Radiographic Assessment of Influence of Cleft Width and Canine Position on Alveolar Bone Graft Success: A Retro-Pro prospective Study

Varsha H. Upadya · H. Hari Kishore Bhat ·
K. Gopalkrishnan

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Abstract

Purpose To evaluate the effect of cleft width and the pre-surgical position of the permanent cuspid, on the success of secondary alveolar bone grafts, using preoperative and post-operative radiographs.

Methodology A total of 20 cases treated with secondary alveolar bone grafting for alveolar clefts were included in the study. Pre-surgical maxillary occlusal radiograph was used to determine the cleft width. Canine position was assessed by marking 6 points on a pre-surgical intra oral periapical radiograph. Alveolar bone contour and the success of bone grafts were determined using 11 points marked on post-operative periapical radiographs taken after a minimum follow-up of 6 months.

Results Linear regression analysis of pre-operative cleft width and pre-operative position of the permanent cuspid

were carried out on the bone graft success which was determined using post-surgical periapical radiographs. $P < 0.05$ was set. The results obtained had weak correlations and were statistically not significant.

Conclusion We concluded that the success of the alveolar bone graft has minimal or no relation to the pre-operative width of the cleft or the position of the permanent cuspid at the time of grafting.

Keywords Cleft width · Canine position · Secondary alveolar bone grafting · Graft success

Introduction

The primary aim of alveolar bone grafting (ABG) is to restore the function and structure of the maxillary arch at the cleft site. The benefits of bone grafting are that it provides: bone support to teeth adjacent to the cleft, bony matrix for eruption of teeth in the line of the cleft, continuity, stability and support to the maxillary arch and alveolar bone contour. ABG also reduces notching of alveolar ridge, eliminates oronasal fistulae and improves aesthetics by restoring facial symmetry, providing alar base support and establishing nasolabial contour [1].

Over the years a number of different treatment modalities have been advocated for the management of the alveolar cleft. However, disagreement exists as to the indications and timing of bone grafting [2].

Before the 1970s, primary ABG (before palatal closure) was commonly performed until its adverse effects on maxillary growth were highlighted by Koberg and others. However, Freide and Johnson (1974) reported a surprising 90 % success rate with primary bone grafting in which a significant number of teeth adjacent to the cleft had

V. H. Upadya · H. H. K. Bhat · K. Gopalkrishnan
Craniofacial Surgery and Research Center, Department of Oral and Maxillofacial Surgery, S.D.M. College of Dental Sciences, Sattur, Dharwad, Karnataka, India

Present Address:

V. H. Upadya
Department of Oral and Maxillofacial Surgery, Farooqia Dental College and Hospital, Tilak nagar, Mysore, Karnataka, India

V. H. Upadya (✉)
Department of Oral and Maxillofacial Surgery, Farooqia College of Dental Sciences, Farooqia Dental College and Hospital, Eidgah, Tilak nagar, Mysore 570 021, India
e-mail: varsha.upadya@gmail.com

Present Address:

H. H. K. Bhat
Department of Oral and Maxillofacial Surgery, Sri Sai College of Dental Surgery, Kothrepally, Vikarabad, Andhra Pradesh, India

migrated into the grafted site [3]. Gingivoperiosteoplasty has been proposed as an alternative to primary alveolar grafting. However, its effect on maxillary growth and the need for subsequent bone grafting is yet to be determined [2].

The optimal age for secondary alveolar bone grafting (SABG) is between 9 and 11 years when the canine is between half and three-quarters formed. [4]. Proponents of SABG claim that there is little disruption to facial growth as a larger percentage of the adult size has been achieved before grafting and the canines are expected to migrate and erupt through the grafted area resulting in improved development of dentition, improved bony environment to facilitate orthodontic and prosthodontic treatment, and improved periodontal health. Opponents state that, bone does not show apposition on the graft surface, which results in the graft's inability to keep pace with vertical alveolar development and subsequent compromised support for the adjacent teeth [5].

One of the factors mentioned in literature that affects the outcome of bone grafts is the development or the position of teeth in the cleft especially the permanent cuspid at the time of grafting. The assumption is that the graft placed around the crown of a partially or fully erupted tooth will not result in alveolar bone height to the same extent as one placed prior to tooth eruption into the cleft [6].

Materials and Methods

The study was conducted on a sample of 18 patients (20 cleft sites). All patients underwent SABG and were followed up for a minimum of 6 months. Cases with complete clinical records, orthodontic study models, pre and post-operative intraoral periapical radiographs (IOPAR) and maxillary occlusal radiographs to assess bone attachment, canine position and alveolar crest height, were included in the sample. Patients operated for bilateral alveolar clefts were considered as two separate cases.

