, the mean values being 98.6 ± 2.8% and 90.4 ± 10.3%, respectively. Again, this difference was statistically significant ($p < 0.05$).

Six months postoperatively, the root coverage ranged from 88.1% to 100% and from 77.5% to 100% in the test and control sites, respectively. This corresponded to a mean coverage of 98.0 ± 4.3% for the microsurgical and 89.7 ± 8.9% for the macrosurgical approach. This difference was, again, statistically significant ($p = 0.04$).

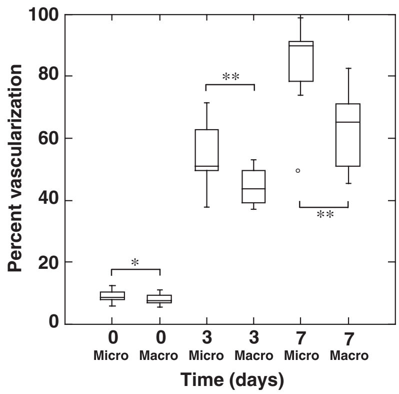

Fig. 2. Results of the angiographic evaluation illustrated in box-and-whiskers plots. Outside value° beyond the lower inner fence. $^{*}p < 0.05$, $^{**}p < 0.01$.

Finally, after 1 year postsurgically, the root coverage was 100% in five and 90–98% in the three microsurgical sites with an average coverage of 98.0 ± 3.4%.

In macrosurgical sites, however, only two sites yielded 100% root coverage with the remainder ranging from 77.8% to 94.6%. This resulted in a mean coverage of 89.9 ± 8.5%. The differences between the results of the micro- and macrosurgical approaches were, again, significant ($p = 0.03$).

Figure 4 shows the differences between the percentages for sites treated with the micro- and macrosurgical approaches. In all measurements the outside value of the microsurgically treated sites still is close to the median of the corresponding macrosurgically treated sites.

It may be noted that the number of sites of complete (100%) root coverage decreased from 7/8 after 1 month to 6/8 after 3 and 6 months and 5/8 after 1 year following the microsurgical procedure. The corresponding figures for the macrosurgical procedures, however,

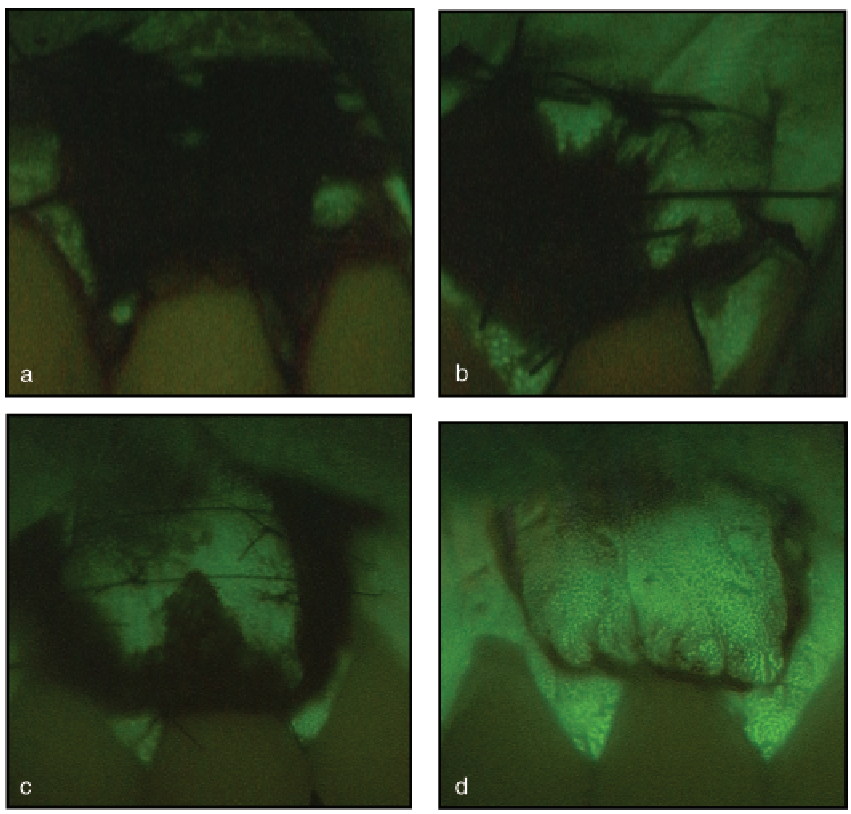

Fig. 3. Angiograms: macrosurgically treated sites, immediately after the intervention (a), and 1 week postoperatively (b); corresponding figures for the microsurgically treated sites, postoperatively (c) and after 1 week (d).

