Alveolar regeneration of the post-extraction site with cortical deficiency using the Lamina Socket Sealing technique: A retrospective study with clinical and radiographic analysis. Part 1/2

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Abstract: Purpose: This retrospective observational study aims to evaluate the outcome of a new alveolar ridge preservation (ARP) technique, "Lamina Socket Sealing" (LSS) technique, using a porcine barrier. **Methods:** 36 subjects with maxillary premolars to be extracted and extensive alveolar wall defects were enrolled and treated. Porcine-derived barriers and mesenchymal membrane were used to seal the extraction socket with alveolar particulate graft. The outcome variables were: radiographical bone changes and clinical outcomes. **Results:** 36 subjects, 21 females and 15 males were treated. The change in mm (mean + SE) of horizontal ridge width from baseline to 4 months after surgery at the coronal level of the alveolus was +1.25 ± 0.20 mm (P< 0.05), mean level was +0.34 ± 0.1 mm (P< 0.05) and at the apical level was +0.08 ± 0.17 mm (P> 0.05) which was not statistically significant. The buccal and palatal height changes in mm (mean + SE) from baseline to 4 months after surgery were respectively 1.21 ± 0.17 mm for the buccal wall (P< 0.05) and 1.06 ± 0.24 mm for the palatal wall (P< 0.05). The bone volume of all sites allowed for the placement of the planned implants. (*Am J Dent* 2024;37:4A-8A).

Clinical significance: The alveolar ridge preservation technique (Lamina Socket Sealing) using resorbable heterologous cortical lamina with flapless approach allowed not only the preservation of the damaged post-extraction socket, but also minimal ridge augmentation, according to the principles of guided bone regeneration.

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Introduction

Remodeling of alveolar bone and soft tissue is a normal physiological response to tooth extraction, but it can be influenced by several factors, such as infection at the extraction site, periodontal disease, buccal bone thickness, and alveolar wall integrity or damage.[1]

Alveolar ridge preservation (ARP) is defined as a procedure performed after extraction to minimize resorption of the alveolar ridge and maximize bone formation within the socket.[2] ARP techniques may include the placement of different grafting materials, with or without the use of membranes.

Typically, the healing process following extraction of a tooth results in more resorption on the buccal side of the alveolar ridge than the lingual/palatal counterpart and consequently, the residual alveolar ridge will assume a more lingual/palatal position.[3] However, complete preservation and regeneration of the bone volume after tooth extraction has not been reported, especially in compromised sites with partial or complete loss of the buccal bone plate, despite these deficient sockets.[4]

Resorbable cortical bone barriers of heterologous (porcine) origin have been used primarily with xenograft for guided bone regeneration (GBR)[5-7] and have also been studied in ARP, again in addition to xenograft, with promising results.[8] In addition, Barone et al[9] showed promising results in turnover of new bone while preserving ridge size in alveoli with wall defects.

This study evaluated the clinical and radiographical outcomes of a new technique for ARP, "Lamina Socket Sealing" (LSS), using a porcine cortical barrier and resorbable mesenchymal membrane with particulate socket graft.

Materials and Methods

Setting and study population - This study is an observational retrospective study. The participants in this study were selected and treated between February 2019 and October 2022 with ARP procedures.

The study was conducted in full compliance with the ethical principles expressed in the Helsinki Declaration of 1975, as revised in 2013. Informed consent to the study, data analysis, and documentation were given to all participants before the start of the research project. The Ethics Committee of the Agostino Gemelli University Hospital Foundation IRCCS approved this study, (Protocol number 0004468).

Inclusion criteria - (1) Over 18 years of age, (2) in need of one upper premolar extraction, (3) in need of implant treatment, (4) all extraction sites had at least one adjacent tooth, (5) wall fenestrations or defects, into at least one alveolar wall, evaluated on a previous CBCT and classified following Kim et al,[10] "Type II" (three-walled bone defect with buccal or palatal/lingual wall resorption and no soft tissue recession) or "Type III" (same bone resorption characteristics, but with soft tissue recession).

