Canine Eruption Into Grafted Bone In Maxillary Alveolar Cleft Defects

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Forty-six patients with clefts of the alveolus who had received alveolar bone grafts (secondary osteoplasties) at ages 7–14 years, were studied. A total of 64 affected canines from 18 bilateral and 28 unilateral alveolar cleft patients was available. Follow up orthopantomographs were examined to determine the state of root development and spontaneous canine movement through the grafted site. The postoperative observation period ranged from 2–8 years (mean 4.3 ± 1.5). All test canines erupted through the graft. Spontaneous eruption occurred for 27% of test canines, 17% required surgical uncovering (either bony or soft tissue), and 56% required surgical uncovering and orthodontic assistance to accomplish eruption. All patients required orthodontic treatment to accomplish arch alignment. The prognosis for canine eruption through a graft site is most favorable if the graft is performed at ¼–½ canine root formation and when the patient is aged 9–12 years. The post graft observation period is very important and requires complete cooperation between the orthodontist and the surgeon.

KEY WORDS: Bone grafting, tooth eruption, root formation, cleft alveolus

Introduction

The management of patients with cleft lip and palate has improved remarkably in the past two decades. However, despite the development of the interdisciplinary team, many such patients continue to be seen with residual alveolar cleft defects and associated oronasal fistulae following closure of the cleft lip and palate. The residual osseous clefts present a problem for the clinician faced with the restoration of function and esthetics to the area.

The first attempts at bone grafting in growing cleft patients were performed by Lexer (1908) and Drachter (1914). Since then, opinions continue to differ on the indication, timing and management of maxillary bone grafting. Early bone grafting has received wide support in the literature (Backdahl and Nordin, 1961; Stellmach, 1963; Muir, 1966; Monroe *et al*, 1968; Robinson and Wood, 1969; Schmid *et al*, 1974; and Nylen *et al*, 1974). However, the deleterious effects of early intervention on the subsequent growth of the max-

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Presented at the 37th Annual Meeting of the American Cleft Palate Association, Lancaster, Pennsylvania, May 28–June 1, 1980.

illary complex have now been well documented (Robertson and Jolleys, 1968; Pickrell *et al*, 1968; Rehrmann *et al*, 1970; and Jolleys and Robertson, 1972). Bone grafting delayed until after eruption of the secondary dentition is now a more widely accepted procedure (Stenstrom and Thilander, 1963; Boyne and Sands, 1972; Hogeman *et al*, 1972; and Johanson *et al*, 1974).

The indications for closure of the alveolar clefts depend primarily upon the size and location of the cleft. Advantages cited include increased stability of the maxillary components in the corrected position if associated with maxillary osteotomies (Backdahl and Nordin, 1961), restoration of the alveolar arch (Skoog, 1965), and stabilization of the premaxilla in the bilaterally clefted palate patients (Pickrell *et al*, 1968). Elevation of the nasal alar base results in an improved lip line and enhanced cosmetic appearance (Pickrell *et al*, 1968; Epstein *et al*, 1970). Dentally related indications include prevention of arch collapse (Epstein *et al*, 1970), closure of oronasal fistulae (Epstein *et al*, 1970), and creation of a new alveolus for the eruption of teeth in the clefted area (Jolleys and Robertson, 1972; Boyne and Sands, 1972; Johansen *et al*, 1974).

Common dental findings in these patients in the area of the cleft include congenitally missing teeth, early loss of deciduous teeth and altered patterns of calcification and eruption. When the permanent lateral incisor is present it is usually located along the side of the bony defect and the permanent canine is usually situated either at the distal margins of the residual alveolar cleft or displaced superiorly along the bony defect. Pickrell and co-workers (1968), in closing the anterior alveolar defect with an autogenous rib graft simultaneously with the closure of the cleft lip, reported that the teeth did not erupt spontaneously through the graft and concluded that rib bone grafts do not form a true alveolar process and a permanent alveolar notch remains. More recently, Boyne and Sands (1972) suggested closing the anterior alveolar cleft when the patient is between 9 and 11 years of age, just before the full eruption of the canine teeth, in order to promote their subsequent eruption. In spite of the recognition that teeth may grow through newly grafted bone in the alveolar cleft, the literature appears to be devoid of any systematic studies of the management of tooth eruption through grafted bone in cleft palate patients.