Table 2. Depths of the gingival recessions (GRs) before and the percentage of coverage 1, 3, 6 and 12 months after the surgical treatment*

	Baseline GR† (mm)	1 month (%)	3 months (%)	6 months (%)	12 months (%)
Patient #1	3.3/3.1	100/100	100/100	100/100	100/100
Patient #2	3.9/4.5	100/75.5	100/77.8	100/80.0	100/77.8
Patient #3	3.8/3.1	100/100	100/96.8	100/90.3	100/93.5
Patient #6	4.2/4.3	95.2/97.7	92.8/90.7	88.1/90.7	90.5/88.4
Patient #7	5.2/5.6	100/100	100/100	100/96.4	100/94.6
Patient #8	4.3/4.5	100/75.5	100/77.8	100/82.2	97.7/82.2
Patient #9	3.3/4.4	100/100	100/100	100/100	100/100
Patient #10	4.6/4.0	100/77.5	95.6/80.0	95.6/77.5	95.6/82.5
Average microsurgical		**99.4** ± 1.7‡	**98.6** ± 2.8‡	**98.0** ± 4.3‡	**98.0** ± 3.4‡
Average macrosurgical		**90.8** ± 12.1	**90.4** ± 10.3	**89.7** ± 8.9	**89.9** ± 8.5

*Patients #4 and #5 could not be followed during the 12 months period (relocation).
†Micro-/macrosurgically treated recessions (xx/yy).
‡Differences statistically significant ($p<0.05$).

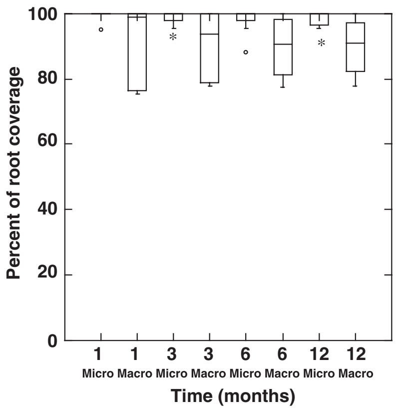

Fig. 4. Percentages of root recession coverage illustrated in box-and-whiskers plots. Outside* and far outside values° beyond the lower inner fence.

were 4/8 after 1 month, 3/8 after 3 months, 2/8 after 6 and 12 months.

Discussion

The present clinical experiment has demonstrated that mucogingival surgical procedures designed for the coverage of exposed root surfaces performed by using a microsurgical approach improved the treatment outcomes substantially and to a clinically relevant level when compared with the clinical performance under routine and macroscopic conditions.

In the present study, all test and control sites were selected for root surface coverage if the adjacent inter-proximal soft tissue was still at a normal level with papillae reaching at least the cemento-enamel junctions of the adjacent inter-proximal tooth sites (Miller 1985: Class I and II). The anatomical characteristics of the recessions did not differ significantly between test and control sites and exceeded 3 mm at all sites. Exclusively, homologous maxillary canines were selected. Thus, it was assured that the baseline data of the recessions were almost identical. In all situations, a double papilla split-thickness flap was performed. Hence, the only variable of the study was the improved visual and tactile approach performed under the microscope as compared with the conventional macrosurgical technique. Furthermore, in conjunction with the microsurgical approach, finer instruments and suture materials were used than for the macrosurgical approach. Hence, it has to be realized that two extreme clinical approaches applying the same clinical technique to the same types of recession defects were performed.

Prior to the surgical procedures of both test and control sites, the oral cavity was subjected to a systematic preoperative cleaning combined with proper oral hygiene instructions and professional dental prophylaxis. This resulted in very low plaque scores and consequently, in the absence of gingival inflammation in all sites (absence of bleeding on probing). The surgical procedures were performed according to the technique described by Harris (1992) after carefully planing of the root surfaces to improve the morphology for recession coverage (Miller 1987).

