A 5-year Post-operative Review of Secondary Alveolar Bone Grafting in the Yorkshire Region

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Abstract. *The objective of this study was to determine the quality of secondary alveolar bone grafting in the Yorkshire region, and consisted of a retrospective review of patients case notes and radiographs at five surgical units within the Yorkshire region.*

The subjects were 109 patients who had secondary alveolar bone grafting between 1.9.91. and 31.8.96. The quality of outcome was assessed using a four-point radiographic scale from occlusal radiographs taken at least 3 months post-operatively: Grade 1 = >75 per cent bony in-fill, Grade 2 = 50–75 per cent bony in-fill, Grade 3 = <50 per cent bony infill, and Grade 4 = no bony bridge.

The radiographic assessment scale was assessed for reliability: inter-examiner weighted kappa = 0·622–0·715 and intra-examiner = 0·818–0·943. Grade 1 results were achieved in 63·2 per cent patients receiving orthodontic expansion and in 40 per cent without expansion before grafting.

The four-point radiographic scale described is a useful tool in assessing alveolar bone grafting. Orthodontic expansion

Index words: Inter-centre, Orthodontic Expansion, Secondary Alveolar Bone Grafting.

Introduction

Secondary alveolar bone grafting has become accepted as a means of uniting and stabilizing the segments of the maxilla in patients with cleft lip and palate prior to definitive orthodontic and restorative dental treatment (Enemark *et al*., 1985, 1988). The surgical technique was described by Boyne and Sands (1972) and this has largely been accepted as the standard approach. These authors recommend raising mucoperiosteal flaps to access the cleft area, with periosteal flaps raised from the bony walls of the cleft to repair the floor of the nose. They advocate that autogenous bone chips harvested from the iliac crest, are packed into the cleft defect, and the mucosal flaps are closed to complete the procedure.

Ideally, the technique is performed early enough to allow eruption of the permanent canine into the grafted bone (Bergland *et al*., 1986; Brattstrom and McWilliam, 1989). Cancellous bone becomes fully integrated with the maxilla and is preferable to cortical and costochondral grafts (Borstlap *et al*., 1990), which may inhibit tooth eruption. However, Witsenburg and Freihofer (1990) suggest otherwise. In a study of 17 cases using autogenous rib grafts, with a mean follow-up of 76 months, these authors showed all permanent canines to have erupted normally.

Assessing the success of the graft radiographically has previously been carried out on a long-term basis. Bergland *et al*. (1986) focused on the height of the interdental septum adjacent to the erupted canine, and used radiographs taken at least 1 year after surgery for the assessment. In 64 per cent of 450 grafted clefts, a normal height of inter-dental septum was achieved and the cleft space was closed in 90 per cent of cases.

Long *et al*. (1995), measured contours of the grafted bone from radiographs of 46 cleft sites in order to determine the level of bony fill. They used radiographs taken at least 6 months after surgery and had a mean follow-up time of 3·1 years. Their sample achieved a bony bridge in 91 per dent of the cases and the mean height of the alveolar crest was 93 per cent of the anatomic root length in the proximal segment and 96 per cent of the anatomic root length in the distal segment. Rosenstein *et al*. (1997) have shown two-dimensional radiography to be as effective as CAT scans in determining the bony coverage of teeth adjacent to the cleft site.

The aims of this study were to assess the outcome of secondary alveolar bone grafting in five units in Yorkshire and, if differences in outcome existed, attempt to identify contributing factors. The outcome of alveolar bone grafting was assessed using a recently developed radiographically-based scale (Kindelan *et al*., 1997), which is described later. It also provided an opportunity to assess the effect of presurgical orthodontic expansion on the outcome, as this provision varied between units. The frequency of bone grafting by the surgeons was assessed and the implications of low volume operators considered.

Methods

The cleft teams at five units in the Yorkshire region were consulted for permission to access the records of patients

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treated by secondary alveolar bone grafting over a 5-year period. To provide anonymity these five units were labelled A–E. Ethical approval was obtained and patients' details were retrieved from theatre records at the various units. All patients who had operations between 1st of September 1991 and 31st of August 1996 were included, except three edentulous patients grafted to facilitate placement of dental implants.

