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Bilateral alveolar bone grafting: a report of 55 consecutively-treated patients

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SUMMARY A retrospective study was undertaken to evaluate the long-term results of bilateral alveolar bone grafting carried out at Great Ormond Street Hospital from 1983 to 1993. Fifty-five consecutive complete bilateral cleft lip and palate patients (36 males and 19 females) who had the operation were included in this study. The total number of cleft sites was 110. At the time of alveolar bone grafting, the mean age of the patients was 12.3 years with a range of 8.4–19.9 years. Cancellous bone from the iliac crest was grafted into the alveolar cleft areas. The cleft sites were studied in two groups according to whether the cleft canine had erupted prior to bone grafting or not. The erupted canine group was composed of 43 cleft sites and the unerupted canine group of 67 sites. At the time of this study, the cleft canine had subsequently erupted at 101 sites. Anterior occlusal radiographs were taken before and after bone grafting. The minimum period of observation after alveolar bone grafting was one year. Criteria described previously were utilized to assess the height of the interdental septum.

The results show that bone grafting before canine eruption has a higher clinical success rate compared with that carried out after canine eruption. The critical variable affecting the quality of bilateral alveolar bone grafting is the timing of the surgery.

Introduction

Facial dysmorphology in complete bilateral cleft lip and palate is often severe. The residual alveolar cleft is considered to be the main obstacle to obtaining optimum results (Bergland *et al*., 1986). Alveolar bone grafting in conjunction with orthodontic treatment has become a well accepted strategy. Secondary alveolar bone grafting helps to stabilize the maxillary segments and the mobile pre-maxilla in bilateral cleft cases (Matthews *et al*., 1970; Boyne and Sands, 1972, 1976; Åbyholm *et al*., 1981; Braun and Sotereanos, 1981; Sindet-Pedersen and Enemark, 1985; Paulin *et al*., 1988; Amanat and Langdon, 1991), to allow eruption of teeth into the cleft and to achieve orthodontic movement of teeth adjacent to the cleft site so as to obtain a non-prosthodontic rehabilitation (Johanson *et al*., 1974; Boyne and Sands, 1976; Braun and Sotereanos, 1981; Bergland *et al*., 1986; Amanat and Langdon, 1991). Compared with the unilateral cleft, bilateral cleft patients have several characteristics (Eppley *et al*., 1986), especially with the mobile pre-maxilla (Bergland *et al*., 1986). These features make bilateral bone grafting more difficult than unilateral grafting. This difference might affect the results obtained by bone grafting between the two groups. Some researchers have found the morbidity of bone graft to be greater in patients with bilateral cleft lip and palate (Hall and Posnick, 1983) and poor immobilization of the pre-maxilla in the post-operative phase contributes to the unfavourable consequence in bilateral cases (Åbyholm *et al*., 1981). It is therefore necessary to study bilateral cleft patients separately.

Timing and complications of alveolar bone grafting are two aspects of wide concern. However, surgical procedures for grafting an alveolar cleft defect should aim toward optimal physiological function, and lead to minimal interference and impairment of growth and development in the maxillofacial complex (El Deeb, 1990). In the 1970s, studies appeared suggesting that if bone

graft repair of alveolar clefts was delayed until the age of the mixed dentition, good function would result, and there would be much less effect on growth and development (Troxell *et al*., 1982). In order to minimize the negative influence on maxillary growth, most authors, perhaps with the exception of Rosenstein *et al*. (1982), agree that the optimal age for bone grafting is during the mixed dentition (Boyne and Sands, 1972, 1976; Koberg, 1973; Åbyholm *et al*., 1981; Nordin *et al*., 1983; Enemark *et al*., 1985; Bergland *et al*., 1986; Amanat and Langdon, 1991; Freihofer *et al*., 1993). Complications of alveolar bone grafting have been discussed (Bergland *et al*., 1986; Sindet-Pedersen and Enemark, 1988; Amanat and Langdon, 1991). The purpose of this investigation is to report the results of treatment of bilateral clefts in patients. It was also hoped that a factor(s) could be identified which improved the outcome of such treatments.

