

Is alveolar ridge preservation (socket grafting) an effective therapy to preserve physiologic bone loss after tooth extraction?

Johan Hartshorne¹

Summary

Systematic review conclusion: Alveolar Ridge Preservation (ARP) is an effective therapy to prevent physiologic bone loss after extraction of non-molar teeth, in both the horizontal and the vertical dimension, as compared to tooth extraction alone.

While in certain cases ARP could result in the maintenance of sufficient bone volume to place an implant in an ideal restorative position without the need of alveolar ridge augmentation procedures, it may not be sufficient in other clinical cases

Critical appraisal conclusion: The evidence from this review showed that ARP has a clinically significant effect on preserving horizontal and vertical dimension of the alveolar bone following extraction of non-molar teeth. However, no evidence has been produced whether ARP provides adequate alveolar ridge volume for successful implant placement and restorative outcome, or reduces the need for further augmentation in conjunction with implant placement.

Implications for clinical practice

At this stage in time the use of ARP in all cases of tooth extraction where implant placement is contemplated in future cannot be recommended actively on the basis of the evidence provided. Applying the ARP evidence presented in the review to facilitate clinical decision-making should be exercised prudently, taking into consideration clinical experience and patient needs and always ensuring that the benefits outweigh the potential risks, added costs and inconvenience to the patient.

Clinical question

Does alveolar ridge preservation (ARP) via socket grafting preserve alveolar ridge dimensions following non-molar extractions, after a minimum healing period of 12 weeks in adult human subjects, compared to extraction alone?

Review methods

Study selection

Three independent reviewers searched and screened five electronic databases [MEDLINE-Pubmed, Google® Scholar (to include the grey literature), Proquest Dissertations and Theses, Web of Knowledge, and the Cochrane Central Register of Controlled Trials] up to December 2012 to identify randomized clinical trials (RCTs) on the topic in the clinical question. Specialized scientific journals from January 2002 to December 2012 were also manually searched for records. No limitation was set regarding language of the article, publication date, or publication status. The same reviewers read the full-text versions of the studies that could be potentially included in the review. Inconsistencies and disagreements in eligibility determination were resolved in a consensus meeting of the 3 reviewers that was refereed by another author. They contacted the corresponding authors of 5 studies for further information regarding study design or missing data to make a decision for inclusion.

¹ Johan Hartshorne B.Sc., B.Ch.D., M.Ch.D, M.P.A. Ph.D. (Stell), FFPH.RCP (UK), Visiting Professor, Department of Periodontics and Oral Medicine, University of Pretoria, Pretoria, South Africa.

E-mail: jhartshorne@kanonberg.co.za

Eligibility criteria

The reviewers searched for RCTs conducted in human subjects, older than 18 years, who had at least 1 non-molar tooth extracted in which investigators compared ARP via socket filling (intervention group) to untreated sockets (control group). The ridge preservation approach must have involved use of a bone-grafting material (i.e. autograft, xenograft, allograft, or alloplast), covered or not with a barrier/membrane, and had a minimum healing time of 12 weeks. Horizontal and/or vertical alveolar ridge dimensional changes must have been assessed clinically.

Exclusion criteria

They excluded studies where molars were included or no bone graft was used. Studies were also excluded that involved the application of any additional therapy that could have affected healing outcomes (e.g., immediate denture delivery, simultaneous soft tissue grafting, or use of healing enhancers such as growth factors). The authors provided a list of excluded full text papers and reasons for exclusion.

Outcome measures and data extraction

Two reviewers extracted and assessed data from the included studies on the mean horizontal ridge (buccolingual) and vertical ridge changes (midbuccal, midlingual, mesial, and distal) – from baseline (tooth extraction) to final assessment (minimum 12 wk).

Data analysis

For quantitative analysis, data from the selected studies were combined to estimate the effect size, defined as the difference in mean parameter change between the experimental and control groups – all measured in millimetres.

Random effects models were utilized throughout to estimate the effect size and provide 95% confidence intervals (CI) of the pooled data. Appropriate tests were conducted to test for heterogeneity and risk of bias. Heterogeneity of effect across the studies was formally assessed with the Cochran Q test and characterized with the I² statistic to describe the proportion of total variation in the estimated effect sizes due to heterogeneity among studies.

The influence of flap elevation, membrane usage, and type of bone substitute employed on the outcome of ridge preservation therapy was assessed by means of subgroup analysis.

Risk of bias of the included RCT's was assessed according the Cochrane Collaboration risk of bias assessment tool.¹

Potential publication bias for the studies was assessed using the funnel plot approach. Two selected RCT's had a split-mouth design, which made pooled meta-analysis with parallel arms studies not feasible; hence, they were excluded from the meta-analysis.