The purpose of the present study was to examine the effect of secondary osteoplasty on the subsequent calcification and management of the eruption of the permanent canines through the graft sites in patients with unilateral and bilateral clefts of the alveolus.

Materials and Methods

SELECTION OF PATIENTS AND TEETH: Between the years 1970 and 1980, secondary osteoplasties were performed in the University of Minnesota Department of Oral and Maxillofacial Surgery on 150 patients age seven to 48 years, utilizing a flap incision and autogenous hip bone grafting, as described by Broude and Waite (1974). The management of each patient was planned and monitored by the University of Minnesota Cleft Palate Team, and the orthodontic treatment was performed by either the Orthodontic Department of that institution or by a private orthodontist.

Forty-six Caucasian patients (32 males, 14 females) had received alveolar bone grafts between the ages of seven and 14 years (Table 1). Clefting of the lip and alveolus (no palate involvement) was present in four patients, and clefting of the lip, alveolus and palate occurred in the remaining 42 patients. Both unilateral ($n = 28$) and bilateral ($n = 18$) cleft patients were included.

In each patient the alveolar cleft extended between the canine and the lateral incisor (or its expected location). Considerable variability was observed in the condition of the lateral incisor (congenitally missing, extracted, or erupted at the time of grafting) and therefore the focus of the study was the maxillary canine. In all cases at the time of grafting both maxillary canines were present but unerupted and the canine associated with the cleft was located high in the alveolus. This tooth was designated the test canine while the contralateral canine in unilateral cleft patients was designated the control canine.

For each patient, preoperative, postoperative, and annual follow-up extra-oral radiographs (orthopantomographs) were available. The radiographic record for each patient extended from the pregrafting stage until com-

TABLE 1. Distribution of Maxillary Alveolar Cleft Patients and Maxillary Canines Studied (46 patients: 32 males, 14 females)

Location of Cleft	*Distribution of Patients and Canines*		
	Patients	*Test Canines*	*Control Canines*
Unilateral Cleft Lip and Alveolus	2	2	2
Cleft Lip, Alveolus and Palate	26	26	26
Subtotal	28	28	28
Bilateral Cleft Lip and Alveolus	2	4	—
Cleft Lip, Alveolus and Palate	16	32	—
Subtotal	18	36	—
Total	46	64	28