Subjects

The subjects in this study comprised 57 bilateral complete cleft lip and palate patients with grafting carried out at Great Ormond Street Hospital, London, England from 1983 to 1993. Two patients without radiographs at one or more years post-operatively were excluded. In this study, 55 patients (49 Caucasians, one Afro-Caribbean, four Asians, and one Oriental) with anterior occlusal radiographs at least 1 year post-alveolar bone grafting were included. The sex distribution was 36 males and 19 females. The total number of cleft sites was 110. The age range at the time of alveolar bone grafting was 8.4–19.9 years, mean 12.2 years.

The cleft sites were studied in two groups according to whether the cleft canine had erupted or not when alveolar bone grafting was performed.

1. The erupted canine group comprised 43 cleft sites. The age range of the patients at the time of the bone grafting was 10.5–19.9 years, mean 14.1 years.
2. The unerupted canine group comprised 67 cleft sites. The age range of the patients at the time of the bone grafting was 8.4–13.9 years, mean 10.9 years.

Method

Clinical management

Orthodontics, prior to and after the alveolar bone grafting, was undertaken. Pre-orthodontic treatment included maxillary expansion, proclination of upper incisors and closure of the space between upper incisors. Cancellous bone from the iliac crest was grafted into the alveolar clefts. Anterior occlusal radiographs were taken pre- and post-operatively. Follow-up radiographs were taken regularly. The evaluation was based on anterior occlusal radiographs. The follow-up period was between 1 and 10 years. The mean observation period was 3.8 years for the erupted canine group and 3.5 years for the unerupted canine group.

The criteria of evaluation

The height of the interdental septum was recorded according to the criteria of Bergland *et al*. (1986):

Type I: height approximately normal;
Type II: height at least 3/4 of normal;
Type III: height less than 3/4 of normal;
Type IV: failure: no continuous bony bridge across the cleft achieved.

Complications were also recorded.

Results

The eruption of the cleft canine

The cleft canine had erupted at 43 (39.1 per cent) sites and had not erupted at 67 (60.9 per cent) sites when the alveolar bone grafting was carried out. One-hundred-and-one (91.8 per cent) cleft canines had erupted at the time of this study. Nine (8.2 per cent) cleft canines remained unerupted when this investigation was undertaken. Radiographs showed that five (4.6 per cent) of the unerupted cleft canines were horizontally impacted and the long axis of the remaining four (3.6 per cent) canines was normal. The patients with normal long axis of unerupted canine were under 12 years of age.

The height of the interdental septum

The height of the interdental septum was evaluated after the cleft canine had fully erupted. One-hundred-and-one cleft sites with fully erupted canines were evaluated.

The whole sample

In complete bilateral clefts, the clinical success rate was 83 per cent (types I and II) and the clinical failure rate (types III and IV) was 17 per cent. The results are shown in Table 1.

The unerupted canine group

Ninety-five per cent of cleft sites were clinically successful (types I and II) and 5 per cent of cleft sites were clinically unsuccessful in the unerupted canine group (Table 2).

The erupted canine group

Sixty-seven per cent of cleft sites were clinically successful (types I and II), whereas 33 per cent of cleft sites were clinically unsuccessful in the erupted canine group (Table 2).

Complications

Four patients had infection of both graft sites resulting in complete failure of the alveolar bone graft. Three patients were in the erupted canine group and one patient was in the unerupted canine group. The oral hygiene of these patients was noted to be poor post-operatively.

Minor wound dehiscences appeared at one graft site. The cleft canine had not erupted at the time of alveolar bone grafting. Poor oral hygiene was noted as in the failed cases.

Three graft sites developed proliferative granulation tissue in two patients. One patient was in

Table 1 Analysis of the total sample of bilateral clefts.

Graft type	Cleft sites Canine in final occlusion (101)	
Type I	67 (66%)	84 (83%) Clinically successful
Type II	17 (17%)	
Type III	6 (6%)	17 (17%) Clinically unsuccessful
Failure	11 (11%)	

Table 2 Analysis of the cleft sites in the two different bone grafting groups.