Exclusion criteria - (1) general contraindications to surgery, (2) taking a long-term non-steroidal anti-inflammatory, corticosteroid, bisphosphonate or immunosuppressant therapy, (3) history of radiotherapy, malignancy or chemotherapy for

malignancy in the head and neck area within the last 5 years, (4) uncontrolled metabolic diseases, (5) blood-related diseases, (6) pregnancy and nursing period, (7) uncontrolled periodontal disease, (8) presence of sites with acute inflammation that cannot be resolved at the time of extraction (e.g., abscess, phlegmon), (9) absence of dental occlusion in the arch opposite to the area of the extractive site, (10) cigarette consumption > 10 per day, (11) reluctance to undergo follow-up visits.

Data measurements - Demographic information, and medical and dental anamnesis were recorded at the first visit. The collected data were analyzed retrospectively by evaluating the clinical examination, photographs, and radiographic records. The diagnosed indications for tooth extractions were deep or root caries, root fracture, endodontic complication, root resorption, and sequelae of periodontal disease.

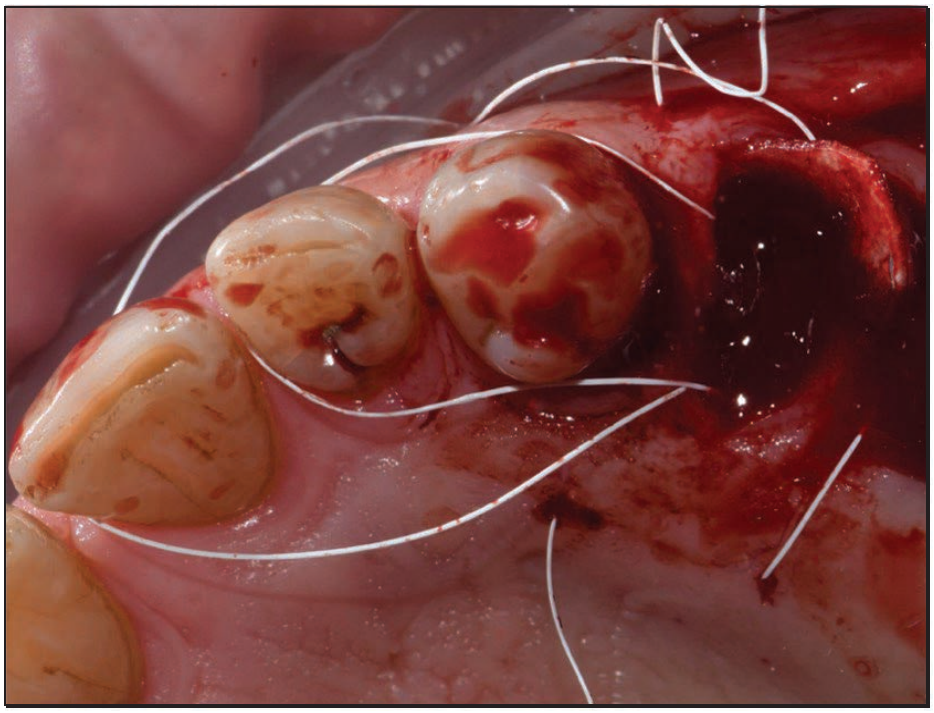

Fig. 1. Pre-embedded sutures anchored to adjacent dental elements to avoid interference after LA and membrane stabilization.

Participants were expected to have a full-mouth plaque score (FMPS) and full-mouth bleeding score (FMBS) below 15%. In addition, they were included in a periodical oral hygiene program and required to have professional oral hygiene sessions at least 2 weeks before surgery.

At baseline, cone beam computed tomography (CBCT) (Pax-i3D Smart,[a] 50-99 kVp/4 - 16 mA) examination and optical scan (Trios 3[b]) of the dental arches were performed.

The occurrence of adverse events (e.g., wound infection, soft tissue dehiscence, or necrosis) was registered at Weeks 1 and 2 and at Months 1, 2, and 4 after surgery.

Surgical procedure - Prior to extraction, all subjects rinsed with chlorhexidine mouthwash 0.20% for 1 minute (Curasept ADS[c]) and the surgical area was carefully anesthetized using an infiltrative technique (mepivacaine 20 mg/ml + adrenaline 1: 100,000[d]).

"Lamina Socket Sealing" - The teeth were extracted in the least traumatically possible way without mucoperiosteal flap elevation, using fine luxators and forceps and avoiding buccolingual movements to prevent further damage. The piezoelectric tips "extraction kit"[e] was utilized to facilitate extraction or to section the tooth.

