Comparative evaluation of vascular and clinical changes in micro and macrosurgical techniques in the management of mucogingival problems

ABSTRACT

Background: Mucogingival surgery is performed to resolve the problems arising due to high frenum attachment and shallow vestibular depth (VD). The surgical procedures are mainly indicated to prevent gingival recession and for esthetic reasons. The aim of this study was to compare the degree of vascularization in the treatment of mucogingival problems by both microsurgical and macrosurgical techniques.

Materials and Methods: Forty-two participants with aberrant frenum and shallow VD were randomly selected for frenectomy, frenotomy, and vestibular deepening either by a microsurgical (test) or macrosurgical (control) approach. Fluorescein angiography was performed at 1, 7, and 14 days after the surgical procedures. In addition, patient’s satisfaction scores were recorded postoperatively.

Results: Angiographic evaluation at test site revealed a statistically significant vascularization at 1, 7, and 14 days after the surgical procedure when compared to control sites. Probing pocket depth (PPD) in both the groups in vestibular deepening procedure decreased from 1 month to 6 months, but the reduction was insignificant. There was significant reduction in VD in both the groups over a period of 6 months. Microsurgical approach in all three procedures was superior in terms of patient satisfaction than macrosurgical approach. Mean surgical time spent in vestibular deepening and frenectomy procedures was highly significant in micro group as compared to the macro group.

Conclusion: This clinical study indicates that microsurgical approach improved the percentage of vascularization and patient satisfaction compared with macrosurgical approach.

Keywords: Fluorescein angiography, frenectomy, microsurgery, mucogingival surgery, vestibular deepening

INTRODUCTION

Mucogingival conditions are concerned with the interrelationship of the attached gingiva, alveolar mucosa, mucogingival junction, aberrant frenum, and depth of the vestibule, etc. When the frenum encroaches the gingival margin, it may affect the gingival health by interfering with oral hygiene maintenance and by causing gingival recession. The presence of an aberrant frenum also plays a role in the development of midline diastema which may present esthetic problem and may compromise the orthodontic treatment. The treatment of mucogingival problems is one of the main aims of periodontal therapy. The success of mucogingival surgical interventions may depend on the several factors such as: the bacterial contamination of the sites, defect morphology, tooth position and tooth surface characteristics and the surgical technique. Three principles goals of surgery are eliminating dead space, closing with appropriate tension, and immobilizing the wound. An appropriate combination of properly selected blade and suture material allows the

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Received: 02 June 2021, Revised: 20 September 2021, Accepted: 09 October 2021, Published: 15 June 2022

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How to cite this article: Yadav K, Dixit J, Chhabra AK, Verma UP. Comparative evaluation of vascular and clinical changes in micro and macrosurgical techniques in the management of mucogingival problems. Natl J Maxillofac Surg 2022;13:269-75.
surgeon to approximate the tissues with as little trauma as possible. Most dental treatment has been rendered with the unaided eye. Without the use of visual magnification such treatment is termed macroscopic. Treatment rendered with visual enhancement supplied by the microscope is termed microscopic.[2] Microsurgery presents such outcomes not possible with conventional surgery, especially in terms of passive wound healing and reduced trauma. The three elements, i.e., magnification, illumination, and instruments are termed “microsurgical triad,” the improvement of which is a prerequisite for improved accuracy in microsurgical interventions.[3]

The rich blood supply is an essential requirement to promote rapid healing. Among the various techniques to study the function of gingival capillaries, fluorescein angiography showed successful evaluation gingival capillary bed.[4] Till date, there are only few studies in which quantification of changes in blood vessels after mucogingival surgery have been attempted.

The aim of the present study was to compare the percentage of vascularization and clinical changes in the management of mucogingival problems (high frenum attachment and shallow vestibular depth [VD]) by micro and macro surgical techniques.