Graft type	Clefts grafted after eruption of canine (43)		Clefts grafted before eruption of canine (58)	
Type I	16 (37%)	29 (67%)	51 (88%)	55 (95%)
Type II	13 (30%)		4 (7%)	
Type III	5 (12%)	14 (33%)	1 (2%)	3 (5%)
Failure	9 (21%)		2 (3%)	

the erupted canine group and the other was in the unerupted canine group.

Two patients showed exposed bone at four cleft sites after the operation. Ten years after the bone grafting, the radiographs showed that there was one failure site, two type III sites, and one type II site.

Donor site infection was found in two patients in the erupted canine group.

Discussion

Pre- and post-operative orthodontics

The main purpose of pre-operative orthodontics is to correct displaced maxillary segments and to provide improved access for the maxillofacial surgeon to perform bone grafting. This procedure is especially important in bilateral cleft cases. Nearly all patients in this study had undergone orthodontic treatment before alveolar bone grafting. In bilateral clefts, often, the upper incisors are retroinclined and both the buccal segments are collapsed. It is relatively easy to procline the upper incisors using removable appliances. Palatal expansion was carried out with removable appliances, but mainly with the quad-helix appliance. Expansion before the bone graft widens the cleft and thereby facilitates closure of the nasal mucosa (Hall and Posnick, 1983).

In bilateral cleft patients, a movable premaxilla may jeopardize the immediate healing process (Bergland *et al*., 1986). In this study, the pre-maxilla was immobilized for 3 months post-operatively so as to minimize the risk, by using fixed appliances. After alveolar bone grafting, ideally the cleft was clinically undetectable and post-surgical orthodontic treatment is similar to that obtaining in routine orthodontics. In some crowded cases, extraction of two malformed or poorly positioned upper lateral incisors seems more reasonable than the extraction of first premolars, because the malformation of the upper lateral incisors is relatively common in cleft lip and palate patients. During the post-operative orthodontic period, correct midline, and good arch form were obtained by moving the upper canines mesially. The crown of the canine can be modified to meet aesthetic requirements.

Cleft canine eruption

At the time of this investigation, most of the cleft canines had erupted. Only a few cleft canines were impacted. Radiographs showed that the long axis of these impacted canines was horizontal prior to the bone grafting. Spontaneous eruption could not be expected. Compared to 15 per cent retention of canines in bilateral clefts (Enemark *et al*., 1987), cleft canine retention was relatively rare in this study. Four further cases demonstrated cleft canines which had not erupted at the time of the study. In these cases, however, the radiographs showed that the long axis of the canines appeared normal and the age of these patients was under 12 years. It could be anticipated that these canines might erupt spontaneously in the future. According to this study, these results demonstrate that the canine retention was mainly due to the abnormal long axis direction, rather than the influence of alveolar bone grafting and occurred in only five cases.

Bone height at cleft site (Bergland et al., 1986, criteria)

The height of the interdental septum after alveolar bone grafting was considered to be the main indication of successful bone grafting. Long-term follow-up is needed to determine the final levels of bone associated with fully erupted canines (El Deeb, 1990). The osseous healing of transplants evaluated on intra-oral radiographs may be regarded as terminated within 6 months post-operatively in 80 per cent of the patients (Johanson *et al*., 1974). In this study, the minimum observation period was 1 year after alveolar bone grafting. The results in the whole sample showed that the clinical success rate in complete bilateral clefts was high (Table 1) and comparable with other studies (Bergland *et al*., 1986; Amanat and Langdon, 1991). However, this result is the combined outcome of bilateral cleft lip and palate patients treated before and after eruption of the cleft canine.

Several factors which might affect the final results of the alveolar bone grafting were investigated.