Recordings were made of the type of cleft involved, the age at the time of grafting, the timing of radiographs in relation to surgery, the identity of the operator, and the surgical technique used. Pre- and post-operative radiographs were examined to determine the outcome of the surgery. The majority of radiographs were occlusal views, with 18 sites having orthopantomograms (OPT's) pre-operatively and nine post-operatively. Patients with only OPT's post-operatively were excluded from the analysis, as image quality is frequently poor. However, nine patients with OPT's per-operatively were included in the analysis. There were 24 sites with no post-operative radiographs. For the analysis, patients whose only post-operative radiographs were taken within 3 months of the surgery were excluded, as further bony resorption can effect the final outcome (Lija *et al*., 1987). The pre-operative radiographs of all the subjects were taken a mean of 7·7 months prior to surgery (range 1–38 months), and the post-operative radiographs were a mean of 8·1 months after surgery (range 1–29 months).

The radiographs were assessed using a previously developed assessment scale (Kindelan *et al*., 1997). This is as follows:

Grade 1 = >75 per cent bony in-fill of the alveolar cleft
Grade 2 = 50–75 per cent bony in-fill of the alveolar cleft
Grade 3 = <50 per cent bony in-fill of the alveolar cleft
Grade 4 = No complete bony bridge

Enemark *et al*.(1987) recommended the use of a similar scale, based on the height of the interdental bone in the cleft area. However, this has the disadvantage that areas devoid of bone adjacent to the apex are not accounted for. Examples of results classified as grades 1–3 are shown in Figures 1–3. The pre and post-operative radiographs were viewed simultaneously to determine the grade of outcome for all patients with complete radiographic records. They were assessed on two separate occasions, at least 1 week apart. Where there was disagreement between the recordings, the radiographs were re-examined to determine the appropriate result.

In order to determine intra and inter-examiner reliability, the two authors assessed the radiographs of 31 patients from the study, on two separate occasions with 1 week between assessments. The results were analysed using the weighted kappa statistic (Cohen, 1960), and the values are displayed in Table 1.

These figures can be interpreted with reference to Landis and Koch's work (1977), which ascribed the following levels of agreement to the Kappa values;

0·00	Poor agreement
0·00–0·20	Slight agreement
0·21–0·40	Fair agreement
0·41–0·60	Moderate agreement
0·61–0·80	Substantial agreement
>0·80	Almost perfect agreement

These results show the level of intra-examiner agreement to be almost perfect, and the inter-examiner agreement to be substantial.

The frequency of presurgical orthodontics was significant. Two units routinely used orthodontic expansion if appropriate prior to bone grafting and one routinely carried out no orthodontic expansion. The other two units varied their approach depending upon which orthodontic consultant was involved in the patient's management. This study therefore provided an opportunity to compare the results of secondary alveolar bone grafting with and without presurgical orthodontic expansion.

FIG. 1 Grade 1 result: (a) pre-operatively; (b) post-operatively.