Procedure of Radiographic Assessment

Measurement of Cleft Width

Cleft width at the narrowest point, determined by inspection, was measured on a pre-surgical maxillary occlusal radiograph which was confirmed using study models.

To determine radiographic elongation or shortening, the mesio-distal width of the tooth adjacent to the cleft was measured and compared with the mesio-distal width of the same tooth measured on the orthodontic study model. The difference was used as the radiographic correction factor.

Assessment of Canine Position

Six points on the pre-surgical IOPAR were used to measure the amount of permanent cuspid crown emerged into the cleft beyond the adjacent alveolar bone and the total crown length of this tooth.

To minimize the effect of radiographic foreshortening and elongation, the eruption measure was expressed as a ratio of the amount of crown emerged, divided by the total crown length (Fig. 1a).

Radiographic Assessment of Alveolar Contour and Bone Graft Success

A modified method of assessing bone architecture of the graft as reported by Helms et al. (1987) was used. Post-surgical IOPARs taken after a minimum follow-up period of 6 months were used. To avoid radiographic errors, all measurements were converted to ratios using the various measures of alveolar bone height as the numerator (variables B, C, D, F and G) and root length of teeth adjacent to cleft (A and E) as the denominator. Measurements of bone attachment were represented by ratios B/A and F/E in the proximal and distal segments respectively. The alveolar crest height, as reflected by its approximation to the cemento-enamel junction, was measured as the ratio C/A for the tooth in the proximal segment and G/E for the tooth in the distal segment (Fig. 1b).

Statistical Analysis

Linear regressions of the various ratios of bone architecture (B/A, C/A, D/A, F/E and G/E) were done on preoperative cleft width and canine eruption ratio. A level of $P < 0.05$ was set to determine a relationship that would be considered statistically significant and the r^2 value was used to determine the strength of correlation and possible clinical significance (Table 1).

Results

A total of 18 patients were included in the study of which 10 were females and 8 were males. The average age of the patients at the time of grafting was 13.8 years.

The cleft width ranged from 0.2 to 0.7 cm (average: 0.4 cm). The canine eruption ratio ranged from 0.2 to 1 cm (average: 0.78 cm).

The ratios B/A, C/A, D/A, F/E and G/E measured on post surgical IOPARs were used to determine the bone graft success.

Fig. 1 **a** Landmark points marked on the pre-surgical radiographs to identify the anatomic crown of the cuspid (points 1, 2 and 3) and the amount of cuspid crown emerged through the alveolus (points 4, 5 and 6) **b** A length of proximal segment anatomic root, B most coronal bone attachment along distal surface of proximal root, C location of alveolar cleft on distal surface of proximal root, D notching of graft, E length of distal root, F (similar to B) on distal root, G (similar to C) on distal root

Bone Graft Contour

The amount of bone at the distal surface of the tooth root adjacent to the cleft in the proximal segment usually relates to the success of the bone graft in providing alveolar support for this tooth. This was expressed in the ratios of B/A and C/A. The mean ratio for the variable B/A was 0.625 and for C/A was 0.2.

Table 1 Correlation between independent variables with each independent variable by Karl Pearson's correlation coefficient

Dependent variables	Cleft width	Canine eruption ratio
B/A	−0.3034	−0.1911
C/A	0.0787	0.1704
D/A	0.2133	0.1525
F/E	−0.1486	−0.2059
G/E	−0.0410	−0.3204

The ratio D/A measured the amount of notching of the alveolar ridge of the grafted site. D was taken from the greatest depth in the alveolar ridge measured along the perpendicular to the intersection of the line between the CEJ of the cleft adjacent teeth, C and G. The mean for this sample indicative of alveolar notching was 0.29. Post-operative elimination of characteristic notching is the measure of the effectiveness of the bone graft.

Similar analysis of bone support to the tooth closest to the cleft in the distal segment is described by the ratios F/E and G/E. The mean for the former was 0.68 and for the latter it was 0.26.

Cleft Width and Bone Graft Success

Correlations were significant but weak between changing cleft widths and success of bone grafting for the ratios describing alveolar bone support for teeth the proximal and distal segments. Low negative correlations which were significant at the 95 % confidence level, existed between cleft width and bone attachments (B/A, F/E) of the graft. There was also a weak positive correlation between increasing cleft width and increase in alveolar notching as indicated by the ratio D/A.

