

The use of stereophotogrammetry in oral surgery: Measurement of area changes after secondary epithelization and grafting vestibuloplasties

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ABSTRACT

Objective: Stereophotogrammetry (SPT) is a method in which three-dimensional coordinates are calculated from multiple two-dimensional projections. The purpose of this study was to compare the surface area changes between the secondary healing and grafting vestibuloplasty techniques in the mandible by using a stereophotogrammetric technique (SPT).

Patients and Methods: Thirteen patients were included in this study: six patients were managed by using full-thickness skin or palatal mucosa grafts (two full-thickness palatal mucosal grafts and four full-thickness skin grafts); the remaining seven patients, who did not accept a second surgery for graft harvesting, underwent secondary epithelization vestibuloplasties. Postoperative changes of surgical areas were measured by using SPT.

Statistical Analyses: The Wilcoxon (intragroup comparisons) and Mann-Whitney U (intergroup comparisons) tests were used for analysis of data.

Results: In the grafting vestibuloplasty group, the surface area gain was statistically significant ($P < 0.05$). In the secondary epithelization vestibuloplasty group, there was no significant difference ($P > 0.05$), with even decrease of surface area being noted in some cases.

Conclusion: SPT is a valid method for measurement of intraoral soft tissue changes.

Key words: Photogrammetry, stereophotogrammetry, vestibuloplasty

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Preprosthetic surgery tries to create an oral environment that can support a prosthetic appliance, and it may be viewed as an essential part of prosthetic reconstruction.^[1] There are two primary reasons for altering the soft tissue of the denture-bearing area: to allow deepening of the flange area to increase the resistance to displacement forces, and to provide a stable soft tissue on which the dentures can rest.^[2]

Increasing the alveolar ridge height by soft tissue interventions (vestibuloplasty or mouth floor lowering) involves deepening of the vestibular sulcus by transpositioning of the soft tissues and/or detaching the muscle origins on the facial or lingual sides of the edentulous ridge. Healing occurs by

secondary epithelization or by soft tissue grafting (where the graft is spread over the exposed vestibular area and held in place with a splint).^[3,4] The change in height of the alveolar ridge is a 'relative' increase because the alveolar ridge is not directly changed.

Photogrammetry is defined as 'the art, science, and technology of obtaining reliable information about physical objects through processes of recording, measuring, and interpreting photographic images.'^[5,6] Stereophotogrammetry (SP) is a method in which three-dimensional co-ordinates are calculated from multiple two-dimensional projections.^[7] Body parts are very complex, and it is normally too difficult to perform measurements on them. Photogrammetry overcomes many of the difficulties and provides an alternative way of measurement. Experience from photogrammetric applications showed accuracies of $1/10$ – $1/3$ of a pixel, which corresponds to submillimeter accuracies in medical images.^[8]

The aim of this study was to compare the surface area changes between the secondary healing and grafting vestibuloplasty techniques by using a stereophotogrammetric technique (SPT).

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MATERIALS AND METHODS

Thirteen patients (mean age: 57.5 ± 11.7), who had problems of complete denture instability resulting from atrophy of the mandibular alveolus, were selected for this study. The first choice of treatment had to be an implant overdenture prosthesis, and this was recommended to all patients. However, some of the patients were not willing for this treatment. Autogenous soft tissue grafting vestibuloplasty for the mandibular anterior region was offered to these patients and six of them consented to the procedure. For the remaining seven patients, secondary epithelization vestibuloplasties were planned. Patients were fully informed about the procedures.

Vestibuloplasty technique

Secondary epithelization vestibuloplasties (Clark's technique^[9]) were performed for the seven patients who were not willing to undergo a second surgery for graft harvesting. If an epulis fissuratum was found in the sulcus, it was removed first. Then a supraperiosteal dissection was made from the mucogingival line down to the mental muscle. After a sufficient vestibular depth was achieved, the mucosal flap was sutured to the deepest point of the vestibular sulcus using resorbable sutures. A prefabricated splint was placed to protect the gained depth and was kept in place for 1 week with perimandibular ligatures.

The same technique was employed for grafting vestibuloplasties as well. However, a soft tissue graft was placed over the exposed tissue surface. Four full-thickness skin grafts that were obtained from the inner side of the upper arm and two full-thickness palatal mucosal grafts were used.