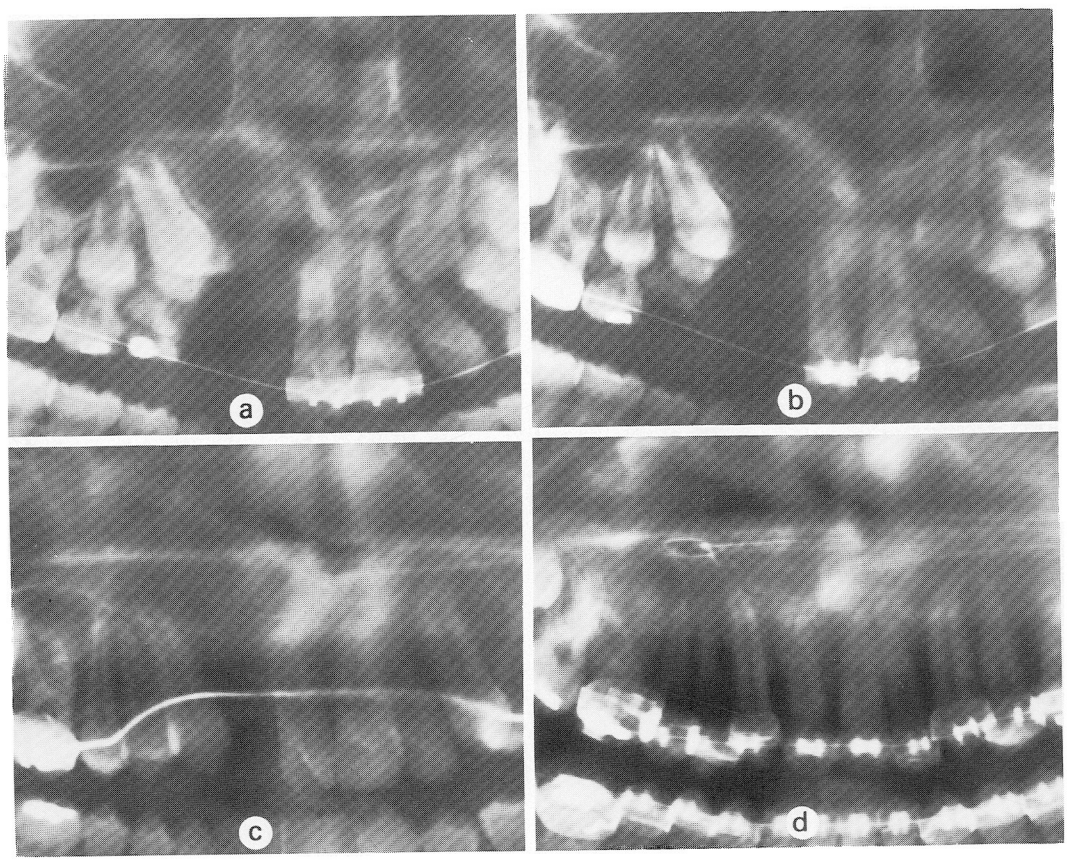

FIGURE 1. a. Preoperative orthopantomograph x-ray. Notice the width of the alveolar cleft area and the position of the canine in relation to the cleft area. b. Five months after alveolar cleft repair using autogenous bone graft. c. Three years after alveolar cleft repair. Notice canine completed eruption into the mouth, and complete root formation, also the gap between the right central incisor and the canine as a result of the congenitally missing lateral incisor. d. Four years after alveolar cleft repair. Orthodontic treatment has been utilized to close the gap between the right central incisor and the right canine and to align the patient's teeth.

plete eruption of both maxillary canines. Figure 1 shows a typical case of canine eruption through the bone graft. The observation periods ranged from two to eight years (mean 4.3 ± 1.5 SD). The stage of crown and root development was recorded at the time of grafting and at each follow-up examination for both test and control canines.

CRITERIA FOR CANINE DEVELOPMENT AND ERUPTION: In all cases the crowns of the test

and control canines were fully developed on pre-grafting radiographs. Root development was evaluated using a modification of the radiographic scoring systems of Moorrees et al (1963), and Liliequist and Lundberg (1971) (Figure 2). The apparent length of root calcification was measured with calipers (± 0.5 mm) and compared with the crown length on the same radiograph and a score of 0–6 assigned in accordance with the criteria shown. The test canines were scored for their position relative to the graft as follows: A: no movement; B: located at the superior border of graft; C: in midgraft; D: through the inferior border of graft; E: clinically erupted into the oral cavity, and F: fully erupted and correctly aligned relative to adjacent teeth. A canine was considered within a given stage until it had reached the beginning of the next stage. All scoring was done by one investigator (MEID), verified by a second (LBM). Whenever the stage was in doubt, the lower one was chosen consistently.

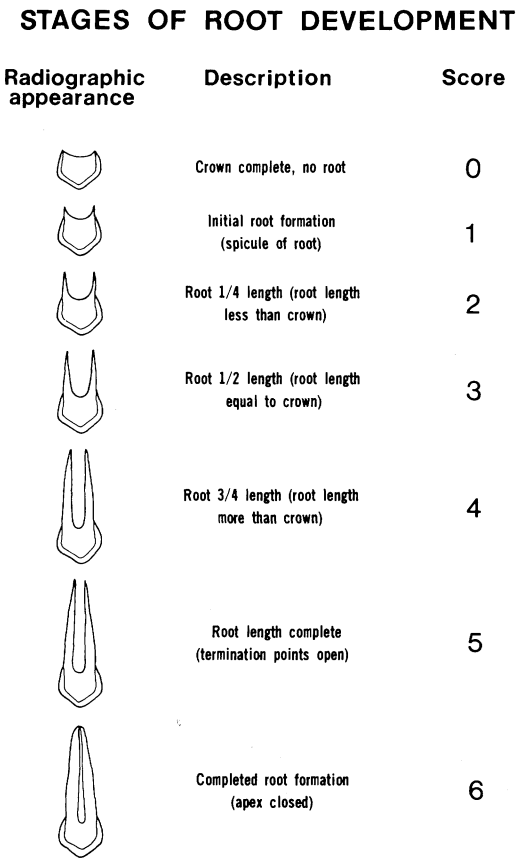

FIGURE 2. Criteria for radiographic scoring of canine root development, (modified after Moorrees et al (1963), and Liliquist and Lundberg, (1971).