MATERIALS AND METHODS

Study population
After the approval of ethical committee of King George’s Medical University Lucknow, 42 patients (24 females and 18 males; age range: 20–30 years) with mucogingival problems were selected from the patient pool of the outpatient Department of Periodontology. Systemically healthy subjects with shallow mandibular VD and high frenum attachment (maxillary or mandibular) with no history of periodontal disease were included. Patients on medication affecting the periodontal tissues; smokers, and who failed to maintain adequate oral hygiene were excluded from the study. The study was approved by Institutional Ethical Committee with approval number 5553/perio/13. The present study was a prospective, randomized, controlled interventional trial with a parallel group design. It was a single-blinded study, i.e., participants were unaware of intervention assigned to them. All risks and benefits involved in the procedures were explained to the patients before they signed an informed consent form.

The patients at the first visit received proper periodontal examination and completed a plaque control program, including oral hygiene instructions and scaling and root planning. Patients were randomly assigned to test group (TG; 21 subjects) and control group (CG; 21 subjects) by the computerized generated method. Participants were enrolled from June 2012 to March 2013. Power analysis indicated that with 36 participants the study has more than 85% to detect 1% increase in vascularization between the two groups.

Twenty-eight participants with aberrant high frenum attachment and fourteen participants with shallow VD were treated with frenectomy, frenotomy and vestibular deepening with conventional macrosurgical approach (CG: 7 subjects each with frenectomy, frenotomy, and vestibular deepening) or the microsurgical approach (TG: 7 subjects each with frenectomy, frenotomy and vestibular deepening).

Clinical parameters
The clinical parameters evaluated were periodontal pocket depth (PD), width of attached gingiva and VD. Measurements were recorded to the nearest millimeter with the help of a calibrated (UNC‑15, Hu‑Friedy, Chicago, IL, USA) probe at baseline, 1, 3, and 6 months. Periodontal PD was measured as the distance from the bottom of the pocket to the most apical portion of the gingival margin. Width of attached gingiva was calculated by subtracting the PD from the distance between gingival margin and mucogingival junction VD was calculated by placing the probe against the labial aspect of one mandibular central incisor and measured the distance from the base of the vestibule to gingival margin.

Microsurgically treated procedures
Microsurgical procedures were performed with the aid of:

a. Surgical microscope (Carl Zeiss OPMI Pico, A Carl Zeiss Meditec Company, Oberkochen, Germany) at 12.5 X magnification.

b. Microsurgical instruments used consisted of: microsurgical ophthalmic knife (Lance Tip 15° Ophthalmic knife, Ovation, International 1583, Jaipur, India), hemostat, needle holder, periosteal elevator, forceps and scissors. Nonresorbable, monofilament 7-0 polypropylene suture (Ethicon, Division of Johnson and Johnson Aurangabad, India) was used for the closure of the wound.

Macrosurgically treated procedures
Macrosurgical procedures were performed without the use of the surgical microscope. The conventional instruments used consisted of a B. P. blade no. 15, hemostat, periosteal elevator, scissors, forceps and a needle holder. Nonresorbable, monofilament 4-0 braided silk suture (Ethicon, Division of Johnson and Johnson Aurangabad, India) was used for approximation of the wound.
Surgical procedure

In both groups, the surgical procedures were performed by a single surgeon. Participants were asked to rinse with 0.2% chlorhexidine gluconate. The facial skin all around the oral cavity was scrubbed with povidone iodine solution. Sensitivity test was done in each subject. Area subjected to surgery was adequately anesthetized by nerve infiltration depending on the surgical site using 2% xylocaine with adrenaline 1:200,000.

The frenectomy procedure was performed according to the technique described by Corn. The frenum was engaged with a hemostat which was inserted into the depth of the vestibule and incisions were placed on the upper and the undersurface of the hemostat until hemostat was free. The triangular resected portion of the frenum with the hemostat was removed. A blunt dissection was done on the bone to relieve the fibrous attachment. The edges of diamond-shaped wound were sutured with interrupted sutures. The area was covered with a periodontal pack. The pack was removed after 24 h for postoperative angiography and then replaced.

The surgical procedure of frenotomy was performed according to the technique described by Curran M. The lip was pulled outward and upward stretching the frenum taut and hemostat was clamped on the frenum. On each side of the frenum from the base, an incision was made inferiorly to the alveolar crest between the central incisors. After this tissue had been loosened, the scalpel blade was brought down the face of the hemostat to complete the excision of the triangular flap of tissue. No sutures were placed in this procedure. The area was covered with a periodontal pack. The pack was removed after 24 h for postoperative angiography and then replaced.