Main results

The search process yielded 8 RCTs with a minimum follow-up of 3 months and a maximum of 7 months for qualitative analysis. Data from 6 studies eligible were combined for quantitative analysis. The total number of subjects was 195, and their ages ranged from 20 to 76 yrs. Outcomes were analysed from a total of 228 sockets (118 experimental and 110 controls). Socket grafting materials used in the intervention group included xenograft (anorganic bovine bone, corticocancellous porcine bone), alloplast (calcium sulphate, Bioglass), and allograft (freeze dried bone). Absorbable collagen membrane was used in all the studies. The estimate of the effect size for the outcome variables measured between the intervention and control group for horizontal dimensional changes were: Buccolingual: 1.89 (95% confidence interval (CI): 1.41, 2.26; $p < .001$), and for vertical dimensional changes:

Midbuccal height: 2.07 (95%CI: 1.03, 3.12; $p < .001$)

Midlingual height: 1.18 (95% CI: 0.17, 2.19; $p = .022$)

Mesial height: 0.48 (95% CI: 0.18, 0.79; $p = .002$)

Distal height: 0.24 (95% CI: -0.05, 0.53; $p = .102$)

Five studies used a xenograft as socket grafting material, while 2 used an alloplastic material and one an alloplastic material. Flap elevation was performed in 5 studies. All the studies used a barrier membrane except in 1 study. Subgroup analysis revealed that flap elevation, use of a xenograft or an allograft and the application of a membrane, are associated with superior outcomes, particularly on midbuccal and midlingual height preservation.

Conclusion

The authors concluded that ARP is an effective therapy to prevent physiologic bone loss after extraction of non-molar teeth, in both the horizontal and the vertical dimension, as compared to tooth extraction alone. Flap elevation, usage of a membrane, and the application of a xenograft or an allograft may contribute towards enhancing treatment outcome, particularly on midbuccal and midlingual height preservation. The authors pointed out that a certain degree of ridge volume loss should be expected with ARP and that the effect of limiting post-extraction physiological bone loss may be variable likely due to local and systemic influences that are not yet fully understood.

The authors received no financial support and declared no potential conflict of interest with respect to the authorship and/or publication of this review.

Commentary

Background and importance

The clinical question addressed in this review is of great importance to the patient and the clinician. The alveolar ridge undergoes a mean horizontal reduction in width of 3.8mm and a mean vertical reduction in height of 1.24 mm within 6 months after tooth extraction.² Bone loss due to the resorptive healing process following tooth extraction may pose a problem for the clinician and the patient because it may make placement of an implant challenging or it may create an aesthetic problem in the fabrication of an implant supported restoration.^{3,4} With implant treatment becoming more widespread the need to anticipate and pre-empt post-extraction bone loss in treatment planning has become a high priority to ensure that sufficient alveolar bone (AB) volume is available for optimum placement of the dental implant. Alveolar ridge preservation (ARP) procedures, also termed extraction socket grafting or socket preservation in the literature, have been proposed to limit post-extraction loss of alveolar bone needed for future implant placement.^{4,5}

Methodological quality of the review and validity of the evidence

It is fair to comment that this systematic review and subsequent meta-analysis followed the guidelines of PRISMA statement⁶ and therefore was conducted with a high level of methodological rigor. However, the methodological quality and subsequent quality of the evidence in the review is just as good as that of the included studies. The studies included in this review had several basic limitations and weaknesses that could potentially compromise the results and affect the quality of the evidence presented.

Limitations

The authors stated that two independent reviewers evaluated the quality of the studies. However, no indication was given about the extent of agreement between the reviewers. The quality assessment they performed revealed that the overall methodological quality of the 8 included RCTs was low. Only two aspects of quality were assessed: that of blinding the examiner of clinical outcomes, which is relevant to the possibility of bias, and that whether the sample size was estimated a priori. This was done for all five outcomes measured. Tests for heterogeneity however showed that the

groups did not differ with respect to outcomes that were measured. The limited number of studies restricted formal quantitative assessment of quality of the evidence. Small sample sizes in the individual studies could potentially reduce the power of the study, thus resulting in estimates of effect with wide confidence intervals (CI) that included both important benefits or no important effects.

The total number of subjects enrolled in the selected studies can be considered sufficient for the assessment of pooled effect size differences between the experimental and control group. However, the reported subgroup analysis results should be read with caution, given the limited number of studies (n = 6). The adequacy of the statistical analysis was difficult to determine.

Age, sex and the number of intact socket wall were the only baseline independent characteristics between groups that were documented. No data were reported on critical factors, such as gingival biotype, width of the keratinised gingiva, thickness of buccal plate or availability of bone for implant placement that may modify the outcome of ARP. Therefore, the possible impact of these factors on ARP could not be determined.