The state of eruption of the cleft canine at the time of bone grafting. Significant differences emerge when the whole sample is divided for study into two groups: the erupted canine group and the unerupted canine group (Table 2 and Figure 1). The unerupted canine group had a significantly higher clinical success rate than the erupted canine group. The type I (approximately normal interdental septal height) graft rate was much higher in the unerupted canine group than in the erupted canine group. The density of the bone in the cleft areas was the same as normal alveolar bone. The results suggest that bone grafting performed before canine eruption is highly successful and the critical variable affecting the quality of bilateral alveolar bone grafting is the timing of the surgery. This is in agreement with other studies (Bergland *et al*., 1986; Amanat and Langdon, 1991). The results of this study support the findings that bone grafting performed before canine eruption produces a better outcome than if the operation is performed after canine eruption.

Figure 2 shows the clinical appearance and post-operative radiographs of failed alveolar bone grafts after the canine had erupted, and Figure 3 shows the clinical appearance, and pre- and post-operative radiographs of a clinically successful case where bone grafting was undertaken before canine eruption.

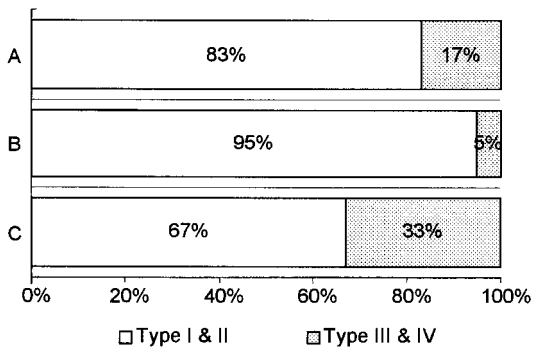


Figure 1 Success of alveolar bone grafting in BCLP cases, assessed by height of interdental septum, I + II: clinically successful; III + IV: clinically unsuccessful. (A) Combined early and late alveolar bone grafting (B + C pooled result). (B) Alveolar bone grafting before canine eruption. (C) Alveolar bone grafting after canine eruption.

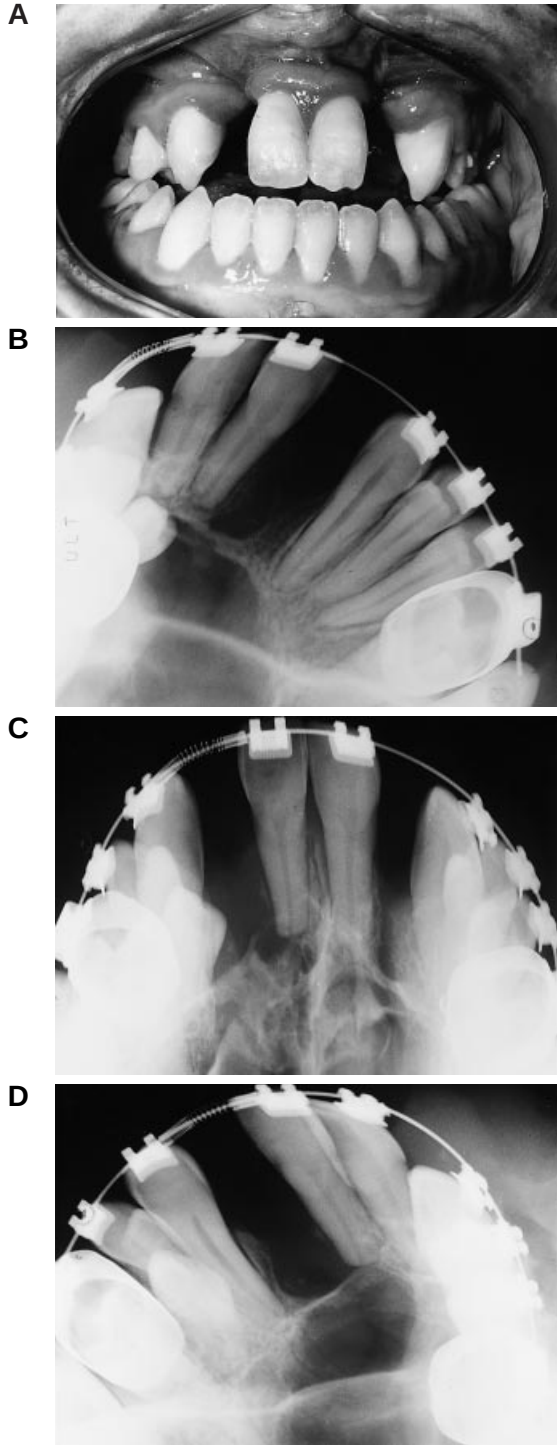


Figure 2 Failed alveolar bone grafting after the canine had erupted. (A) Clinical appearance. (B, C, and D) Post-operative radiographs.