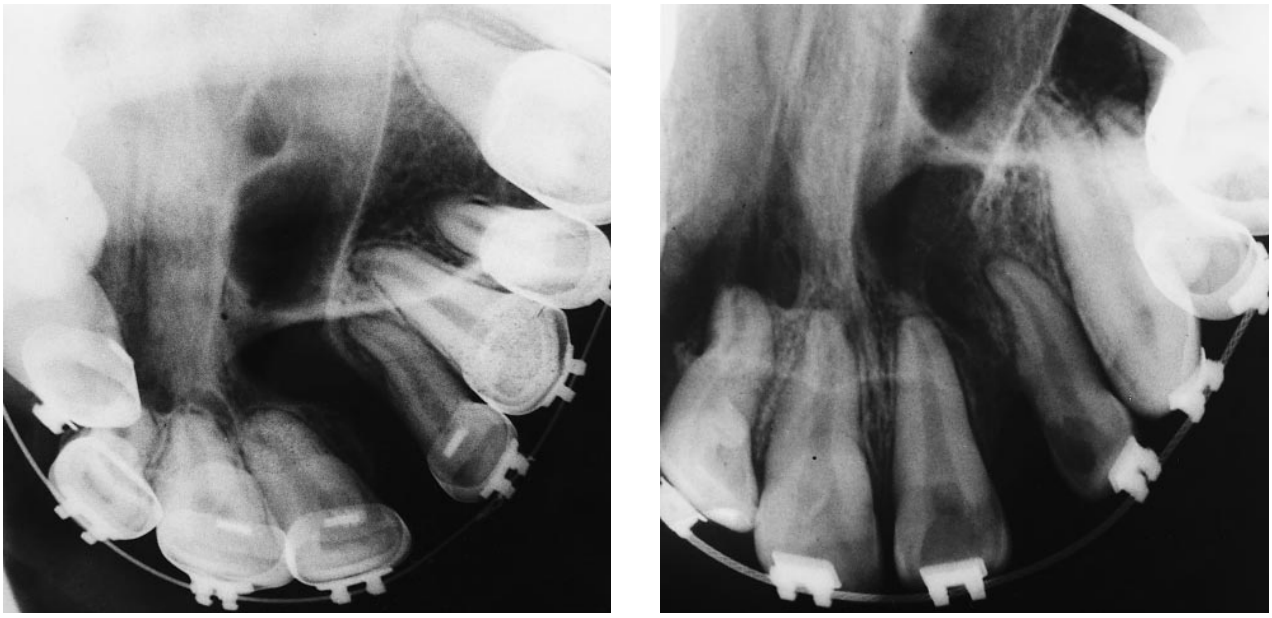

FIG. 2 Grade 2 result: (a) pre-operatively; (b) post-operatively.

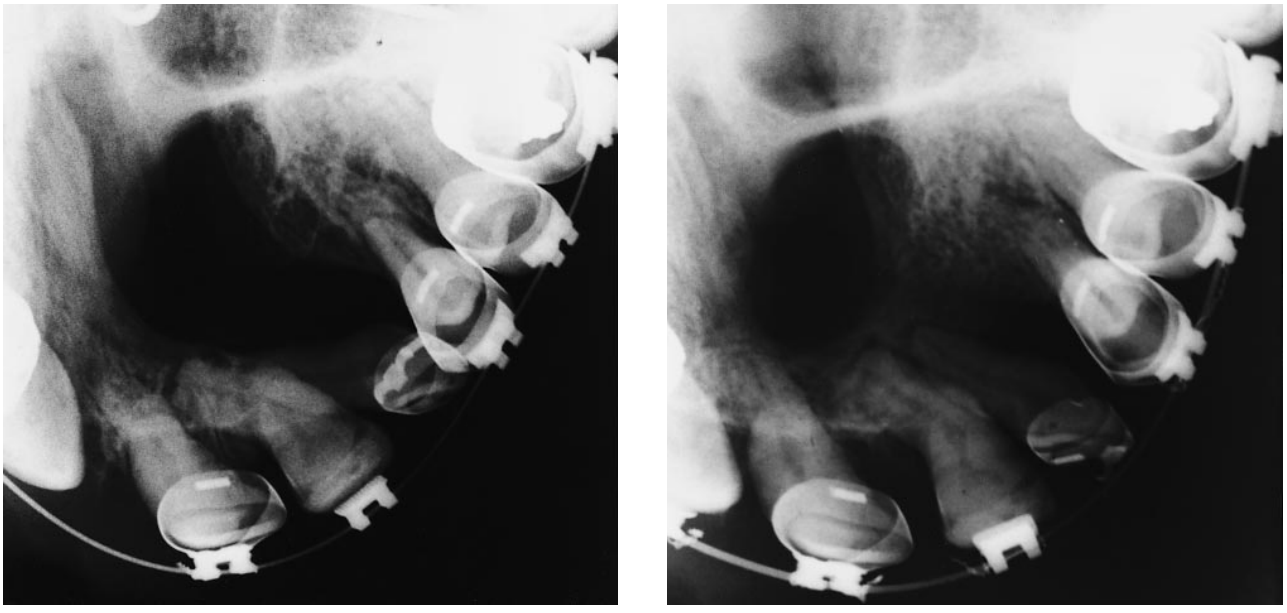

FIG. 3 Grade 3 result: (a) pre-operatively; (b) post-operatively.