Afterward, the socket was gently treated with an alveolar curette to remove all granulomatous tissue and irrigated with iodopovidone solution (10%). The internal marginal gingiva of the socket was de-epithelialized with a diamond bur under copious irrigation. The mucoperiosteum around the socket was detached with periodontal microsurgical instruments[f] to create an envelope, up to 3 mm apically, to the dehiscent wall. The alveolus was filled with particulate graft (OsteoBiol GTO[g]). Then a soft cortical porcine lamina (LA) (OsteoBiol Lamina,[g] thickness 0.6 mm,) contour was assessed using its sterile foil wrapping as a surgical template, tested and cut to the correct size to cover the socket and shaping dehiscent wall. The sutures (4-0 PTFE, Perma Sharp Sutures[f]) were pre-embedded and anchored to adjacent dental elements to avoid interference after LA and membrane stabilization (Fig. 1). Therefore, LA was trimmed following the previously prepared surgical template. Then, it was inserted under the periosteum and overlayed in close contact with the remaining bone walls of the mesial and distal alveolar ridge. A resorbable mesenchymal membrane (OsteoBiol Evolution,[g] thickness 0.5 ± 0.1 mm) was placed over the LA with the rough side facing the soft tissues. Finally, sutures were knotted to stabilize the membranes, and wound margins were left to heal by the second intention.

Post-operative procedures - All subjects were given verbal and written post-operative instructions and instructed to rinse with chlorhexidine 0.12% mouthwash twice daily for 14 days. In addition, subjects were asked to avoid mechanical tooth brushing in the healing area during this period.

An antibiotic (amoxicillin/clavunate, 1 gram every 12 hours for 7 days or, in case of penicillin allergy, azithromycin 250 mg for 4 days) and an anti-inflammatory drug (600 mg, ibuprofen, every 12 hours for 3 days) were prescribed to all participants.

Subjects were recalled after 7 days for a first follow-up visit and 14 days after extraction for suture removal. In the follow-up period, subjects were revisited at months 1, 2, and 4 after extraction, when a new optical digital impression was taken, and follow-up CBCT was performed, which is also necessary for the next phase of implant site rehabilitation.

Linear measurements on CBCT images - Four months after extraction, CBCT (Pax-i3D Smart, 50-99 kVp/4 - 16 mA) of each subject enrolled in the study was obtained. The data obtained were converted into Digital Imaging and Communications in Medicine (DICOM) format and imported into open-source software (Slicer 4.11[h]) for 3D image or pro-