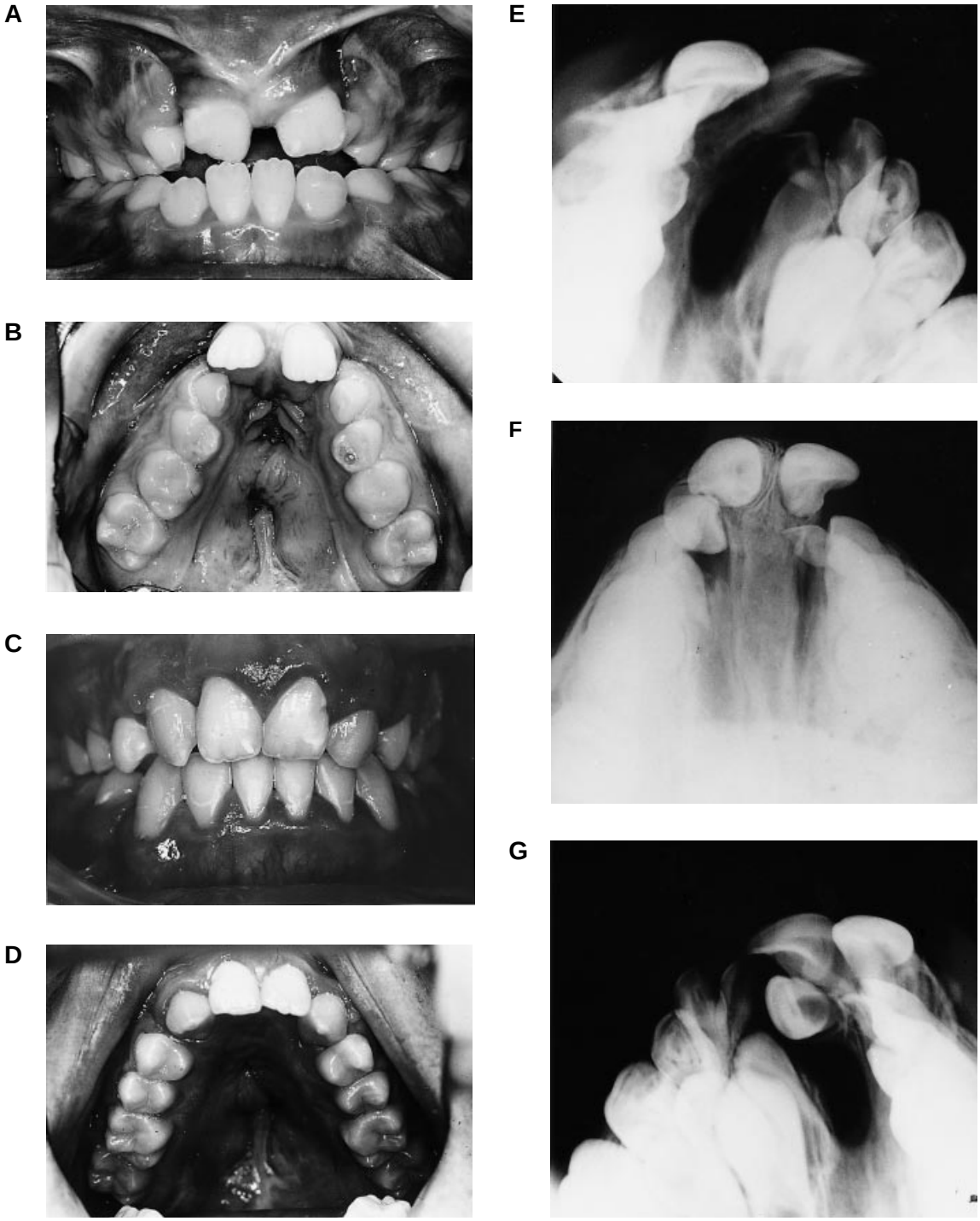
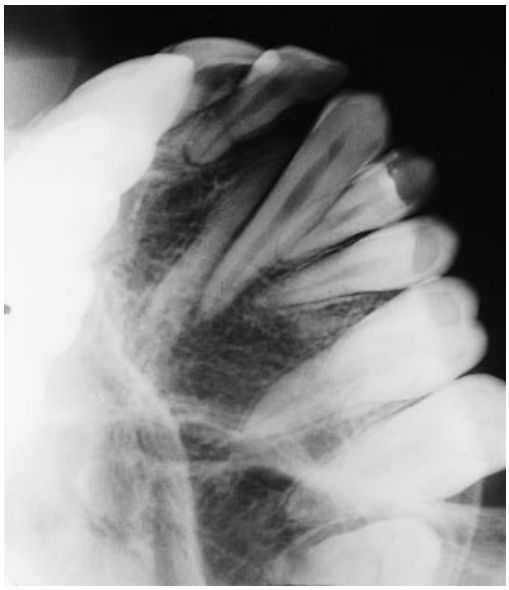