The purpose of the angiographic evaluation of the study was to compare the vascularization (wound healing) of the subepithelial connective tissue grafts that were placed in conjunction with the double papilla coronally advanced flaps.

The angiographic evaluation performed immediately after the surgical treatment resulted in a better vascularization of the microsurgically operated sites with a mean percentage of 8.9 ± 1.9% compared with the macrosurgically treated sites with 8.0 ± 1.8%, correspondingly (Fig. 2). This difference reached statistical significance ($p = 0.02$). The difference encountered, presented evidence that a minimally invasive technique may lead to less tissue trauma. It may be assumed that the sharper and finer surgical blades together with finer suture material used in the microsurgical approach were responsible for the reduced tissue damage. In addition, the magnification provided by the microscope may help to split a flap in a well-defined thickness and to keep the thickness for the entire flap preparation. This may, indeed, result in decreased vessel injury. The angiograms of the third and seventh postoperative days revealed a markedly improved vascularization of the microsurgically treated sites, expressed in a mean percentage of vascularization of 53.3 ± 10.5% after 3 and 84.8 ± 13.5% after 7 days. However, for the macrosurgically operated sites, only 44.5 ± 5.7% and 63.9 ± 12.3%, respectively, were vascularized. These differences were statistically highly significant ($p<0.001$). The results of the present study support the wound healing studies that have shown a revascularization of free gingival grafts starting shortly after the surgical procedure and lasting for about 10 days (Oliver et al. 1968, Nobuto et al. 1988). Based on the present results it may be assumed that reduced vessel injury may facilitate the development of anastomoses between the wound bed and the graft. In addition, the capillary proliferation and ingrowth may also be accelerated by the reduced trauma.

A large number of case series or prospective cohort studies have been published over the past 40 years promoting different techniques for root coverage. However, only about 20 controlled or randomized controlled clinical trials have been presented. These have recently been analysed in a systematic review (Roccuzzo et al. 2002). In this systematic review, the mean percentages of root coverage ranged from 64.7% (Bouchard et al. 1994) to 95.6% (Rosetti et al. 2000) following the application of connective tissue grafts. In comparison with this variability of clinical outcomes the results of the present study after 1 year achieved 98.0 ± 3.4% and 89.9 ± 8.5%

for test and control sites, respectively. Similar outcomes of root coverage following the double papilla technique (Harris 1994) were reported on a prospective cohort of 100 consecutively treated recessions with a mean root coverage of 97.7%. This clearly indicates that root surface coverage applying connective tissue grafts and coronally advanced double papilla flaps represents a surgical technique with predictable and clinically satisfying outcomes. It has to be realized, however, that factors influencing the degree of coverage, such as root preparation, delicate tissue handling, tissue thickness, meticulous plaque control have to be controlled in order to maximize treatment outcomes. In that respect, the microsurgical approach clearly contributed with a significant (average 8%) improvement in the present study.

From an aesthetic and subjective point of view, complete root coverage represents a desired treatment goal. The percentages of sites with complete root coverage after 1 month were 90% and 40% in the test and control sites, respectively. In the systematic review mentioned (Roccuzzo et al. 2002) the largest percentage of cases with complete root coverage for connective tissue grafts was 83.3% (Tatakis &Trombelli 2000). In 10 out of 12 studies included, complete coverage was achieved in 20–50% of the sites. The results of the present study indicate that an improved blood supply during early wound healing may be essential and may improve the percentage of root coverage. This is also evident by the fact that only 25% of the control, but 62.5% of the test sites yielded complete coverage even after 1 year. It has to be realized that the initially achieved complete coverage in 90% and 50% for test and control sites after 1 month, respectively, decreased during the subsequent 11 months to 62.5% and 25%, respectively. This closely corresponds to the results of the systematic review (Roccuzzo et al. 2002) and documents the tendency of tissue shrinkage during first year. Obviously, the degree of shrinkage is influenced by the surgical approach with microsurgical procedures providing significantly improved outcomes than conventionally performed mucogingival surgery.

The mean surgical operation time in the test sites (72 ± 8 min.) was more than 40% longer than in the control sites (51 ± 5 min.). In studies of oral surgical procedures, the incidence and severity of complications and pain following periodontal surgery correlated well with the duration of the surgical procedure (Curtis et al. 1985). It may be speculated that an extended operation time may compensate for the beneficial treatment effect of minimally invasive techniques. However, the present study does not support such a hypothesis.