Cuspid Eruption and Bone Graft Success

Except for four cleft sites, in which the canine was almost into occlusion at the time of grafting, the other cases showed eruption of the canine through the graft. Although the regression lines of the least square for each of the variables sloped in the direction of poorer results with increasing cuspid eruption in the cleft at the time of grafting, none of the regressions were statistically significant. All of the r^2 values were exceptionally low, also indicative of weak and clinically insignificant relationships.

Discussion

Kling (1961) and Boyne and Sands (1972, 1976) described a technique of SABG in the mixed dentition using cancellous bone from the iliac crest or tibia. This technique,

which results in a favourable outcome, has been used widely since then and is now considered a standard procedure in cleft lip and palate surgery [6].

This study confirms the benefits of SABG, other than the objective of establishing a morphologically and functionally normal alveolar process. The grafted site has the capacity to permit eruption of teeth, support normal tooth bearing function, and undergo remodelling to allow orthodontic movement [1].

Autogenous cancellous bone from the ilium were used in all our cases. This graft is highly cellular and resistant to infection. Several reports [7, 8] agree with our choice of the ilium as the donor site and show a graft success rate of 90 % or greater.

The optimal time for bone grafting and fistula closure appears to be between 10 and 12 years of age. This age is in agreement with Enemark [9], Deeb [10] and Bergland et al. [11]. As the sagittal and transverse anterior maxillary growth normally is completed at the age of eight to nine years, this may explain the unaffected growth [12].

The evaluation of bone bridge formation after bone grafting in alveolar clefts is usually done by dental, occlusal, or panoramic radiographs. Three dimensional analysis however has also been performed using CT scans [13] but Rosensteil et al. found no significant differences in the results with the two methods and therefore concluded that routine dental radiographs can be used to estimate bone support for the roots of cleft-adjacent teeth. Hynes [14] also concluded that IOPAR is a cost effective and simple method of assessment of SABG success and results in low X-ray exposure.

The analysis of bone contour in our study depicts, in majority of cases, adequate bone support for both teeth adjacent to the cleft. The alveolar crest level was slightly higher for the tooth in the proximal segment indicated by the average G/E ratio being greater than C/A, contradictory to the results achieved by Long et al. [1] and Teja et al. who showed in their studies that the alveolar crest height for the tooth in the proximal segment is consistently lower than that of the tooth in the distal segment. They attributed this difference to the eruption of the proximal segment tooth into an unfavourable position prior to bone grafting and to presurgical orthodontic manipulation which could have contributed to compromised bone levels.

Majority of our patients underwent pre-surgical orthodontics for arch expansion and correction of crowding and rotations prior to bone grafting. A well known common side effect of arch expansion is the formation or exacerbation of oro-nasal fistulae. If expansion is carried out after bone grafting and the fistulae appear, these will then require an additional surgical procedure. On the other hand if fistulae appear during the pre-bone grafting stage of arch

expansion, they can be simultaneously handled at the time of grafting [2].

An important finding of this study was that size of presurgical cleft defect appears to have no correlation with the success of the SABG. Regression analysis showed weak correlations between cleft width and outcome of the bone graft. There were indications significant at $P < 0.05$, that the amount of bone support for teeth adjacent to the grafted cleft site and notching of the alveolar ridge were dependant on variations in presurgical cleft width. Low correlation co-efficients however suggested a relationship of questionable clinical significance. Certainly no cause and effect relationship could be deduced from these findings. This implicates other factors or a combination of them that may be the cause behind the variability of success of bone grafts and alveolar bone heights of teeth adjacent to grafted cleft sites. This was a confirmation of the study by Long et al. [1] who found that the presurgical cleft width appeared to have no impact on the success of alveolar bone grafts. However, Walle and Forbes (1992) found that percentage of bone fill was affected by the area of the defect. The lack of significant correlation between cleft width and graft success seems to indicate that pre-surgical arch expansion can be carried out at least up to a cleft width of 7 mm as per this study (11.2 mm [1]), without the likelihood of graft failure.

As per a study [15], the ratios B/A, G/E, and F/E before the grafting surgery were significantly related to success rate of SABG. That is, if the presurgical ratio B/A = 1, a satisfactory outcome was 5.8 times more likely. If the presurgical ratio F/E = 1, a satisfactory outcome was 3.79 times more likely, and if the presurgical ratio G/E = 0, a satisfactory outcome was 3.79 times more likely.

The eruption stage of teeth in the distal segment, periodontal status of teeth in the proximal segment at the time of grafting, type of graft material, surgical flap design and handling of tissues during grafting and the skill of the surgeon are all factors that contribute to the success of a bone graft.