Figure 3 Successful alveolar bone grafting before the canine had erupted. (A and B) Clinical appearance prior to bone grafting. (C and D) Clinical appearance post bone grafting. (E, F, and G) Pre-operative radiographs. (H, I, and J) Post-operative radiographs.

Age at alveolar bone grafting. With increasing age, bony healing is impaired and graft success diminishes. This could be caused by changes in the healing potential with increasing age (Sindet-Pedersen and Enemark, 1985). The mean age of the patients who had type I bone grafts in the unerupted canine group was 10.7 years. These results support the view that bone grafting should ideally be performed between 9 and 11 years of age. Although chronological age might not be coincident with dental age, successful grafting before the canine erupts is more likely. This is in agreement with other authors (Boyne and Sands, 1972; Hall and Posnick, 1983; Bergland *et al.*, 1986; Paulin *et al.*, 1988; Kortebein *et al.*, 1991; Freihofer *et al.*, 1993). In order to avoid interfering

H



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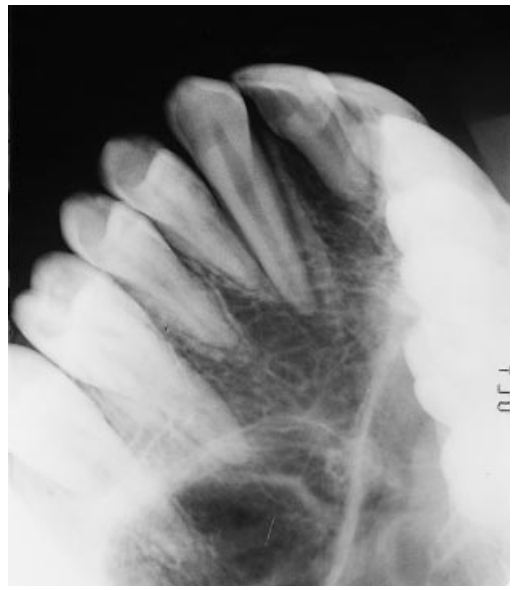

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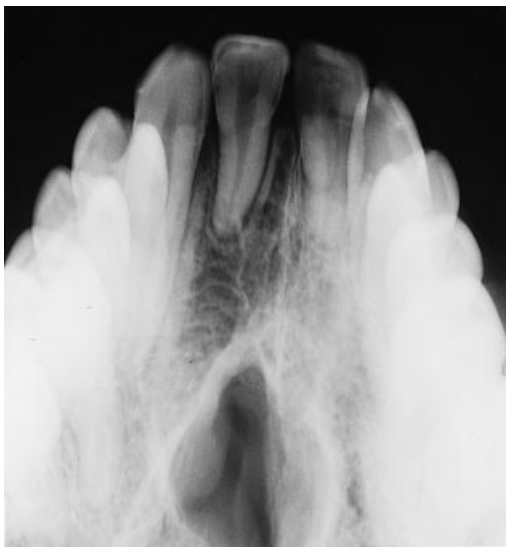

with maxillary growth, it is not recommended to perform the osteoplasty before 8 years of age (Bergland *et al*., 1986).