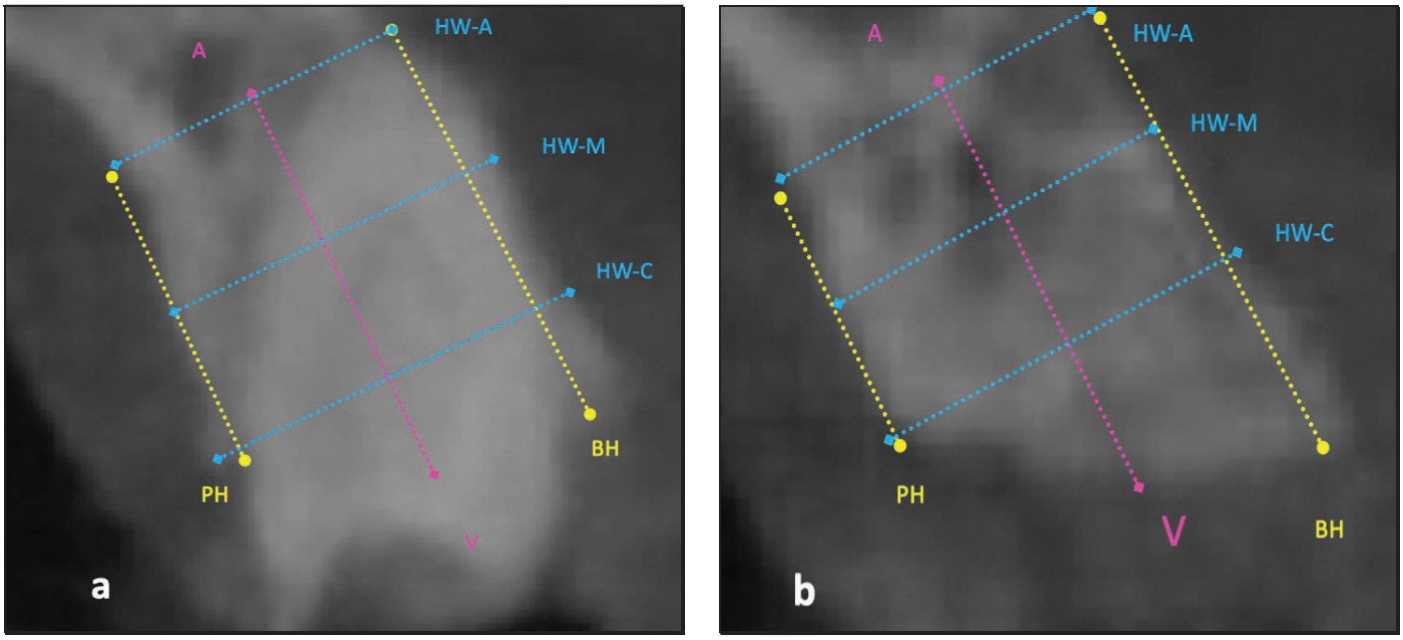

Fig. 2. Linear measurements on CBCT (a, b). Horizontal (H, pink) and vertical (V, pink) reference line and most apical point (A, pink) of the alveolus. (a) Palatal (PH, yellow) and buccal (BH, yellow) bone ridge height; horizontal ridge width identified by a horizontal line passing from the most coronal point of the vertical lines crossing the buccal or palatal walls and intersecting them orthogonally (HW-C, light blue), the same applies to the apical line that starts from the most apical point of the alveolus (HW-A) and between these two lines another horizontal line is placed in the middle (HW- M) at baseline. (b) Palatal (PH, yellow) and buccal (BH, yellow) bone ridge height at follow-up; coronal horizontal ridge width (HW-1, light blue), apical (HW-3), and middle width (HW-5) at 4-month follow-up.

cessing. Each subject's DICOM files at baseline and at the 4-month follow-up were imported into the software and overlaid using anatomical landmarks where no changes had occurred during the follow-up period (e.g. the palatal vault, the anterior posterior nasal spine, present teeth or the border and lower corner of the mandible). Once the images were superimposed, a manual check was performed to ensure that they matched perfectly.

Linear measurements on the CBCTs were performed similarly as previously described,[11] at baseline (T1) and at the 4-month follow-up (T2) adapting the reference points and lines to the cases undergoing surgery, where there is alveolar wall compromise.

A vertical reference line was drawn in the center of the socket, crossing the apical landmark, i.e., in line with the most apical point of the extractive socket defined on the preoperative CBCT. Two horizontal reference lines were drawn perpendicular to the vertical line, crossing the most coronal portion of the palatal/buccal bone crest and the most apical point of the extraction socket.

Subsequently, the following parameters were recorded:

1. Buccal (BH) and palatal (PH) bone ridge heights were measured, parallel to the vertical line, on a line drawn from the projection of the residual distal and mesial bone peaks at baseline and at the 4-month follow-up.
2. The horizontal width of the alveolar ridge was measured through three horizontal lines (Fig. 2).

The most coronal line originates from the most coronal point identified as the vertical lines that pass through the buccal or palatal walls and cross them both orthogonally (HW-C). The same applies to the apical line that starts from the most apical point of the alveolus (HW-A). Between these two lines, another horizontal line is placed in the middle (HW-M). Measures were taken at baseline and the 4-month follow-up (Fig. 2).

Descriptive statistics included the mean and standard deviation values at baseline and after 4 months. The outcome of interest was the radiographic extent of vertical and horizontal bone resorption measured on CBCT images (BH, PH, HW-A, HW-M, HW-C).

Statistical analysis - Continuous variables were presented as mean ± standard deviation (standard error for differences), and qualitative variables were described as absolute and relative frequencies.