Vestibular extension was carried out by the technique described by Edlan and Mejchar to correct a shallow vestibule. Mesial to one of the mandibular canines and starting at the junction of the attached and free gingiva, an incision was made for a distance of 10–12 mm extending on to the lower lip. A similar incision was made corresponding to the other mandibular canine. These two incisions were joined by a horizontal incision across the mid line. The mucosa included within this incision was reflected from the underlying muscular tissue using sharp dissection. This resulted in a loose flap of labial mucosa with its base on the gingiva. The loose flap of labial mucosa was folded upward, and a horizontal incision was made on the periosteum. The incision was made so that it extended between the two initial vertical incisions mesial to the canines. The incision of the periosteum was extended in a vertical direction at its ends. The periosteum was then separated from the bone, forming a second flap with its base on the apical portion of the mandible. The loose flap of labial mucosa was folded back and placed on the bone from which the periosteum had been removed. It was fixed with interrupted sutures to the inner surface of the periosteum, which had been removed from the bone. The upper edge of the periosteum was also sutured to the mucous membrane of the lip to cover the area denuded by the reflection of the first (labial mucosa) flap. The area was covered with a periodontal pack. The pack was removed after 24 h for postoperative angiography and then replaced [Figure 1].

Postsurgical care

All patients were instructed to avoid trauma and to discontinue tooth brushing at the surgical site during a 7-day period. Participants were instructed to rinse with a 0.2% chlorhexidine digluconate solution for 1 min, twice a day for 15 days, and a nonsteroidal anti-inflammatory agent was prescribed for pain control and antibiotics were prescribed for 3 days. After 7 days, sutures and coe pack was removed. Participants were recalled at 24 h after the surgery, and after 7 and 14 days for postoperative angiography. In the same session, photographs were taken of the treated areas with a digital camera (Nikon Cool Pix S9100).

Figure 1: Subject presenting with a shallow mandibular vestibular depth (a) and immediately after a vestibular deepening procedure performed using the microsurgical technique with suture in place (b). Healing 6 months after surgery (c). Another subject presenting with a shadow mandibular vestibular depth (d) and immediately after a vestibular deepening procedure performed using the macrosurgical technique with suture in place (e). Healing 6 months after surgery (f)
Postoperative angiography

A photographic system for fluorescein angiography to observe the blood circulation in healthy and inflamed gingiva was described by Mörmann et al.[8] The machine to record the angiogram consisted of (1) fundus camera (Fundus Camera FF450 Plus IR) (2) external video camera.(Sony ICX-282 AQ ZK-5) A rigid head gear was connected to the angiographic machine to immobilize the patient for the standardization of the technique. For the postsurgical angiographies, sodium fluorescein was used as contrast medium. Fluorescein sodium responds to electromagnetic radiation and light between the wavelengths of 465–490 nm and fluoresces, i.e., emits light at the wavelength of 520–530 nm. Thus, the hydrocarbon is excited by blue light and emits light that appears yellowish green. Following intravenous injection of fluorescein sodium in an aqueous solution, the unbound fraction can be excited with a blue light flash from a fundus camera as it circulates through the vasculature, and the yellowish green fluorescence of the dye is captured by the camera. This medium had also been used as a dye for studying plaque formation[9] and to examine the marginal integrity of fillings.[10] Hence, biocompatibility of these dyes was well documented, although rare side effects such as nausea and vomiting have been reported after intravenous injection. In this study, only four patients experienced mild nausea and vomiting.

To obtain high-contrast angiogram gingival vessels must be perfused with maximum concentration of fluorescein. All participants received an intravenous injection of 2 ml of 20% solution of sodium fluorescein at 24 h after the surgical procedure within 2–3 s into the antecubital vein of the participants which resulted in an adequate fluorescein through the gingival vasculature.