Determination of measurement area

Before the surgical procedure, the old dentures of all patients were relined and casts were made up from dental stone. All the impressions were obtained with same impression material (Cavex Outline Impression Paste, Holland). In the first postoperative week, the dentures were replaced into the mouth and the surgical margins of the vestibuloplasty incisions were marked on them. These points were transferred to the preoperatively made casts by using the dentures. Between these points, the margins of the denture were outlined on the cast with a pencil. This line determined the measurement area's lower margin. The upper margin was settled by a line drawn along the top of the alveolus on the cast. These two transverse lines were connected by drawing two vertical lines from both ends of the lower margin [Figure 1]. New dentures were made for all patients in about the sixth postoperative week. The same procedure was repeated using new dentures and new casts 8 months after the operation. In this repeat procedure, the borders of the measurement areas were determined by using the old upper margins' lengths as a reference. All patients

were invited for periodic follow-up visits for adapting the margins of the prostheses to the operation sites recreated over 8 months.

SP technique

Images of the models were taken from several angles to make all points visible on two or more images. A Nikon COOLPIX™ 950 digital camera (image size: 1600×1200 pixels, pixel size: $6 \mu\text{m}$) was used. For photogrammetric restitution, a framework that forms a point network was constructed. The X and Y coordinates of the ground control on this framework were measured with a Zeiss Jena photogrammetric instrument that had a precision of $\pm 10 \mu\text{m}$. The Z coordinates of these points were obtained with a mechanical caliper that had 150 mm measuring span and a precision of $\pm 50 \mu\text{m}$. For the digital photogrammetric restitution, Pictran® software (Technet GmbH, Berlin, Germany) was used. Measurements of object points were done by using at least three images. To produce a digital model of the areas, three-dimensional coordinates of about 60 points were measured. After these points were coordinated in the Pictran® software, the areas were calculated based on these coordinates [Figure 2].

RESULTS

Grafted patients had less postoperative pain and faster healing. Donor site healing was completed in approximately 6 weeks in the palatal mucosa harvesting areas. Skin graft harvested patients had no significant morbidities except for excessive pigmentation in some cases. Denture borders needed fewer adjustments in grafting patients because soft tissue contraction was less than in the secondary healing vestibuloplasty group.

Data of measurement areas for both groups are shown in Tables 1 and 2. Analysis of data was done with the Wilcoxon test (intragroup comparisons) and the Mann-Whitney U test (intergroup comparisons). In the grafting vestibuloplasty group, surface area gain was statistically significantly

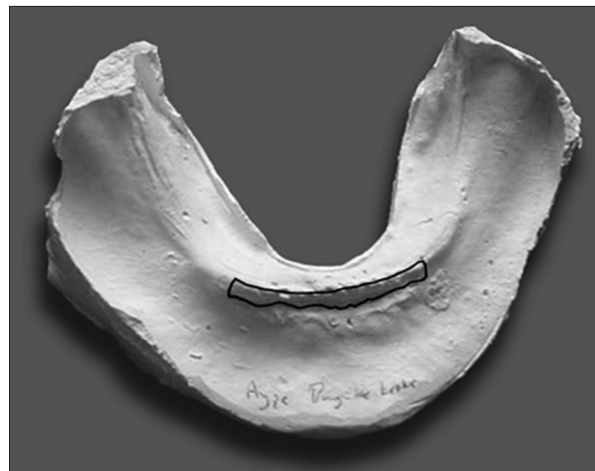


Figure 1: The measurement area marked on the model

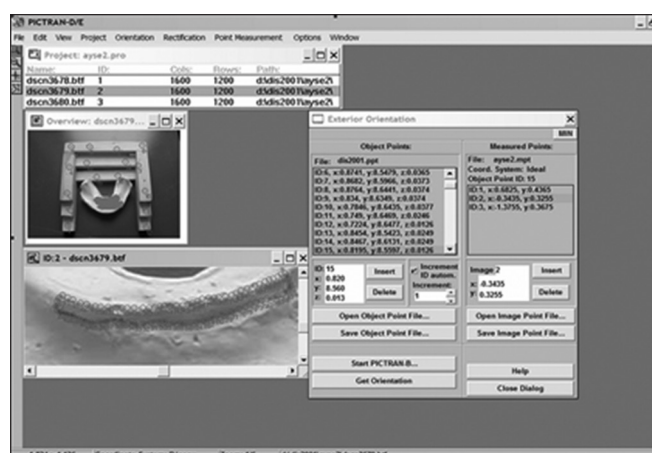


Figure 2: Obtaining of real three-dimensional space coordinate values: a screenshot from the software used in this study

Table 1: Results of measurement area of grafting vestibuloplasty (mm²)

Patient No.	Preoperative	Postoperative
1	185.55	221.37
2	142.23	249.45
3	128.22	293.27
4	206.99	459.11
5	188.64	367.85
6	223.01	354.40

Table 2: Results of measurement area of secondary epithelization vestibuloplasty (mm²)

Patient No.	Preoperative	Postoperative
7	79.38	65.56
8	387.22	346.36
9	90.37	74.08
10	438.63	367.90
11	131.00	146.98
12	182.18	201.09
13	237.58	242.85

($P < 0.05$). In the secondary epithelization vestibuloplasty group, there was no significant difference ($P > 0.05$), with even decrease of surface area noted in some cases.