Results

In the five units there was a total of 109 patients with 128 sites operated. Centres B and C operated on bilateral cases one side at a time, with some sites outside of the time period chosen. Centre E had one bilateral cleft patient in whom one side of the alveolus was intact. The distribution is shown in Table 2. Information regarding the specific type of clefting was not available for a significant number of patients and is therefore not quoted. There was wide variation in the frequency of operating, ranging from 13 to 35 sites in the five units. The mean age at grafting was 12 years and 4 months, ranging from 7 years 11 months to 28 years 11 months. The figures for each unit are displayed in Table 3. In three of the units most patients were approximately 10 years old, with a smaller percentage in their mid-twenties. The older patients were cases who had previously been lost to regular care. In unit D, the age range was narrower, but the spread of ages was more even and in unit E timing of surgery was almost ideal.

The surgical technique used in the five centres was largely uniform, and based on that described by Boyne and Sands (1972). Three units exclusively used this standard technique, and 93 per cent of all the bone grafts in this

review were performed in that manner. At unit A, all but one graft utilized the standard technique and one was performed simultaneously with a maxillary osteotomy. At unit D some variation in technique existed, 76 per cent were of the standard technique, 15 per cent utilized iliac crest fascia to repair the floor of nose and the remaining 9 per cent were carried out in conjunction with an osteotomy or using the inferior turbinate to repair the floor of nose. All operators harvested autogenous cancellous bone chips from the iliac crest. At unit B for approximately half the cases the bone was harvested using a trephine, although this has previously been shown not to affect the outcome assessed radiographically (McCanny and Roberts-Harry, 1998). Units B and C performed the grafts in bilateral cases in two stages.

A total of 12 surgeons in the five units were involved in alveolar bone grafting (Table 4). Only one unit had a single surgeon, three units performed joint procedures with two operators. The remaining unit had three surgeons each operating independently. The centres with joint teams tended to have one surgeon harvesting the bone, while the second surgeon prepared the graft site. It was not always clear from the operating notes which surgeon had which duty and the figures of sites per surgeon may, therefore, be falsely elevated. The mean number of sites grafted over the 5 years is 10·6 per surgeon, although there was wide variation, with two surgeons performing 33 and 35, respectively, and two surgeons performing only 1 bone graft each.

TABLE 1 *Weighted kappa values indicating levels of intra-examiner and inter-examiner reliability of the four-point radiographic assessment scale.*

	JK2	DRH1	DRH2
JK1	0·943	0·685	0·715
JK2		0·622	0·652
DRH1			0·818

TABLE 2 *Distribution of operated cleft sites between the units.*

Unit	No pts	No sites	Bilateral	Unilateral
A	18	20	4	14
B	22	26	7	15
C	26	35	10	16
D	30	34	4	26
E	13	13	1	12
Total	109	128	26	83

Statistical Analysis

Results for all unilateral cases were entered, and the bilateral cases had one site randomly selected for analysis to satisfy the assumption of independence between sites. This resulted in 78 sites being analysed (59 unilateral and 19 bilateral) and the results for each unit are displayed in Table 5.

In order to determine if any statistically significant difference existed between the different units' results, a Kruskal–Wallis one-way ANOVA was applied. However, this could not demonstrate a significant difference although numbers in some centres were low. The 78 cases provided a sample for comparison of results when orthodontic expansion was (38 sites) and was not (40 sites) used. These results (Table 6) demonstrate that the cases in which orthodontic expansion was used pre-operatively produced 63·2 per cent of grade 1 results. When no presurgical expansion was undertaken, only 40 per cent were in the grade 1 group of results. These figures were compared using a Mann–Whitney U-test and showed a significant difference at the 5 per cent level.