In contrast, the present study has demonstrated that a microsurgical approach for covering localized gingival recessions resulted in a faster vascularization of the injured tissues and hence, in a statistically significant and clinically relevant higher percentage of root coverage. Although the mean results were stable during the observation period of 12 months, the percentage of sites with complete root coverage decreased during the first year.

Although the microsurgical approach for root coverage was clearly superior in outcomes than the conventional mucogingival approach, the choice of micro- or macrosurgical approaches must be seen in the light of both treatment outcomes, logistics, cost and patient-centred parameters.

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References

Bouchard, P., Etienne, D., Ouhayoun, J. P. & Nilveus, R. (1994) Subepithelial connective tissue grafts in the treatment of gingival recessions. A comparative study of two procedures. *Journal of Periodontology* **65**, 929–936.

Bouchard, P., Malet, J. & Borghetti, A. (2001) Decision-making in aesthetics: root coverage revisited. *Periodontology 2000* **27**, 97–120.

Burkhardt, R. & Hürzeler, M. B. (2000) Utilization of the surgical microscope for advanced plastic periodontal surgery. *Practical Periodontics and Aesthetic Dentistry* **12**, 171–180.

Christen, A. G. & Mitchell, D. F. (1966) A fluorescent dye method for demonstrating leakage around dental restorations. *Journal of Dental Research* **45**, 1485–1492.

Cohen, D. W., Stoller, N. H., Chace, R. & Laster, L. (1972) A comparison of bacterial plaque disclosants in periodontal disease. *Journal of Periodontology* **43**, 333–338.

Cortellini, P. & Tonetti, M. S. (2001) Microsurgical approach to periodontal regeneration. Initial evaluation in a case cohort. *Journal of Periodontology* **72**, 559–569.

Curtis, J. W., McLain, J. B. & Hutchinson, R. A. (1985) The incidence and severity of complications and pain following periodontal surgery. *Journal of Periodontology* **10**, 597–601.

Harris, R. J. (1992) The connective tissue and partial thickness double pedicle graft: a predictable method of obtaining root coverage. *Journal of Periodontology* **63**, 477–486.

Harris, R. J. (1994) The connective tissue with partial thickness double pedicle graft: the results of 100 consecutively-treated defects. *Journal of Periodontology* **65**, 448–461.

Hefferren, J. J., Cooley, R. O., Hall, J. B., Olsen, N. H. & Lyon, H. W. (1971) Use of ultraviolet illumination in oral diagnosis. *Journal of the American Dental Association* **82**, 1353–1360.

Joshipura, K. J., Kent, R. L. & DePaola, P. F. (1994) Gingival recession: intraoral distribution and associated factors. *Journal of Periodontology* **65**, 864–871.

Khocht, A., Simon, G., Person, P. & Denepitiya, J. L. (1993) Gingival recession in relation to history of hard toothbrush use. *Journal of Periodontology* **64**, 900–905.

Komatsu, S. & Tamai, S. (1968) Successful replantation of a completely cut-off thumb. *Plastic and Reconstructive Surgery* **42**, 374–386.

Kornman, K. S. & Robertson, P. B. (2000) Fundamental principles affecting the outcomes of therapy for osseous lesions. *Periodontology 2000* **22**, 22–43.

Lang, N. P., Östergaard, E. & Löe, H. (1972) A fluorescent plaque disclosing agent. *Journal of Periodontal Research* **7**, 59–67.

Larato, D. C. (1970) Alveolar plate dehiscences and fenestrations in the human skull. *Oral Surgery, Oral Medicine and Oral Pathology* **29**, 816–819.

Löe, H. (1967) The gingival index, plaque index and retention index systems. *Journal of Periodontology* **38**, 610–616.

Löe, H., Ånerud, Å. & Boysen, H. (1992) The natural history of periodontal disease in man: prevalence, severity and extent of gingival recession. *Journal of Periodontology* **63**, 480–495.

Lorenzana, E. R. & Allen, E. P. (2000) The single-incision palatal harvest technique: a strategy for esthetics and patient comfort. *International Journal of Periodontics and Restorative Dentistry* **20**, 297–305.

Miller, P. D. (1985) A classification of marginal tissue recession. *International Journal of Periodontics and Restorative Dentistry* **5**, 9–13.