Infection. Alveolar bone graft infection was found in four patients. Three of them were in the erupted canine group and one was in the unerupted canine group. It caused eight bone grafts to fail completely. Two years later, one of the failed cases was regrafted. Oral hygiene was improved and no infection was found post-operatively. These two bone grafts were totally successful. Anterior occlusal radiographs showed that the height of the interdental septum was normal (type I).

Oral hygiene is one of the factors related to infection, and good oral hygiene should be emphasized. Oro-nasal communication frequently causes a gingival inflammation in the cleft area, due to secretion from the nasal cavity (Enemark *et al*., 1985). Other authors have also found that immediate post-operative infection leads to a greater incidence of eventual resorption of the graft (Johanson *et al*., 1974; Lilja *et al*., 1987).

Shortage of tissue. Bilateral cleft lip and palate is considered to be a more severe craniofacial deformity than unilateral cleft. The relative amount of soft tissue to cover the transplant is less in bilateral than in unilateral cleft cases. This is probably an important factor influencing the treatment results (Sindet-Pedersen and Enemark, 1985). In this study, two patients had exposed bone at both cleft sites after surgery. Ten years later, radiographs showed that there was one failure, two type III grafts, and one type II graft site. In bilateral clefts, shortage of tissue and increased tension at the cleft site might have caused the exposed bone which subsequently affected the results of the alveolar bone grafting.

Other factors affecting outcome. In this study, 17 per cent of graft sites were type III and failed. This result is less than the 21.4 per cent in a previous report (Collins *et al*., 1998). At the start of the programme in 1983, a significant proportion of patients presented for surgery when the canines had already erupted. As the programme continued, the number of such patients diminished; therefore, in latter years, the vast majority of the patients presented for surgery when the canines had not erupted. This would account for the improvement in results as the programme developed. The team's experience in managing these cases, might be a further factor affecting the results of the alveolar bone grafting in bilateral clefts. However, no significant difference was found between the success rate of the early and late alveolar bone grafting cases.

Main complications

Minor wound dehiscences. Minor wound dehiscences were not common in this study. It was found at one graft site in one patient whose canine had not erupted at the time of alveolar bone grafting. The cleft site healed well 4 weeks after the alveolar bone grafting. Two-and-half years after alveolar bone grafting, the anterior occlusal radiographs showed that the interdental septal height was normal (type I). The reason for wound dehiscences was related to poor oral hygiene.

Proliferative granulation tissue. Proliferative granulation tissue developed at three graft sites in two patients. After a 2-week topical application of silver nitrate, the proliferative granulation tissue was treated successfully.

Donor site. Cancellous bone can be harvested from many sites (Freihofer *et al*., 1993). However, iliac crest is the most commonly used site for alveolar bone grafting (Bergland *et al*., 1986) and was used in all the patients at the Great Ormond Street Hospital. Donor site infection was found in two patients 3 weeks after surgery. Antibiotics were prescribed and the donor site healed completely 6 weeks after bone grafting.

Conclusions

The results of the bilateral alveolar bone grafting performed before the canine eruption had a higher clinical success rate (types I and II, 95 per cent) and lower clinical failure rate (types III and IV, 5 per cent). When it was carried out after the canine eruption, the clinical success rate was lower (types I and II, 67 per cent), and the

clinical failure rate was higher (types III and IV, 33 per cent).

The critical variable affecting the quality of bilateral alveolar bone grafting is the timing of the surgery.

Cleft canine retention was not common in this study and was mainly due to an unfavourable axial inclination rather than any influence of alveolar bone grafting.

No severe complications were found during and after alveolar bone grafting.

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