To determine the influence of the variables on the result of bone grafting, the data was submitted to logistical regression analysis. This analysis allows entry of two

TABLE 3 *The mean age and age range at the time of secondary alveolar bone grafting for the five units.*

Unit	Mean age	Age range
A	15 years 5 months	8 years 5 months to 28 years 11 months
B	11 years 2 months	7 years 11 months to 23 years 3 months
C	12 years 5 months	8 years 5 months to 27 years 6 months
D	12 years 7 months	8 years 6 months to 18 years 2 months
E	10 years 9 months	8 years 4 months to 14 years 4 months
Total	12 years 4 months	7 years 11 months to 28 years 11 months

TABLE 4 *Number of surgeons and their frequency of operating per surgical unit.*

Unit	No of sites	No of surgeons	Sites per surgeon
A	20	3	8, 11, 1
B	26	1	26
C	35	2*	35, 4
D	34	3*	33, 28, 1
E	13	3*	7, 4, 2
Total	128	12	
Mean	25·6	2·4	10·6

* Centres with joint surgical teams.

TABLE 5 *Results of secondary alveolar bone grafting in the five units.*

	Centre					
	A	B	C	D	E	Total
Grade 1	7 (53·8%)	12 (63·2%)	6 (40%)	12 (50%)	3 (42·9%)	40 (51·3%)
Grade 2	3 (23·1%)	4 (21·1%)	7 (46·7%)	7 (29·2%)	2 (28·6%)	23 (29·5%)
Grade 3	3 (23·1%)	3 (15·8%)	2 (13·3%)	5 (20·8%)	2 (28·6%)	15 (19·2%)
Grade 4	0	0	0	0	0	0

Kruskal–Wallis one-way ANOVA demonstrated no statistically significant difference between the results of the five different centres ($P = 0{\cdot}845$).

TABLE 6 *Grades of bone graft achieved with and without orthodontic expansion.*

	No Ortho	Ortho
Grade 1	16 (40%)	24 (63·2%)
Grade 2	14 (35%)	9 (23.7%)
Grade 3	10 (25%)	5 (13·2%)
Grade 4	0	0

Mann–Whitney *U*-test demonstrated orthodontically expanded cases had significantly better results ($P = 0{\cdot}0416$).

possible outcomes only, therefore, grade 1 was classified as success, and grades 2, 3, and 4 as failure. The analysis demonstrated outcome to be independent of age, hospital or if the cleft was unilateral or bilateral. However, when orthodontic expansion was analysed, the odds ratio for a successful graft was 1·6 (Table 7). That is, a patient receiving presurgical orthodontic expansion is approximately 1·6 times more likely to have a successful result of their alveolar bone grafting.

Discussion

This study was retrospective and relied heavily on the quality of clinical records available. The units in Yorkshire are currently working towards centralization and collect standardized records. However, this has not previously been the case. For many of the patients included in this study, the severity of the original cleft varied, as did the surgical technique used for primary repair. In addition, the timing of radiographs in relation to surgery varied between the units. These factors serve to undermine the quality of data being analysed and conclusions drawn should, therefore, be viewed with caution. It had also been hoped to assess the need for expansion from study casts of the occlusion. However, these were unavailable for many patients.

The relationship between the output and outcome for several general surgical procedures has been documented (Hannan *et al*., 1989). The evidence suggests that operators who perform a high number of a given surgical procedure will perform it to a higher standard than a low volume operator. Studies relating to cleft lip and palate care support this view (Shaw *et al*., 1992) and attempts have been made to influence cleft care in the light of these findings (Shaw *et al*., 1996), particularly following the recent CSAG report (Department of Health, 1998). Hannan *et al*. (1989) also showed that high volume hospitals performed better than low volume hospitals in some general surgical procedures. This point was previously made by Roos *et al*. (1986) who were in favour of centralization of general surgical services in Canada, although they showed the single most important factor in determining the level of post-surgical complications was the operators' surgical experience. The results of the present study show that centre B, the only centre with one dedicated surgeon, had the highest percentage of grade 1 results, although the difference was not statistically significant.

