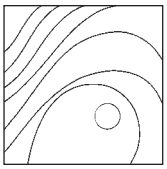
Analysis of Socket Preservation Using Polylactide and Polyglycolide (PLA-PGA) Sponge: A Clinical, Radiographic, and Histologic Study



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The aim of this study was to evaluate the extraction socket healing and dimensional changes following alveolar ridge preservation using polylactide and polyglycolide (PLA-PGA) sponge. Fifteen patients were selected for alveolar socket preservation immediately following tooth extraction. Monoradicular maxillary and mandibular teeth were evaluated. The selected sockets had intact sockets walls with a minimum of 7 mm of residual alveolar bone height. The test sites were thoroughly debrided and grafted with PLA-PGA sponge, while the control sites underwent natural healing. Computed tomography (CT) measurements were taken at baseline and 6 months. After 6 months of healing, final CT measurements were performed, and trephine core biopsy specimens were obtained for histologic analysis. Implants were placed immediately after biopsy harvesting. All subjects completed the study, and all sites healed without adverse events and allowed for implant placement. The mean difference in socket height, width, and density after 6 months was statistically significantly higher in the test sites compared with control sites. Clinical measurement at the midbuccal site of the alveolar socket showed a mean loss of 2.45 ± 0.67 mm in the control group, compared with a mean gain of 1.28 ± 0.58 mm in the test group. All test sites showed minimal ridge alterations, and statistically significant differences were observed between the test and control sites with respect to bone composition and horizontal and vertical bone loss, indicating that PLA-PGA sponge is suitable for alveolar ridge preservation. (Int J Periodontics Restorative Dent 2014;34:e36–e42. doi: 10.11607/prd.1375)

The preservation of the extraction socket has been proposed as a means of controlling alveolar ridge resorption, preserving crestal buccal plate integrity, improving vital bone fill, and reducing the need for future ridge augmentation.[1–5] An ideal graft material placed in alveolar sockets prevents the volume reduction that often occurs following tooth extraction[6–8] and remains in situ until sufficient healing (bone formation) has occurred. Polylactide and polyglycolide (PLA-PGA) sponge (Fisiograft Ghimas) is a synthetic resorbable alloplastic material formed by 50–50 lactide–glycolide polymer.[9] This study clinically determined the resorption of the buccal and lingual alveolar crest and changes in socket height, width, and radiographically determined density from baseline to

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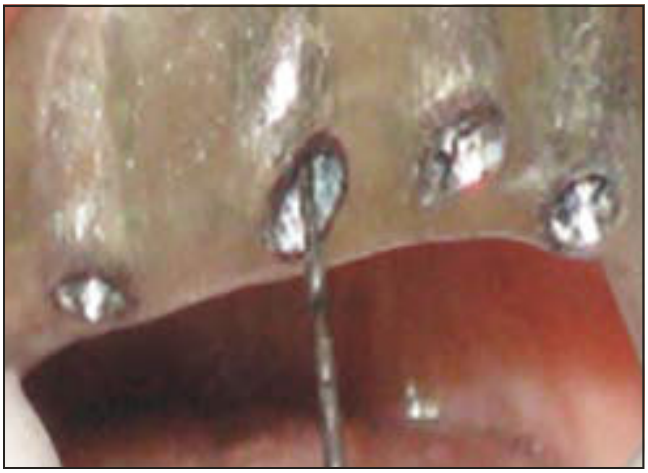

Fig 1 *Measurements taken on prefabricated surgical stent.*

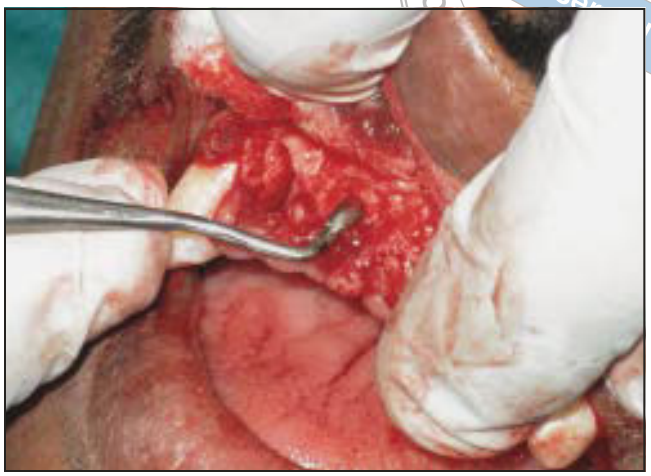

Fig 2 *PLA-PGA sponge is condensed up to the highest coronal point of the socket*

6 months using a computed tomography (CT) scan (Dentascan). Histologic examination after 6 months further confirmed the clinical and radiographic findings.