Risk of bias

In all 8 studies, the risk of bias due to inadequate random sequence generation and allocation concealment was considered to be low. However, blinding of personnel was disclosed in only one study. Participants were not blinded in any of the studies. The examiner was blinded/masked in 5 of the 8 studies included in the meta-analysis. In only one study was the examiner calibrated for measuring the outcomes of interest. Seven studies clearly reported that none of the subjects were lost to follow-up, thus the completion was similar in both intervention and control group. The risk of selective reporting was considered low for all included studies. Two studies stated that there was no conflict of interest. Two studies indicated that biomaterials were supplied by a company, but made no explicit claims regarding conflict of interest. The remaining 4 studies did not address conflict of interest at all. Funnel plots constructed to assess potential publication bias among included studies were found to be insignificant. The authors however did report that it is possible that some grey literature could have been missed, because only one database containing this type of information was searched.

Key findings

Generally there was marked variability and inconsistencies

between the studies included in the meta-analysis for all outcomes measured. This is likely due to differences in the sample population characteristics, interventions used, and outcome measurement. Overall, the pooled estimates for outcome variables: reduction of buccolingual width, buccal height, lingual height and mesial height bone loss, showed consistency in favour of ARP (statistically and clinically significant). Flap elevation, use of a xenograft or an allograft, and the application of a membrane, had superior outcomes in terms of the vertical dimensions only. This finding however should be interpreted with caution due to the limited number of studies used in the subgroup analysis.

Irrespective of the limitations and weaknesses of review we can reasonably assume that in 95% of cases when ARP is applied the true effect of the magnitude of bone preservation for each outcome measured will lie between the lower and upper level of the confidence interval as indicated by the results of the review. The results of this review are in accordance with that reported in other systematic reviews on this topic.^{7,8,9}

Clinical importance of the results

Alveolar ridge undergoes a mean horizontal reduction in width of 3.8mm and a mean vertical reduction in height of 1.24 mm within 6 months after tooth extraction.² Thus, a preservation of horizontal width of the alveolar bone by 1.89mm (95% confidence interval (CI): 1.41, 2.26) and that of the vertical midbuccal dimension by 2.07mm (95%CI: 1.03, 3.12) can be considered as clinically significant. A recent study by Linde and co-workers¹⁰ found that placement of biomaterial in extraction sockets retarded healing and that bone graft material were not resorbed but became surrounded by new bone. They suggested that this phenomenon might explain why grafted sockets may fail to undergo dimensional change.¹⁰ The amount and the quality of the newly formed osseous tissues in the socket area are essential, especially when the justification of ARP is to facilitate the placement of a dental implant in the position of a previously extracted tooth. It is doubtful, whether an ARP technique should be claimed successful, if it only preserves the external contour of the AR, but the newly formed tissue is of inferior quality and quantity (percentage of matured trabecular bone) to what is normally achieved following a tooth extraction.⁸

Whether bone preservation has any clinical benefit is a different issue from that of statistical and clinical significance. The clinical rationale for ARP is to reduce the necessity for alveolar ridge reconstruction and to enable successful implant

placement. If the ARP procedure fails to meet this requirement, it may be considered as an unnecessary or even unsuccessful procedure.¹¹ Alternatively, if ARP is not done the patient will not be able to have an implant placed. In this review the mean changes were measured. It would be clinically more meaningful to know what the mean horizontal and vertical dimensions of the alveolar ridge were immediately after extractions and at re-entry when implants are placed. This review did not report on availability of bone volume or the feasibility of implant placement at re-entry, or whether further GBR or ridge expansion was required in the experimental and control groups at the implant placement stage. ARP procedures are not indicated for each and every tooth extraction socket where implant placement is contemplated. In some cases bone volume may be adequate that will negate the need for ARP even if the patient wants to wait for an extended period before having an implant placed. Furthermore, the review had no data to provide insight into other critical and important clinical, biological, social and economical outcomes such as adverse effects, inconveniences, complications, cost implications, affordability, cost benefit analysis and the need for subsequent ridge augmentation procedures to facilitate aesthetic and functional requirements for implant placement. It would be helpful to understand patient experiences such as concomitant discomfort or adverse effects associated with ARP in order to avoid a further, extensive reconstructive surgery. On the other hand, the additional costs of ARP at the time of extraction may not be desirable if the outcome and benefit of such extra treatment were not predictable. There are no data yet to inform on these questions.⁸

Applicability of the results in clinical practice

It will be difficult to generalize the conclusion from this review to all patients in the clinical setting. The review investigated the effect of ARP in non-molar extraction sites. The review does not take into consideration different biological and social differences between patients that may influence the rate and extent of ridge resorption and healing process. Important independent variables that may affect ridge resorption and healing processes such as the influence of other independent variables i.e.: Which tooth will be extracted? Is it an upper or lower tooth?; What periodontal biotype are we dealing with (buccal plate thickness and soft tissue thickness)?; What is the quality of the bone?; Are there teeth adjacent to the tooth being extracted?; and What will it cost and can the patient afford the treatment? Are still lacking.