Williams *et al*. (1994) showed that one third of cleft surgeons in England and Wales performed less than five primary cleft repairs per year. This evidence must be evaluated against the knowledge that in 1994 the Standing Dental Advisory Committee to the Clinical Standards Advisory Group, suggested that a caseload of 40–50 cleft repairs each year would be desirable (Department of Health, 1994), although this was revised to 30 cases per year. It would seem logical to apply these figures to secondary alveolar bone grafting. Therefore, based on the results of this review, it may be appropriate for the bone grafting for the five units to be carried out by one surgeon or surgical team. Since this data was collected the five units are moving towards two nominated surgeons working as a dedicated team.

Asher-McDade and Shaw (1990) carried out a survey of 45 cleft teams in the United Kingdom. They found that centres had, on average, 10·2 new cleft patients per year with a range of 2–40 per year. Across the five units included in this study, approximately 60 new clefts are born each year, about 55 per cent of which would require bone grafts. Over a 5-year period this would be approximately 165 bone grafts. There were 128 grafts in the 5 years covered in this study, which suggests some patients may not have received bone grafting, because they had been lost to follow-up. Indeed, because of the significant age range in the sample it may be that more patients have been missed, and initial plans should be based on a 'catch-up' philosophy with greater numbers planned for.

Asher-McDade and Shaw (1990) also showed that over 70 per cent of cleft teams they surveyed combined orthodontic expansion with secondary alveolar bone grafting. The evidence of this review was that approximately half the patients were not expanded prior to the surgery. The difference in results obtained when orthodontic expansion was used was quite striking. Sixty-three per cent of orthodontically-expanded cases achieved a grade 1 result (i.e. greater than 75 per cent bony in-fill of the clef). However, only 40 per cent of the non-expanded cases achieved grade 1 result. This difference may be related to the improved surgical access following orthodontic expansion, particularly in facilitating closure of the floor of the nose. An improved repair to the floor of the nose would allow a more satisfactory placement of grafted bone chips, which may otherwise be lost per-nasally (Boyne and Sands, 1972).

This study sample displayed no demonstrable difference

TABLE 7 *Logistic regression analysis demonstrating odds ratio (and 95 per cent confidence intervals) for the effect of orthodontic expansion on the result of bone grafting.*

Variable	Regression coefficient	Standard error	Significance	Odds ratio	95% Confidence interval for odds ratio
Ortho	0·4722	0·2331	0·0427	1·6035	1·015–2.532
Constant	−0·0668	0·2331	0·7745		

in outcome of bone grafting when considering the age of the patient or the complexity of the cleft. These factors have previously been shown to have an influence on the result of grafting, with younger patients (Paulin *et al*., 1988; Brattström and McWilliam, 1989) and unilateral clefts (Sindet-Pedersen and Enemark, 1985) having better results. The results in this review may have been influenced by the large number of variables; different hospitals, with different surgeons, variable provision of orthodontic expansion, and the large age range will all have contributed to make the demonstration of differences difficult. The fact that relatively small groups were sampled only serves to compound these problems. A centralized care model should help to improve the quality of material available for research.

In comparison to previously reported studies of alveolar bone grafting, these results are favourable. Amanat and Langdon (1991), Long *et al*. (1995), and Kindelan *et al*. (1997) reported between 5 and 9 per cent of cases in which there had been failure to form a complete bony bridge across the cleft. This study demonstrated approximately 50, 30, and 20 per cent of grades 1, 2, and 3, respectively, with no complete failure of the grafts.

This study was retrospective and approximately 15 per cent of the 128 grafted sites had to be excluded from the final analysis, mainly due to incomplete radiographic records. This may have introduced bias into the sample, as cases which progressed unfavourably may not have been radiographed, thus falsely elevating a unit's overall performance. It is planned to prospectively study the provision of alveolar bone grafting in the Yorkshire region, with all units adhering to a standardised protocol of data collection.

Conclusions

1. The use of orthodontic expansion prior to secondary alveolar bone grafting, may result in greater degrees of bony in-fill to the alveolar cleft site, and is a variable that should be examined in future studies.
2. The four-point radiographic scale described demonstrates substantial inter-examiner agreement and almost perfect intra-examiner agreement as assessed by the weighted kappa statistic.

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