Method and materials

This study was conducted in the Department of Periodontology, Saraswati Dental College and Hospital, Lucknow, Uttar Pradesh, India. Permission from the local ethical committee was obtained, and written consent was acquired from all patients. After completing the initial therapy, 15 motivated, systemically healthy, compliant patients (8 women and 7 men between the ages of 20 and 45 years) were selected for the study. Alveolar sockets of maxillary or mandibular monoradicular teeth (14 central incisiors, 16 lateral incisors, 14 canines, and 16 premolars), indicated for extraction, were included. Multiple adjacent extractions as well as extractions next to saved teeth were included in the study. The inclusion criterion was at least 7-mm residual alveolar bone height as measured clinically and radiographically from periapical radiographs with intact socket walls.

The crowns of the teeth scheduled for extraction were eliminated from the cast models. Surgical acrylic resin stents were fabricated using cast models of the mouths of all patients. A hole corresponding to the central part of the alveoli was made in the acrylic resin stent. The grooves were marked using a long straight carbide bur at four locations (mesiobuccal [MB], midbuccal [MidB], distobuccal [DB], and midlingual [MidL]) on metallic sleeves of prefabricated acrylic resin stents (Fig 1). The same surgical stents were also used to harvest the biopsy specimens and to guide the implants.

After administering local anesthesia, the teeth were extracted atraumatically with the help of periotomes followed by debridement of the socket with surgical spoon curettes. Extraction sockets were randomly allocated for test and control groups by the toss of a coin into equal numbers. Thirty test sites were condensed up to the highest coronal point of the socket with a commercially available bioabsorbable PLA-PGA sponge (Fig 2), whereas 30 contralateral sites did not receive any graft material and served as the control group. To retain the graft material and to close the wound, cross-mattress sutures were given on both test and control sites to avoid tension from soft tissue to the wound area, with no attempt to achieve primary closure of the surgical wound. Patients were instructed to rinse with chlorhexidine digluconate 0.2% twice daily for a 2-week period. Antibiotic therapy

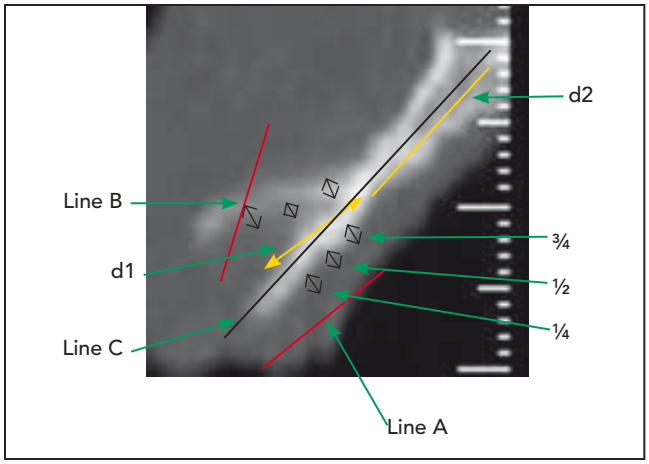

Fig 3 *Sagittal view of extraction socket for CT evaluation (line A is parallel to the palatal wall of the socket; line B is parallel to the buccal wall of the socket; line C bisects the center of the socket; d1 is the socket height; and d2 is the vertical distance from base of the socket up to the apical end of the basal bone).*

Fig 4 *Biopsy specimens harvested from the central part of sockets after 6 months (with suture tied at the apical end).*

(amoxicillin, 500 mg, three times daily) was given for 7 days, and an analgesic medication (ibuprofen, 500 mg) was prescribed in case of postoperative pain. The sutures were removed 1 week following the surgical procedure.