Do the benefits outweigh the potential harm and costs?

It is important to consider whether the potential benefit is greater than the potential harm, added cost or inconvenience associated with ARP.

Important clinical questions that should be raised during clinical decision-making should include the following: Will additional surgery be required to further augment the ridge to facilitate implant placement? Is it justified to subject the patient to ARP procedure with the aim of achieving the expected benefit as reported in this review? Will the proposed post-extraction ARP reduce the risk of inadequate bone availability for implant placement at a later stage? Will further interventions be required? Benefits should primarily be focussed on reducing morbidity, inconvenience, reducing time and cost for the patient.

Conclusions

This review addresses an area of considerable interest to most specialists and dentists placing implants. The evidence from this review showed that ARP has a clinically significant effect on preserving horizontal and vertical dimension of the alveolar bone following extraction of non-molar teeth. This review however does not provide any evidence regarding the clinical benefit of ARP, namely whether ARP provides adequate alveolar ridge volume for successful implant placement and restorative outcome, or the reduction or need for further augmentation in conjunction with implant placement. In many cases there may be adequate bone available to let the socket heal without ARP procedures, or alternatively placing an immediate implant after tooth extraction with or without ridge augmentation may also be a viable options to consider. Applying the ARP evidence presented in the review to facilitate clinical decision-making should be exercised prudently taking into consideration, clinical experience and patient needs and always ensuring that the benefits outweigh the potential risks, added costs and inconvenience to the patient.

This review stresses the importance and need for precise and objective quantification of the total three-dimensional changes after tooth extraction and ARP, and at re-entry to assess the necessity of re-augmentation at implant placement. Further research is also required to investigate the influence of other factors like: reason for extraction, tooth location, initial buccal plate thickness, and bone quality on the efficacy of ARP. Also, no efficacy and cost-effectiveness comparative studies between ARP and ridge augmentation has yet been done.

Disclosure

Dr Johan Hartshorne is trained in clinical epidemiology, biostatistics, research methodology and critical appraisal of research evidence. This critical appraisal is not intended to, and do not, express, imply or summarize standards of care, but rather provide a concise reference point for dentists to aid in understanding and applying research evidence from referenced early view or pre-published articles in top ranking scientific publications and to facilitate clinically sound decisions as guided by their clinical judgement and by patient needs.

References

1. Higgins JP, Altman DG, Gotzsche PC, Juni P, Moher D, Oxman AD et al. The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. *B Med J* 2011; 343: d5928.
2. Hämmerle CHF, Araujo MG, Simion M, Araujo MG. Osteology Consensus report. Evidence-based knowledge on the biology and treatment of extraction sockets. *Clin Oral Impl Res* 2012, 23(Suppl 5): 80-82.
3. Lekovic V, Camargo PM, Klokkevold PR et al. Preservation of alveolar bone in extraction sockets using bioresorbable membranes. *J Periodontol* 1998; 69(6): 1044-1049.
4. McAllister BS, Haghihat HK. Bone augmentation techniques. *J Periodontol* 2007; 78: 377-396.
5. Tarnow DP, Eskow RN. Preservation of implant esthetics: soft tissue and restorative considerations. *J Esthetic Dent* 1996; 8: 12-19.
6. Moher D, Liberati A, Tetzlaff J, Altman DG. PRISMA Group Preferred reporting items for systematic reviews and meta-analysis: The PRISMA statement. *Ann Intern Med* 2009, 151(4): 264-269.
7. Vignoletti F, Matesanz P, Rodrigo D, Figuero E, Martin C, Sanz M. Surgical protocols for ridge preservation after tooth extraction. A systematic review. *Clin Oral Impl Res* 2012; 23 (Suppl. 5): 22-38
8. Horváth A, Mardas N, Mezzomo LA, Needleman IG, Donos N. Alveolar ridge preservation. A systematic review. *Clin Oral Invest* (2013) 17:341–363
9. Morjaria K, Wilson R, Palmer RM. Bone healing after tooth extraction with or without intervention. A systematic review of randomized control trials. *Clin Impl Dent Related Res* 2014; 16:1-20.
10. Lindhe J, Cecchianato D, Donati M, Tomasi C, Liljenberg B. Ridge preservation with the use of deproteinized bovine bone mineral. *Clin Oral Impl Res* 2014; 25: 786-790.
11. Mardas N, Chadha V, Donos N (2010) Alveolar ridge preservation with guided bone regeneration and a synthetic bone substitute or a bovine-derived xenograft: a randomized, controlled clinical trial. *Clin Oral Implants Res* 21:688–698