Alveolar bone grafting: results of a national outcome study

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ABSTRACT

INTRODUCTION In 1998, the Clinical Standards Advisory Group (CSAG) report demonstrated a successful radiographic outcome of 58%, for alveolar bone grafting, from 157 cases of unilateral cleft lip and palate (UCLP) in children aged 12 years. No further national studies have assessed the current level of radiographic outcome following the re-organisation of cleft services since the recommendations from the CSAG report.

PATIENTS AND METHODS In 2008, radiographic images were requested for alveolar bone grafts performed in calendar year 2006 from each of the now established UK cleft centres. A sample of 206 patients with 235 grafted sites was scored by a panel of trained assessors, following a calibration exercise, using a modified Kindelan index. Inter- and intra-observer variation was assessed.

RESULTS The overall radiographic success rate for the 2006 images assessed was 85%. There was no statistical difference for radiographic success between centres or surgeons or cleft type when defined as either a bilateral or unilateral alveolar defect for a patient.

CONCLUSIONS Alveolar bone grafting appears to have improved radiographic outcomes when compared with the CSAG report following the re-organisation of surgical services for children with cleft lip and/or palate.

KEYWORDS

Alveolar bone graft – Children – Radiography – Cleft lip – Cleft palate

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In 1998, the Clinical Standards Advisory Group (CSAG) reported on cleft services in the UK and highlighted the poor outcome for children born with cleft lip and/or palate.¹ This led to the re-organisation of cleft surgery in the UK, with the development of 'high volume' cleft centres. One of the parameters originally measured in the CSAG study was the radiographic outcome of alveolar bone grafting. This procedure aims to restore bone volumes in the tooth-bearing portion of the maxilla when a cleft defect has disrupted the development of bone in the area, with the intention of facilitating subsequent orthodontic and surgical treatment. The CSAG study reported that 42% of alveolar bone grafts in 12-year-olds were unsatisfactory when assessed with intra-oral radiographs.^{1,2} Alveolar bone grafting in children born with cleft lip and/or palate offers the opportunity for the closure of residual oronasal fistulae, an improvement in

alar base aesthetics,³ the unification of the cleft maxilla, and greatly improved orthodontic outcomes for the patients concerned.^{4,5}

The purpose of this study was to establish the current radiographic outcome of alveolar bone grafting in the UK cleft centres and establish if standards had improved since the implementation of the CSAG report. This could then provide a benchmark for future national projects assessing radiographic outcome in alveolar bone grafting.

Patients and Methods

A request for information was sent to the clinical directors of each of the nine regional cleft centres in England and Wales. The postoperative anonymous intra-oral radiographs for all alveolar bone grafting procedures in 2006

were requested along with some basic information regarding the number of alveolar bone graft procedures undertaken in 2006. This particular year was selected as it would reflect practice after re-organisation of cleft services and allow an appropriate length of time after surgery for follow-up with appropriate radiographs. Digital images, when possible, were requested to facilitate the analysis. Units were contacted again after 8 weeks if no initial response was received. The digital images were imported into PowerPoint slides with a black background and the assessors were blinded to the surgeon and/or the centre providing the images.

A modified Kindelan index was used to assess the radiographic appearance of the alveolar bone graft procedure.⁶

The Kindelan index

Score	Bone levels	
1	> 75%	Success
2	50–75%	Success
3	< 50%	Failure
4	No bone bridge	Failure

Table 1 Radiographic success of alveolar bone grafting for children born with unilateral and bilateral alveolar cleft defects in England and Wales according to surgical unit operated on during 2006

Surgical unit	Unilateral Number of sites(%)	Bilateral Number of sites(%)
Surgical unit 1	35 (89.7)	19 (95)
Surgical unit 2	30 (85.7)	3 (75)
Surgical unit 3	12 (92.3)	2 (100)
Surgical unit 4	12 (100)	3 (50)
Surgical unit 5	15 (100)	3 (75)
Surgical unit 6	12 (100)	4 (66.7)
Surgical unit 7	23 (76.7)	3 (50)
Surgical unit 8	12 (70.6)	12 (85.7)
Total	151 (87.3)	49 (79)

The modification allowed for the assessment of the level of bone at the nasal floor, which was not described in the original indices. Thus, for success to be scored, a bony layer at the apices of the teeth either side of the original defect was required. When apical bone levels were below the apices of the teeth, a rating of failure was scored.

The three assessors received training and undertook a calibration exercise assessing 40 randomly selected radiographic images different from the 2006 national sample, in a PowerPoint format as described above. This calibration exercise included scoring on two separate occasions, independent of each other. These were compared to a 'gold standard scoring', which was generated by agreement from two experienced assessors on a previous project.

The submitted images were assessed on two separate occasions by the assessors. From this, six scores were generated for each radiographic image. Independent of the assessors, these were analysed to generate a final score by using a prospective method designed to allocate the most frequently occurring score from the six scores. If this was not clear, the assessors were contacted to discuss and agree a final score. Three subjects had images excluded due to the poor quality of the image. Intra- and interassessor reliability was calculated using kappa statistics at the dichotomous level, success (grades 1 and 2) and failure (grades 3 and 4).

Results

Data were received from six of the regional cleft centres in England and Wales, which included eight surgical units, giving a total sample of 206 patients, who had received an alveolar bone graft in 2006. Of these 206 patients, three were excluded due to poor quality of the images. Some patients had two grafted sites, in the bilateral defect cases, giving an overall total of 235 grafted sites assessed during this study. The radiographic follow-up rate for this sample, from the submitting surgical units, was 95% (range, 85–100%).