The angiogram was characterized by the filling phase of the capillaries. It was important to capture the first consecutive images of the high concentrated fluorescein burst.[11] An initial photographic sequence of 25 exposures documenting the intra-capillary phase of the fluorescein labeling was started 10 s after the beginning of the injection. The fluorescein was then allowed to permeate through the vessel walls and to diffuse evenly into the gingival tissue. Additional photographs were taken 1, 2, 3, 4, 5, 10, and 15 min after injection to document postangiographic plasma fluid diffusion. The consecutive angiograms were performed 24 h after the surgery and after 7 and 14 days [Figure 2].

Data analysis

The percentage of vascularization was analyzed on the standardized angiographic images in defined areas of the gingival surfaces. Evaluation squares with same dimensions served as a basis for evaluation. By the help of an image analysis software (Image J Software, National Institute of Health, Bethesda), calculations were made to determine the percentage of fluorescence within defined squares.

Patient satisfaction

Each patient was questioned about his/her satisfaction with regard to the following patient-centered criteria:[12]

- Surgical procedure (macro and micro) (Any discomfort experienced due to the procedure and handling by the operator)
- Postsurgical phase (pain, swelling, and postoperative complications which included pain, functional limitations, scarring, and lip tightness) and time spent during surgery was recorded by the surgeon.

Patient satisfaction was assessed using a three-point rating scale:

Fully satisfied = 3; Satisfied = 2; and Unsatisfied = 1.

Statistical analysis

Data were summarized as mean ± standard deviation. Groups were compared by the factorial analysis of variance (ANOVA) and repeated-measures ANOVA wherever applicable and the significance of mean difference within and between the groups was done by Tukey’ honestly significant
difference test. Discrete (categorical) groups were compared by the Chi-square ($\chi^2$) test. A two-sided ($\alpha = 2$) $P$ values less than 0.05 ($P < 0.05$) was considered statistically significant. All analyses were performed using a statistical program SPSS for Windows version 15.00 (SPSS Inc., Chicago, IL, USA).

RESULTS

All patients completed follow-up of 14 days for postoperative angiography and of 6 months for clinical outcomes. The results from the evaluation of vascularization as revealed by fluorescein angiography are depicted in Table 1. There was a statistically significant increase in mean percentage vascularization in the microsurgical approach than the macrosurgical approach ($P < 0.001$). Twenty-four hours after the vestibular deepening procedure a mean vascularization of 24.00% ± 0.12% and 19.26% ± 0.10% was reported in the microsurgically and macrosurgically treated sites. At the 14$^{th}$ day in the frenotomy procedure, a mean of 94.04% ± 0.98% and 85.05% ± 0.14% of the sites were vascularized in the test and control groups, respectively. After 7 days of healing, a maximum percentage change in vascularization comparing the test and control group was reported in frenotomy (32.7%) and least at day 14 in vestibular deepening (5.3%) procedures.

Six months following micro or macrosurgical deepening of the shallow vestibule, a net change in PPD level was 0.06 ± 0.12 mm and 0.13 ± 0.18 mm in the test and control group [Table 2]. The differences were statistically insignificant at all time periods ($P > 0.05$), whereas a statistically significant difference was found in both the groups with regard to width of attached gingiva at 1, 3, and 6 months postoperatively [Table 2].

Six months following vestibular deepening procedure by both the approaches, there was a net change of 3.57 ± 0.78 mm in the test and 2.07 ± 0.78 mm in the control sites, respectively. This difference was statistically significant in the microsurgical group at all time periods.

The mean satisfaction scores in all the three procedures in microsurgical group were higher than the macrosurgical group, and there was a significant difference between the participants “overall satisfaction” with microsurgically treated vestibular deepening ($P < 0.0001$), frenectomy ($P < 0.001$) and frenotomy procedures ($P < 0.05$) [Table 3].

The mean surgery time was 124.57 ± 5.13 min, 39.00 ± 4.04 min, and 22.43 ± 2.51 min for the microsurgically and 86.43 ± 5.56 min, 23.86 ± 2.91 min and 17.00 ± 3.06 min for the macrosurgically treated vestibular deepening, frenectomy and frenotomy procedures respectively. These differences were highly significant ($P < 0.001$) [Table 4].