DISCUSSION

It is difficult to fabricate a dental prosthesis for severely atrophic alveolar ridges. Dental implants can solve this problem with fixed or overdenture prostheses. However, they may not be applicable in some cases. Vestibuloplasty can be a treatment alternative, although the outcomes will not be as satisfactory as implant-supported prostheses.

It has been now accepted that the best results in vestibuloplasty procedures can be achieved by grafting techniques. Secondary epithelization vestibuloplasty methods are now widely abandoned since they could result in losing of the distance gained in the long-term and because they are associated with a long and painful healing period. Although there is no consensus as yet, autogenous graft materials are generally preferred. The most frequently used graft materials

are mucosa,^[10] full-thickness and split-thickness skin, and dermal grafts.^[11] Amnion, cultured epithelial cell grafts,^[12,13] solvent-preserved dura mater, and fascia lata grafts^[10] have also been used in vestibuloplasty operations.

There have been many studies about the long-term outcomes of the methods or of the graft materials. One of the most important criteria considered in these studies is whether the denture-bearing area that was increased with surgery could be protected. Most researches designed for this purpose are based on clinical measurement of the alveolar crest height from different points.^[14] Although one may reach quite correct results by using this method, contractions that have occurred in the areas between the measurement points might be overlooked.

Photogrammetry is the process of obtaining measurements by using photographs, while SP refers to the particular case where two or more cameras are used to take three-dimensional information of a scene.^[15] In this study, the accuracy of points that were obtained from photogrammetric method and used for area calculation was in the range stated by Patias^[8] (i.e., $\frac{1}{10}$ – $\frac{1}{3}$ of a pixel), which was quite satisfactory for our purpose. Therefore, we suggest that the use of SPT can give more accurate results about the postoperative stability of the vestibuloplasty.

In researches related to geological and architectural structures, the term 'photogrammetry' was used to refer to three-dimensional reconstructions from two-dimensional images. The use of the term continued when the technique was used in medical applications.^[15,16] the stereophotogrammetric platform usually consists of two or more cameras that capture images of the subject simultaneously, or one or more cameras that capture images sequentially, with the subject remaining in the same pose. Landmarks may be selected manually by clicking a mouse on homologous points on stereo images displayed on a computer monitor or by using image-processing algorithms.^[15]

Most of the medical photogrammetry applications relate to the determination of the volume and surface areas of the whole body or various body parts. It is not easy to perform manual or mechanical measurements on some areas of the body. The face is easily distorted by pressure on the soft tissues and some areas, particularly around the eyes, are very sensitive to touch. SP has been used on the face more often than on any other part of the body.^[16] The period of interaction with the patient is shorter for indirect measurements, and these methods are therefore also less dependent on patient behavior and the need for the patient to keep still for long periods. They are particularly helpful when children are being examined.^[17]

In preprosthetic surgical procedures, methods aimed to determine long-term stability are usually based on clinical

and radiographic assessments. However, the principles of SP are different and unique. The advantages of SP are:^[6,15,18]

- It works by using photographic images and does not harm hard or soft tissues in any way.
 - It has the capacity of displaying surfaces that have not a certain shape or untouchable and it can also make computations on them.
 - There is no radiation exposure for the patient.
 - It is possible to collect objective data about changes of the body's shape by using the same coordinate system and the points calculated in different periods.
- The disadvantages of SP are:^[6,15,18]
- Metric cameras and analysis devices are rather expensive and are not easily available. The size and cost of the equipment may prevent its clinical use.
 - If taking of the photographs and analyses are performed in different centers, the cooperation between the analysis expert and the clinician will be difficult.

We conclude that surface area gain is more stable in grafting vestibuloplasty, and SP is a suitable technique for measuring surface changes of soft tissues. Using SP can help to arrive at more objective results, and it can be used to assess the results of oral surgical procedures.

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