Table 1 shows the number and percentage of images assessed as having a successful radiographic outcome with

Table 2 Kindelan index scores for unilateral and bilateral alveolar defects for the individual sites grafted in 2006

Score	Bone levels	Outcome	Unilateral n (%)	Bilateral n (%)	Total n (%)
1	>75%	Success	124 (71.7)	34 (54.8)	158 (67.2)
2	50–75%	Success	27 (15.6)	15 (24.2)	42 (17.9)
3	< 50%	Failure	7 (4.1)	6 (9.7)	13 (5.5)
4	No bone bridge	Failure	15 (8.7)	7 (11.3)	22 (9.4)
Total			173 (100)	62 (100)	235 (100)

Table 3 Kappa values indicating levels of intra-examiner and interexaminer reliability using the dichotomous radiographic scale of success (grades 1 and 2) versus failure (grades 3 and 4)

	EP2	HS1	HS2	CM1	CM2
EP1	0.80***	0.33*		0.32*	
EP2			0.37*		0.31*
HS1			0.90***	0.43**	
CM1					0.91***
HS2					0.50**

*Fair agreement; **moderate agreement;

***substantial to almost perfect agreement.

a modified Kindelan index. There is a small difference in the overall percentage of success between unilateral and bilateral defects, but was shown not to be statistically significant (chi-squared test P -value = 0.1).

Table 2 shows the results according to the Kindelan index score and demonstrates the overall success rate for the 2006 images assessed to be 85.1%, with the majority of the successful outcomes being assessed as grade 1.

The level of intra-examiner agreement was substantial to almost perfect, whereas the interexaminer agreement varied from fair to moderate in this study. These figures have been summarised in Table 3.

Discussion

Alveolar bone grafting has become a commonly performed procedure over the last 25 years for children born with cleft lip and/or palate. These data demonstrate a successful radiographic outcome for alveolar bone grafting, in England and Wales for 2006, as 85% (95% CI 83.5–93.5%). Though not directly comparable, radiographic outcome for alveolar bone grafting appears to have improved since the CSAG reported figure of 58% success from the 57 units included prior to centralisation of services.² Direct comparison with the CSAG data should be treated with caution, as this was undertaken with a different (though related) index by two experienced assessors. The original CSAG report utilised a modified Berglund score to assess bone graft outcome. The Berglund index⁷ is similar to the Kindelan index; both assessments are semi-quantitative subjective two-dimensional assessments of bone filling the cleft alveolar defect. The Berglund index is best suited to older patients who have an erupted canine tooth next the grafted site.⁷ Both of these assessment methods have a degree of subjectivity,

which can affect the interexaminer reliability. This is apparent in this sample and previous reports when using this type of assessment tool.⁸ New three-dimensional volumetric assessments might prove to be more valid and reliable in the future.^{9,10} Also, the CSAG project only assessed outcome in unilateral cleft lip and palate (UCLP) cases, unlike the current study which assessed all cleft types, reflecting a greater variety of case difficulty.

Different surgeons at the surgical units show no statistical difference for outcome (chi-squared test P -value = 0.74). This is also demonstrated in Figure 1, a caterpillar plot showing that there was no statistical difference between surgeons for failure rates in the procedures undertaken in 2006. Radiographic success does not appear to vary between the two cleft type subgroups, the unilateral alveolar defects versus bilateral alveolar defects, (chi-squared test P -value = 0.1). Cleft type has not been shown consistently in previous reports to affect radiographic outcome in alveolar bone grafting.^{7,11–15} Other factors which were not assessed in this current project which might affect the radiographic outcome include: (i) age;^{12,14} (ii) ethnicity;¹⁴ (iii) size of the alveolar defect;¹⁵ (iv) pre-alveolar bone grafting expansion with orthodontic appliances;^{12,15} and (v) blood flow to the alveolar cleft site.

These will need to be assessed in the future to determine which factors contribute to radiographic failure in alveolar bone grafting. In addition, this project also only assessed one parameter of success in alveolar bone grafting. This is currently the only established parameter in the UK which has been utilised to measure outcome in alveolar bone grafting.^{11,12,14,16} Further studies will be needed on a national basis to establish best practice with regards to clinical parameters such as anterior oronasal fistulae closure and nasal symmetry following alveolar bone grafting.⁵

Figure 1 Caterpillar plot of failure rate following alveolar bone grafting in 2006 according to surgical unit. Rates are compared against the national average (0.15 per 100 patients with 99.8% confidence limits).

The radiographic follow-up with adequate quality radiographs was high when compared to the previous national study. Only 1.4% of radiographs in this study were too poor to score compared with 14% previously. This may suggest that the reconfiguration has encouraged improved quantity and quality of records for assessing the radiographic success of alveolar bone grafting.

Data were not received from three regional cleft centres in England and Wales. However, based on birth rates of children receiving treatment at the regional centres, those centres who submitted data represent 70% of potential cases in England and Wales.¹⁷ Currently, differences in outcome may be apparent in these centres. Despite the lack of response from some regional centres, this study analysed outcomes in a larger sample of bone grafted sites than did the original CSAG study.² It is hoped, therefore, that these findings are representative of the re-organised regional cleft centres and could provide a benchmark for future service evaluation when assessing alveolar bone grafting. To improve the quantity of these types of data, they should be prospectively submitted to a national database, such as the CRANE database.

Conclusions

Outcomes for alveolar bone grafting in the UK have improved since 1998. Although there appear to be small differences between surgical centres, our figures suggest that there is no significant difference in outcome between those centres that submitted data to this study.

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