Miller, P. D. (1987) Root coverage with the free gingival graft – factors associated with incomplete coverage. *Journal of Periodontology* **58**, 674–681.

Mörmann, W., Bernimoulin, J. P. & Schmid, M. O. (1975) Fluorescein angiography of free gingival autografts. *Journal of Clinical Peridontology* **2**, 177–189.

Mörmann, W. & Ciancio, S. G. (1977) Blood supply of human gingiva following periodontal surgery. *Journal of Periodontology* **48**, 681–692.

Mörmann, W. & Lutz, F. (1974) Fluoreszenzangiografie der Gingiva. *Schweizerische Monatsschrift für Zahnmedizin* **84**, 798–819.

Nobuto, T., Imai, H. & Yamaoka, A. (1988) Microvascularization of the free gingival autograft. *Journal of Periodontology* **59**, 639–646.

Oliver, R. G., Löe, H. & Karring, T. (1968) Microscopic evaluation of the healing and revascularization of free gingival grafts. *Journal of Periodontal Research* **3**, 84–95.

Powell, R. N. & McEniery, T. M. (1981) Disparities in gingival height in the mandibular central incisor region of children aged 6–12 years. *Community Dentistry and Oral Epidemiology* **9**, 32–36.

Raetzke, P. B. (1985) Covering localized areas of root exposure employing the ''envelope'' technique. *Journal of Periodontology* **56**, 397–402.

Roccuzzo, M., Bunino, M., Needleman, I. & Sanz, M. (2002) Periodontal plastic surgery for treatment of localized gingival recessions: a systematic review. *Journal of Clinical Periodontology* **29** (Suppl. 3), 178–194.

Rosetti, E. P., Marcantonio, R. A., Rossa, C. J., Chaves, E. S., Goissis, G. & Marcantonio, E. J. (2000) Treatment of gingival recession: comparative study between subepithelial connective tissue graft and guided tissue regeneration. *Journal of Periodontology* **71**, 1441–1447.

Rustogi, K. N., Triratana, T., Kietprajuk, C., Lindhe, J. & Volpe, A. R. (1991) The association between supragingival calculus deposits and the extent of gingival recession in a sample of Thai children and teenagers. *Journal of Clinical Dentistry* **3** (Suppl. B), 6–11.

Sangnes, G. & Gjermo, P. (1976) Prevalence of oral soft tissue lesions related to mechanical toothcleansing precedures. *Community Dentistry and Oral Epidemiology* **4**, 77–83.

Salkin, L. M., Landay, M. A., Hildebrand, C. N. & Leve, R. A. (1974) A fluorescent microscopic study of human bacterial plaque smears stained with plak-lite fluorochrome. *Journal of the Californian Dental Association* **2**, 60–63.

Serafin, D. (1980) Microsurgery: past, present and future. *Plastic and Reconstructive Surgery* **66**, 781–785.

Serino, G., Wennström, J. L., Lindhe, J. & Eneroth, L. (1994) The prevalence and distribution of gingival recession in subjects with a high standard of oral hygiene. *Journal of Clinical Periodontology* **21**, 57–63.

Shanelec, D. A. & Tibbetts, L. S. (1994) Periodontal microsurgery. *Periodontal Insights* **1**, 4–7.

Shanelec, D. A. & Tibbetts, L. S. (1996) A perspective on the future of periodontal microsurgery. *Periodontology 2000* **11**, 58–64.

Tatakis, L. & Trombelli, L. (2000) Gingival recession treatment: guided tissue regeneration with bioabsorbable membrane versus connective tissue graft. *Journal of Periodontology* **71**, 299–307.

Tibbetts, L. S. & Shanelec, D. A. (1994) An overview of periodontal microsurgery. *Current Opinion in Periodontology* **2**, 187–193.

Tibbetts, L. S. & Shanelec, D. A. (1996) Current status of periodontal microsurgery. *Current Opinion in Periodontology* **3**, 118–125.

Wennström, J. L. (1996) Mucogingival therapy. *Annals of Periodontology* **1**, 671–701.

Wessing, A. & Eichelberg, D. (1968) Fluorescing substances from the Malpighian tubules of wildtype and various eye color mutants of drosophila melanogaster. *Zeitschrift für Naturforschung B* **23**, 376–386.

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