DISCUSSION

This fluorescein angiographic study shows that mucogingival surgical procedures designed for the treatment of high frenum attachment and shallow VD performed by using microsurgical approach revealed better vascularization and improved treatment outcomes when compared under macroscopic conditions. The difference encountered the evidence that the microsurgical technique was responsible for less tissue damage. It may be due to the use of fine blade and suture material and also due to optical magnification provided by the microscope.[11]

Only three mucogingival surgeries, i.e., vestibular deepening, frenectomy, and frenotomy were included in the angiographic study to estimate the extent of vascularization. To the best of our knowledge, above-mentioned mucogingival intervention comparing micro and macro surgical techniques were not conducted in the past. Previous research on the assessment of vascularization by fluorescein angiography focused on various modifications of flap design[4] mucoperiosteal flap surgery[13] and root coverage procedures.[11,14]

Table 1: Comparison of percentage of vascularization after macro and micro surgical techniques

| Periods | Procedures       | Mean±SD | Percentage change | P          |
|---------|------------------|---------|-------------------|------------|
|         |                  | CG      | TG                |            |
| At day 1| Vestibular deepening | 19.26±0.10 | 24.00±0.12 | 19.7       | <0.001     |
|         | Frenectomy        | 21.19±0.38 | 26.56±0.76 | 17.5       | <0.001     |
|         | Frenotomy         | 26.76±0.35 | 31.88±0.89 | 16.1       | <0.001     |
| At day 7| Vestibular deepening | 28.64±0.68 | 39.20±0.14 | 26.9       | <0.001     |
|         | Frenectomy        | 30.57±0.87 | 44.99±0.44 | 32.0       | <0.001     |
|         | Frenotomy         | 34.42±0.52 | 51.18±0.79 | 32.7       | <0.001     |
| At day 14| Vestibular deepening | 77.50±0.09 | 81.79±0.11 | 5.3        | <0.001     |
|          | Frenectomy        | 81.03±0.22 | 86.94±0.79 | 6.8        | <0.001     |
|          | Frenotomy         | 85.05±0.14 | 94.04±0.98 | 9.6        | <0.001     |

 TG: Test group, CG: Control group, SD: Standard deviation
In our short-term study, patients were recalled for postsurgical angiographies at 24 h, 7 and 14 days as compared to previous studies of: (24 h and 4–7 days), (8, 10, and 12 days) and (immediately, 3 and 7 days) after surgery. For the postsurgical angiographies, sodium fluorescein was used as a contrast medium. The method allowed successful evaluation of functional conditions in the gingival capillary bed. Sodium fluorescein, being a small molecule, stays only for a short time in the gingival capillary bed. To overcome this, the photographic sequence must start early after the injection (10 s) and must cover a post injection period up to 15 min, in order to make a clear distinction possible between intracapillary fluorescence and fluorescence due to plasmatic diffusion of the dye. Additional pictures were followed after 1, 2, 3, 4-, 5-, 10-, and 15-min. Angiographic series was similar to that of Busschop et al.

Primary outcome measures depicted in our study were percentage of vascularization, periodontal PD, width of attached gingiva, and VD. Frenotomy procedure reported maximum increase in vascularization among all the procedures followed by frenectomy and vestibular deepening in both the groups. While in terms of time period, there was a consistent increase in vascularization from 24 h to 14 days after the surgical intervention. Frenotomy portrayed better vascularization due to its being less invasive and absence of sutures as compared to frenectomy and vestibular deepening as revealed by. He observed that intracapillary circulation was often absent near the location of sutures. Among the three procedures, percentage increases in vascularization in vestibular deepening procedure was least at all time periods which might be due to the presence of both horizontal and vertical incisions. Furthermore, during this procedure, gingival vessels might have been severed at the surgical site.

However, in term of periods, the percentage change in vascularization in the microsurgical group when compared to macrosurgical groups increased from day 1 to day 7, but at day 14, a drastic decline was observed in all three procedures suggesting maximum healing till 7 days after microsurgical surgical interventions.