Baseline evaluations

Clinical measurements were taken to evaluate the distance between the four landmarks (mesiobuccal, midbuccal, distobuccal, and midlingual) marked on individually prefabricated stents and the buccal alveolar crest. The measurements were recorded using a UNC-15 periodontal probe (Hu-Friedy). The direction of the probe was guided by grooves on the metallic sleeve of the stent. Corresponding to those four locations marked on the metallic sleeve, the distance from the cornal extent of the stent up to the crestal plate was recorded.

CT scans (GE Medical System) were taken immediately after surgery (baseline). The following parameters were recorded in the reconstructed sagittal images (Fig 3): socket height, buccolingual width of socket at one-fourth, one-half, and three-fourths height of socket, mesiodistal width, and density. The density was recorded at the center of the socket at the apical, middle, and coronal third, as well as at the buccal, palatal, mesial, and distal walls of the socket.

Six-month procedures

Postoperative CT scans were obtained at 6 months prior to performing implant surgery. The socket height was calculated by subtracting it from the total distance, measured from the highest coronal part of the socket up to the apical end of the basal bone. Following local anesthesia, a full-thickness mucoperiosteal flap was elevated and clinical parameters were recorded with a prefabricated surgical stent. All sites had the required 4-mm ridge width to proceed with trephine core biopsies (Fig 4). For the socket height of 7 mm, as per the inclusion criteria, a surgical trephine (Stoma) with an internal diameter of 3 mm and length of 6 mm facilitated harvesting of 6 × 3 mm of newly formed bone from the central part of the preexisting sockets. The holes following the core harvesting were then enlarged and deepened to receive endosseous implants (Frialit-2, Dentsply). Tissue biopsy specimens harvested at osteotomy sites were sent for histologic examination. A suture was tied at the apical end of the biopsy specimens.

Histologic examination

The specimens were retrieved and stored immediately in 10% buffered formalin and processed to obtain thin ground sections with the manual Sentwin microtome (Shree Sati Scientific Industries). The specimens were sectioned longitudinally along the major axis with a high precision diamond disk on a hard tissue microtome to approximately 150 µm and then ground down on Arkansas stone using pumice powder and glycerin to approximately 30 µm. Slides were obtained for all samples, stained with toluidine blue and acid fuchsin, and viewed under microscopes at ×20 magnification. Histomorphometry to evaluate the percentage of mineralization was carried out using a histometry software package (Dewinter Biowizard version 4.1, Matrix Vision).

All observations were recorded by a single observer and subjected to statistical analysis. The statistical analysis of data was performed with a software program (SPSS, IBM). The values were represented in mean ± SD. A *t* test, paired *t* test, and bivariate correlation were used to determine statistical significance at a level of $P < .05$.

Results

Clinical parameters

All subjects reported uneventful healing at all sites (n = 60). The inference drawn from the results obtained depicts changes in crestal bone height after 6 months (Table 1). For both the control and test groups, the mean value change for crestal height after 6 months revealed resorption at all sites, except for MidB (–1.28 ± 0.58 mm) and MidL (–1.08 ± 0.64 mm) regions of the test group. In the control group, resorption was maximally observed in the MidB region (2.45 ± 0.67 mm), in contrast to a mean value change in the test group of –1.28 ± 0.58 mm for the same sites after 6 months. Furthermore, at MB and DB sites, the control group (1.85 ± 0.48 mm and 1.53 ± 0.54 mm, respectively) showed more resorption in crestal height compared with the test group (1.22 ± 0.47 mm and 1.33 ± 0.48 mm, respectively).

Table 1 Crestal height (mm) at baseline and 6 months

Group	Variable	Baseline Mean ± SD	6 mo Mean ± SD	*t*	*P*
Control	Mesiobuccal	7.52 ± 0.80	9.37 ± 0.91	–21.28	< .001
	Midbuccal	8.15 ± 0.89	10.60 ± 1.19	–19.91	< .001
	Distobuccal	7.74 ± 0.98	9.27 ± 1.02	–15.53	< .001
	Midlingual	6.68 ± 0.75	6.68 ± 0.75	0	> .999
Test	Mesiobuccal	7.55 ± 0.90	8.77 ± 0.96	–14.25	< .001
	Midbuccal	8.40 ± 0.84	7.12 ± 1.19	12.07	< .001
	Distobuccal	8.03 ± 0.97	9.37 ± 1.15	–15.23	< .001
	Midlingual	6.62 ± 0.85	5.53 ± 0.96	9.21	< .001

Radiographic parameters

In the control group, there was an increase in mean values for buccolingual width at one-fourth, one-half, and three-fourths and mesiodistal width of the socket, which were statistically significant 6 months postoperatively, except for socket height, where it showed a decrease in mean value (–1.33 ± 2.85 mm). However, in the test group, all of the above parameters, including socket height (2.04 ± 2.29 mm), revealed a statistically significant increase.