In the statistical analysis, the alveolus was considered as the statistical unit, and a comparison of variables was made between baseline and at 4 months. Considering the non-normal distribution (Shapiro-Wilk test) and small sample size, Wilcoxon's paired-sample signed ranks test was used for within-group comparison; the significance threshold was set at $P< 0.05$. Statistical analysis was performed with R statistical software.[i]

Results

Thirty-six recruited subjects were included (age range 39-68 years); 21 females (58.3%) and 15 males (41.7%). Fifteen teeth in this study were extracted because of crown/root fractures (41.7%), nine due to destructive carious lesions (25%), and 12 due to periodontal reasons (33.3%).

Each subject underwent a single upper premolar extraction, totaling 12 single root and 24 bi-radicular teeth.

All the surgeries were successfully carried out and no intraoperative complications were recorded. None of the subjects presented biological complications and/or signs of periapical radiolucency at 4 months after surgery.

The change in mm (mean + SE), of the horizontal ridge width from baseline to 4 months after surgery at HW-C was +1.25 ± 0.20 mm (+13.6%) (P< 0.05); at HW-M was +0.34 ± 0.1 mm (+3.1%) (P< 0.05); and HW-A was +0.08 ± 0.17 mm (+0.62%) (P> 0.05) not statistically significant.

The buccal and palatal height changes in mm (mean + SE) from baseline to 4 months after surgery were respectively 1.21 ± 0.17 mm (+10.9%) for the buccal wall (P< 0.05) and 1.06 ± 0.24mm (+9.7%) for the palatal wall (P< 0.05). The bone volume of all sites allowed for the placement of the planned implants.

Discussion

The LSS technique appears to be effective in maintaining bone and soft tissue volumes even in the presence of partially dehiscent buccal walls, with even a minimum bone augmentation at PH, BH, HW-M, and HW-C.

Because of the mechanical properties of the LA, it could be superior to conventional collagen membranes in cases with greater needs for stabilizing the defect and inhibiting soft tissue ingrowth, thereby enhancing ridge regeneration.[12]

Amr et al[13] compared horizontal ridge regeneration using an autologous block graft and a porcine cortical lamina graft. Clinically, radiographically, and histomorphometrically, no statistically significant differences were found between the two groups regarding increased bone volume; therefore, cortical lamina might be an alternative to autogenous block bone grafting.[13]

Festa et al[8] conducted a study on ARP with porcine cortical lamina. In this clinical study with a split-mouth design, 15 extractive alveoli were treated using a porcine-derived collagenic xenograft (OsteoBiol Gen-Os) in association with LA, while the corresponding extractive sites were allowed to heal without grafting. After 6 months, a horizontal ridge reduction of 18.3% was observed in the ARP-treated sites and 37.3% in the extraction-only sites, with a significant difference of 2 mm. Vertical ridge changes were minimal for the ARP group (-0.6 ± 1.4 mm mid-buccal) compared with controls (-3.1 ± 1.3 mm mid-buccal). The study concluded that using a porcine bone substitute and a thin porcine cortical membrane significantly reduced ridge size changes after tooth extraction. In addition, the surgical procedure in which the LA was inserted, overlapping the bone defect may have promoted a greater bucco-lingual width per bone augmentation procedure.[14]

Regarding the regenerative potential of vestibular defects, Barone et al[9] reported that buccal bone deficiency of the anterior region was treated using the flapless technique, porcine xenografts, PRF, and collagen membrane. For hard tissues, an increase in height was reported, also related to overfilling.

The use of the lamina as a vestibular barrier allows, therefore, inhibition of the osteoclastic activity of the vestibular periosteum, as suggested by Nguyen et al.[15] In their study, they used a vestibular-stabilized d-PTFE membrane at the post-extraction socket, achieving not only preservation but also increased thickness and height augmentation from the bottom of the alveolar defects and not only from the mesial and distal projections of the remaining bone. However, LA has the advantage of no reintervention for removal, thus with a less surgical insult to the site and less morbidity for the patient.

Given the high heterogeneity among studies in the literature in terms of socket morphology, biomaterials, surgical technique, and healing period, caution is needed when comparing results.

Within the limits of this study, the Lamina Socket Sealing technique, using a porcine-derived barrier, appears to be a promising technique for ARP in cortical alveolar defects. Its strengths are simplicity of execution, less surgical insult, and the possibility, in addition to maintaining the volume, of being able to increase it according to the principles of GBR. In addition, it will be interesting to measure bone.