Several studies have suggested that SABG should be done before the eruption of canines. The indicator for timing of bone grafting in most studies has involved root development of the canine (i.e., when the root has developed between one-fourth and two-thirds of its length) [11, 16] This criterion for root development, however, was designed especially for the canine and not for the lateral incisor. To determine when the bone grafting procedure should be performed, it is preferable to use the thickness of bone covering the crown (of the lateral incisor or canine), rather than the degree of root formation of these teeth, as the indicator [6].

If the graft was loaded it would have influenced the success of the graft and our study only aimed to assess graft

success radiographically based on the canine position at the time of grafting and its eruption through the graft. As opposed to validating previous investigations, when linear regression statistics were applied to the data from this sample, no significant relationships between the degree of cuspid eruption and the ultimate bone graft success were found. Although the slopes of the trend lines were all in the direction of decreasing graft success with increasing degrees of cuspid eruption, none represented statistically significant relationships. Furthermore the negligible r^2 values further diminished the likelihood of any clinically significant relationship. Our results coincided with the results of Long et al. [5].

Conclusion

The findings of this study indicate the following:

- (1) Differences in cleft width prior to grafting, some of which were created by presurgical orthodontic expansion, seemed to have little bearing on the success of bone grafting as evaluated objectively utilizing long term periapical and occlusal radiographs.
- (2) In assessing the relationship of cuspid eruption status to the graft success, although the least squares regression lines for each of the variables sloped in the direction of poorer results with increasing cuspid eruption in the cleft at the time of grafting, none of the regressions were statistically significant and hence cuspid eruption status could not be shown as a significant factor in determining graft success.

References

1. Long RE Jr, Sprangler BE, Yow M (1995) Cleft width and secondary alveolar bone graft success. *Cleft Palate Craniofac J* 32:420–427
2. Leonard, Bailey DW, Thompson L (1970) Delayed bone grafting in cleft palate patients. *Plast Reconstr Surg* 46:363–367
3. Witherow H, Cox S, Jones E, Carr R (2002) A new scale to assess radiographic success of secondary alveolar bone grafts. *Cleft Palate Craniofac J* 39:255–260
4. Helms JA, Speidel MT, Denis KL (1987) Effect of timing on long-term clinical success of alveolar cleft bone grafts. *Am J Orthod Dentofac Orthop* 92:232–240
5. Long RE Jr, Paterno M, Vinson B (1996) Effect of cuspid positioning in the cleft at the time of secondary alveolar bone grafting on eventual graft success. *Cleft Palate Craniofac J* 33:225–230
6. Lilja J, Kalaaji A, Friede H, Elander A (2000) Combined bone grafting and delayed closure of the hard palate in patients with unilateral cleft lip and palate: facilitation of lateral incisor eruption and evaluation of indicators for timing of the procedure. *Cleft Palate Craniofac J* 37(1):98–105
7. Hall HD, Posnick JC (1983) Early results of secondary bone grafts in 106 alveolar clefts. *J Oral Maxillofac Surg* 41:289–294
8. Amanat N, Langdon JD (1991) Secondary alveolar bone grafting in clefts of the lip and palate. *J Craniomaxillofac Surg* 19:7–14
9. Enemark H, Simonsen E, Schramm JE (1985) Secondary bone grafting in unilateral cleft lip palate patients: indications and treatment procedure. *Int J Oral Surg* 14:2–10
10. Deeb ME, Messer LB, Lehnert MW, Hebda TW, Waite DE (1982) Canine eruption into grafted bone in maxillary alveolar cleft defects. *Cleft Palate J* 19:9–16
11. Bergland O, Semb Gunvor, Abyholm Frank (1986) Elimination of the residual alveolar cleft by secondary bone grafting and subsequent orthodontic treatment. *Cleft Palate J* 23:175–205
12. Enemark H, Pederson SS, Bundgaard MM (1987) Long term results after secondary bone grafting of alveolar clefts. *J Oral Maxillofac Surg* 45:914–918
13. Honma K, Kobayashi T, Nakajima T, Hayasi T (1999) Computed tomographic evaluation of bone formation after secondary bone grafting of alveolar clefts. *J Oral Maxillofac Surg* 57:1209–1213
14. Hynes PJ, Earley MJ (2003) Assessment of secondary alveolar bone grafting using a modification of the Bergland grading system. *Br J Plast Surg* 56:630–636
15. Aurouze C, Moller KT, Bevis RR, Rehm K, Rudney J (2000) The presurgical status of alveolar cleft and success of secondary bone grafting. *Cleft Palate Craniofac J* 37:179–184
16. El-Deeb ME, Hinrichs JE, Waite DE, Bandt CL, Bevis RR (1986) Repair of alveolar cleft defects with autogenous bone grafting: periodontal evaluation. *Cleft Palate J* 23:126–136