The CT results further indicated an increase in socket density at the apical (529 ± 335.3 HU), middle (515 ± 279.3 HU), and coronal third (518 ± 306.8 HU) of the socket in the test group after 6 months compared with the control site (218 ± 303.2 HU, 311 ± 322 HU, and 246 ± 246 HU, respectively). Further, in the test group, a statistically significant ($P < .01$) mean change was observed in the density of buccal (366.6 ± 294.9 HU), palatal/lingual (428.4 ± 376.3 HU), mesial

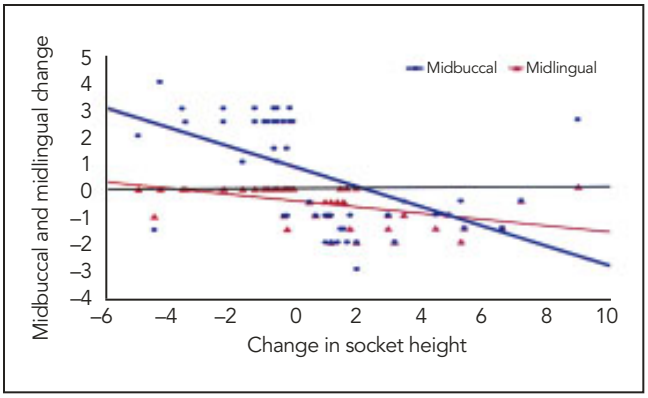

Fig 5 *Graph depicting a quantitative bivariate correlation between clinical and radiologic findings (for height only) between change in socket height and midbuccal and midlingual change.*

Fig 6 *Histologic slides from the regenerated sites after 6 months of healing.* (a) *Test specimens coronally show newly formed trabecular bone with marrow spaces and apically show more mature and compact bone.* (b) *Control specimens coronally show newly formed trabecular bone with large marrow spaces and apically show more mature and compact bone.*

(356.3 ± 249.7 HU), and distal (384.2 ± 259.1 HU) walls of the socket compared with the control group (21.1 ± 208 HU, 35.2 ± 383.7 HU, 33.1 ± 195.4 HU, and 70.3 ± 207.4 HU, respectively), where the mean change was nonsignificant ($P > .05$).

Correlation between clinical and radiologic results

In clinical as well as radiologic assessment, bone resorption was seen to be significantly higher in the control group. A quantitative bivariate correlation between clinical and radiologic findings was explored (for height only), as shown in Fig 5. The correlation between change in socket height and midbuccal ($r = –0.525$; $P < .001$) and midlingual change was found to be moderate ($r = –0.516$; $P < .001$).

Histologic findings

Histologic examination found that in both the test and control group specimens, the coronal part of the biopsy specimens consisted of newly formed trabecular bone with large marrow spaces (Fig 6). A more mature and compact bone was observed in the apical portion of the specimens from both the control and test groups. No particles of the grafted materials could be identified in the alveolar sockets on histologic examination.

Histomorphometric findings revealed that the mean value of mineralized tissues in the control group specimens with 2-mm increments for the coronal, middle, and apical third of the socket were 48.60%, 52.80%, and 69.0% respectively. For the test group specimens, the mean values were 60.80%, 64.40%, and 71.0%, respectively, for the coronal, middle, and apical third of the socket. The mean percentage difference between the two groups was smallest in the apical third of the socket.

Discussion

The resorption of the alveolar process following tooth extraction is significantly greater on the buccal aspect than the lingual or palatal, so that the reduction in width of the alveolar ridge is greater than the loss of height.[10,11] Hence, the shift in the paradigm from the fixed partial denture to the implant has placed a new emphasis on management of the extraction socket.[12]

This study evaluated the efficacy of PLA-PGA sponge in socket preservation. It was observed that

the grafted sockets healed with less bone resorption than the control sockets at the MidB, MB, and MidL portions. One possible explanation for this is that in the test sites, the sponge served as a supporting element to prevent the collapse of the surrounding soft tissues in the fresh extraction sockets once the teeth were avulsed. The mean value change was inversely related to the socket height; therefore, there was a decrease in socket height for the control group at all sites. Similar to the findings of Serino et al,[13] socket healing in the midbuccal portion revealed lesser resorption and, hence, buccal plate preservation over a period of 6 months in the test site (mean value change, –1.28 ± 0.58 mm) compared with control sites (mean value change, 2.45 ± 0.67 mm).