Further studies are needed to confirm these results by comparing them with those of other established techniques and with long-standing studies to support them.

a. Vatech, Hwaseong, Korea.
b. 3Shape, Copenhagen, Denmark.
c. Curasept S.p.A., Saronno, Italy.
d. Pierrel S.p.A., Capua, Italy.
e. Mectron, Carasco, Italy.
f. Hu-Friedy, Chicago, IL, USA.
g. Tecnoss, Giaveno, Italy.
h. Slicer, www.slicer.org.
i. Foundation for Statistical Computing, Vienna, Austria.

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References

1. Avila-Ortiz G, Chambrone L, Vignoletti F. Effect of alveolar ridge preservation interventions following tooth extraction: A systematic review and meta-analysis. *J Clin Periodontol* 2019;46:195-223.
2. Darby I, Chen S, De Poi R. Ridge preservation: What is it and when should it be considered. *Aust Dent J* 2008;53:11-21.
3. Araujo M, Linder E, Lindhe J. Effect of a xenograft on early bone formation in extraction sockets: An experimental study in dog. *Clin. Oral Implants Res* 2009;20:1-6.
4. Nevins M, Camelo M, De Paoli S, Friedland B, Schenk RK, Parma-Benfenati S, Simion M, Tinti C, Wagenberg B. A study of the fate of the buccal wall of extraction sockets of teeth with prominent roots. *Int J Periodontics Restorative Dent* 2006;26:19-22.
5. Carinci F, Ormianer Z, Lauritano D. The use of resorbable cortical lamina and micronized collagenated bone in the regeneration of atrophic crestal ridges: A surgical technique. Case series. *J Biol Regul Homeost Agents* 2016;30:81-85.
6. Wachtel H, Fickl S, Hinze M, Bolz W, Thalmair T. The bone lamina technique: A novel approach for lateral ridge augmentation - A case series. *Int J Periodontics Restorative Dent* 2013;33:491-497.
7. Rossi R, Rancitelli D, Poli PP, Rasia Dal Polo M, Nannmark U, Maiorana C. The use of a collagenated porcine cortical lamina in the reconstruction of alveolar ridge defects. A clinical and histological study. *Minerva Stomatol* 2016;65:257-268.
8. Festa VM, Addabbo F, Laino L, Femiano F, Rullo R. Porcine-derived xenograft combined with a soft cortical membrane versus extraction alone for implant site development: A clinical study in humans. *Clin Implant Dent Relat Res* 2013;15:707-713.

9. Barone A, Ricci M, Romanos GE, Tonelli P, Alfonsi F, Covani U. Buccal bone deficiency in fresh extraction sockets: A prospective single cohort study. *Clin Oral Implants Res* 2015;26:823-830.
10. Kim JJ, Ben Amara H, Chung I, Koo KT. Compromised extraction sockets: A new classification and prevalence involving both soft and hard tissue loss. *J Periodontal Implant Sci* 2021;51:100-113.
11. Jung RE, Philipp A, Annen BM, Signorelli L, Thoma DS, Hämmerle CH, Attin T, Schmidlin P. Radiographic evaluation of different techniques for ridge preservation after tooth extraction: A randomized controlled clinical trial. *J Clin Periodontol* 2013;40:90-98.
12. Fischer KR, Götz W, Kauffmann F, Schmidlin PR, Friedmann A. Ridge preservation of compromised extraction sockets applying a soft cortical membrane: A canine proof-of-principle evaluation. *Ann Anat* 2020; 231:151524.
13. Amr AEH, Abdel Ghaffar KA, Abuel-Ela HA, Abd Elhamid ES. Xeno-genic flexible bone lamina graft: A successful alternative to the autogenous onlay bone block graft in alveolar ridge augmentation: A clinical, radiographic and histological evaluation. *J Dent Treat Oral Car* 2017;1:104.
14. Assaf JH, Assaf DD, Antoniazzi RP, Osório LB, França FM. Correction of buccal dehiscence during immediate implant placement using the flapless technique: A tomographic evaluation. *J Periodontol* 2017; 88:173-180.
15. Nguyen V, von Krockow N, Pouchet J, Weigl PM. Periosteal inhibition technique for alveolar ridge preservation as it applies to implant therapy. *Int J Periodontics Restorative Dent* 2019;39:737-744.