In the present study, there was increase in width of attached gingiva in both test and control groups but not reached statistical significance. The original rationale for mucogingival surgery was predicted on the assumption that a minimal width of attached gingiva was required to maintain optimal gingival health. However, several studies have challenged this view and stated that persons who practice excellent oral hygiene may maintain healthy areas with almost no attached gingiva.

At 1, 3, and 6 months follow-ups, the depth of the vestibule increased significantly in the test group ($P < 0.05$) as compared to the control group. Gain in VD in our study was $2.07 \pm 0.78$ mm in macrogroup and $3.57 \pm 0.78$ mm in microsurgical group.

### Table 2: Clinical parameters for baseline, 1, 3, and 6 months after the surgical treatment

| Groups          | Baseline | 1 month | 3 months | 6 months | Net change (baseline to 6 months) |
|-----------------|----------|---------|----------|----------|----------------------------------|
| PD, mean±SD     |          |         |          |          |                                  |
| CG              | 4.14±0.81| 4.14±0.81| 4.14±0.81| 4.07±0.77| 0.06±0.2                        |
| TG              | 4.37±0.77| 4.37±0.77| 4.28±0.84| 4.24±0.80| 0.13±0.18                       |
| Width of attached gingiva, mean±SD |          |         |          |          |                                  |
| CG              | 0.05±0.12| 0.47±0.26| 0.66±0.27| 0.66±0.27| 0.61±0.23                       |
| TG              | 0.05±0.16| 0.61±0.49| 0.85±0.26| 1.14±0.43| 1.05±0.36                       |
| Vestibular depth, mean±SD |          |         |          |          |                                  |
| CG              | 1.36±0.47| 2.29±0.48| 2.29±0.48| 3.43±0.60| 2.07±0.78                       |
| TG              | 1.29±0.48| 2.57±0.53| 3.07±0.60| 4.64±0.47| 3.57±0.78                       |

**Table 3: Comparison of patients satisfaction scores after macro and microsurgical techniques**

| Procedures         | Mean±SD | P    |
|--------------------|---------|------|
| Vestibular deepening | 8.57±0.97| <0.0001 |
| Frenectomy         | 11.29±1.38 | 0.001 |
| Frenotomy         | 12.57±1.90 | 0.04 |

**Table 4: Comparison of duration of surgery after macro and microsurgical techniques**

| Procedures         | Mean±SD | Percentage mean change | P   |
|--------------------|---------|------------------------|-----|
| Vestibular deepening | 86.43±5.56| 30.6                  | <0.001 |
| Frenectomy         | 23.86±2.91 | 38.8                  | <0.001 |
| Frenotomy         | 17.00±3.06 | 24.2                  | 0.146 |
in microgroup. Only the results of the control group of our study could be compared with the previous studies because microsurgical approach was not conducted in vestibular deepening procedures. Our study is comparable with the study Bergenholtz A et al. who attained 2.1 mm increase in VD.

Like the clinical results, patients rated microsurgery better than macrosurgical procedures. Less postoperative pain and discomfort encountered in the microsurgical group might be due to increased precision in the delivery of surgical skills which resulted in more accurate incision by finer instruments, less trauma, and quick postoperative healing. Concerning duration of surgery, the percentage mean change in the duration of surgery in vestibular deepening, frenectomy and frenotomy procedures conducted by microsurgical approach was 30.6%, 38.8%, and 24.2% longer than macrogroup. These findings were comparable with the study of Burkhardt and Lang who observed mean operation time in test sites (72 ± 8 min) i.e., 40% longer than in the control sites (51 ± 5 min). In spite of extended operation time in microsurgical group, high precision technique resulted in better wound healing in the present study. Moreover, this factor might not compensate the beneficial treatment effects of microsurgical technique.

CONCLUSION

Microsurgical technique provides a significant increase in degree of vascularization as compared to macrosurgical technique. Regarding clinical parameters in vestibular deepening procedure increase in width of attached gingiva was found statistically significant in both the groups while increase in VD was statistically significant in microsurgical group. Regarding “satisfaction criteria” patients rated microsurgical technique better than macrosurgical technique.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

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