Socket height, width (both buccolingual and mesiodistal), and density change recorded using CT revealed that the mean value of the control group was significantly lower than that of the test group for all parameters, and this difference was statistically significant. This is important for future implant placement as the diameter of the implant to be inserted is an important criterion for overall success.[14,15]

The change in density of the socket (in HU) measured using CT was more evident in the apical part of the socket compared with the middle and coronal third in both the control and test sites. This can be correlated to the increased mineralization seen in the apical portion of the biopsy specimens in the test sites on histologic examination. In accordance with Cardaropoli et al,[10] this finding further proved that bone formation initiated from the old bone of the lateral and apical sockets walls toward the center of the wound. The most common failure observed was due to the collapse of the socket, which was more appreciable in the buccal wall of the maxillary anterior region. Also, it is noteworthy that lesser corticalized and thin maxillary buccal bone has a lower potential to regenerate the missing wall compared with mandibular bone.[13]

In contrast to the present study, Froum et al,[16] Artzi et al,[17] and Becker et al[18] showed the presence of particles from the grafted materials (bioactive glass and deproteinized natural bovine bone mineral) in the sockets 6 to 9 months following their insertion. Similarly, Araújo et al[19] also found residual grafted particles of xenograft at the central and marginal segments of the grafted socket that were coated by multinucleated cells. As suggested by Serino et al,[13] the degradation process of hydrolysis and hydrolytic mechanisms may result in resorption of PLA-PGA acids.[20,21] Also, PLA-PGA sponge formed by 50–50 lactide–glycolide polymer has the fastest degradation rate of the D–L lactide/glycolide materials, with the polymer degrading in approximately 50 to 60 days.[9]

CT findings revealed that the bone in the apical portion of the biopsy specimens (corresponding to a depth of approximately 3 mm from the bone crest) was dense, with few marrow spaces. In the coronal part of the specimens, the bone was well structured with no signs of ingrowth of tissues other than bone; the sponge may be functioning as a barrier to the ingrowth of surrounding tissue that could have impeded the process of bone regeneration.[22] Furthermore, following the extractions and suturing, the consistency of the material retained the buccal and lingual flaps in their original positions, while this was not always the case in the control sites, where the gingival flap collapsed into the alveolar sockets. Also, since the sponge had a substantial consistency that made it possible to trim and shape it to the alveolar socket, once dampened with sterile saline water for 3 minutes it could be handled and compressed without applying too much pressure.[22]

A surgical trephine was used to harvest bone for histologic examination and implant site preparation. The direction of the trephine bur was guided by the prefabricated stents. The metal sleeves were placed around the holes that were made in the stents to prevent distortion at the time of osteotomy. The single observer who retrieved all specimens experienced more resistance, in terms of pressure applied, for the test site. This could be due to the increased mineralization and bone density observed in the apical portion of the healed test site.

A socket located within the maintained dentition (a socket between two teeth), where the interproximal bony peaks are maintained, may heal differently from a socket between two extraction

sockets, where the peaks may not be maintained. Extraction sockets in the maxillary and mandibular arches may also heal differently. Nevertheless, in this study, contralateral tooth sockets were selected for both test and control sites; hence, the total number of each tooth type was similar in both groups. Further limiting the study to seek almost identical tooth sockets could have resulted in a statistically significant reduction of the sample size. In addition, similar healing patterns are difficult to ascertain even in identical sockets. Hence, future research should be carried out with intra-arch identical tooth sockets to obtain more defined results.

Conclusion

Within the limitations of this study, it could be concluded that alveolar bone resorption following tooth extraction was prevented and new bone formation was enhanced with the use of a bioabsorbable synthetic sponge of polylactide-polyglycolide acid for socket preservation in humans. This was substantiated by clinical, radiographic, and histologic examinations.

Acknowledgment

The authors reported no conflicts of interest related to this study.

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