The radiographic records (54 orthopantomographs) of 10 randomly selected patients (22% of total sample of patients) were reexamined as above to assess investigator reproducibility according to the method of Davies et al (1967). For 96% of the radiographs there was complete agreement on the stage of calcification at both first and second evaluations; complete agreement was 88% for the state of eruption. In no case did the second score vary from the first by more than one developmental stage for root development and one scoring unit for canine eruption.

Statistical Treatment of the Data: The Student's t test for paired data was used to compare the test and control canines in unilateral cleft patients for the mean stage of canine root development at time of grafting and at time of eruption, and also for the length of time required to reach full eruption. The Student's t test for unpaired data was used to compare males and females in the unilateral cleft patients for the mean stage of canine root development at time of grafting and at time of eruption, the mean ages in years at the time of eruption, and the length of time required to reach full eruption. The data were examined for statistical significance at a probability level of 0.05.

Results

Age and Stage of Canine Development at Grafting: Patients ranged from seven to 14 years (mean 10.1 ± 1.6 S.D.) at the time of grafting, with 34 patients (73% of sample) between nine and 12 years (Table 2).

Table 3 shows the distribution of canines with respect to root development at the time of grafting. The mean stage for root development for all test canines was 2.4 ± 1.1 S.D. Most of the test canines (65% of total) were at stages 2 and 3 (length of root less than or equal to the crown length). The mean stage for root development for all control canines was 2.9 ± 1.4 S.D. while 57% were at stages 2 and 3.

In the unilateral cleft group the test and control canines were at a similar stage of root development in 19 patients, and in nine patients the control canines were one stage in

TABLE 2. Age of Patients at Time of Maxillary Alveolar Cleft Grafting

Location of Cleft (no.)	*Distribution of Patients and Age Range at Time of Grafting*			
	7–8 yrs	*9–10 yrs*	*11–12 yrs*	*13–14 yrs*
Unilateral (28)	4	16	5	3
Bilateral (18)	2	9	4	3
Total	6	25	9	6

TABLE 3. Stage of canine root development at time of maxillary alveolar cleft grafting

Distribution of Canines	*Distribution of Patients and Root Development Stages at Time of Grafting**					
	0	*1*	*2*	*3*	*4*	*5*
Test Canines						
Unilateral (28)	3	2	11	3	6	3
Bilateral (36)	0	5	19	9	3	0
Total Test Canines (64)	3	7	30	12	9	3
Control Canines						
Unilateral (28)	0	3	10	6	4	5

* Refer to Figure 2 for criteria for each stage.

advance of the test canine. There were no instances in which the test canine was ahead of the control canine in root development. There were no statistically significant differences between stages of root formation between the test (2.6 ± 1.4) and the control canines (2.9 ± 1.4). Males (n = 20) and females (n = 8) did not differ significantly (2.7 ± 1.4 vs 3.5 ± 1.4) for the stage of root development at time of grafting.

In the bilateral cleft group, the right and left canines were at the same stages of root development at the time of grafting.

AGE AND STAGE CANINE DEVELOPMENT AT ERUPTION TIME: As determined radiographically, none of the test and control canines showed abnormalities of crown or root morphology and all erupted into the oral cavity. Complete root formation (with either open or closed apex) occurred for all canines. The mean age at the time of eruption of the test canines (achievement of stage E) was 13.5 years ± 1.6 S.D. No statistically significant difference was observed between males (13.7 ± 1.6) and females (13.4 ± 1.5).

In the unilateral cleft group, the test canines erupted later than the control canines (mean age at eruption 13.4 ± 1.9 S.D. vs. 12.3 ± 1.4 S.D.); this difference was statistically significant ($p < 0.05$). The mean stage of root formation at the time of eruption was 5.3 ± 0.5 S.D. for the test canines, and 5.2 ± 0.7 S.D. for the control canines, which, was not a statistically significant difference. Males (n = 20) and females (n = 8) did not differ significantly (5.1 ± 0.7 S.D. vs. 5.4 ± 0.9) for stage of root development at time of eruption.

In the bilateral cleft group, the mean age at time of canine eruption (14 yrs) and the stage of root development at time of eruption (5.4) was similar for both the right and left maxillary canines.

LENGTH OF TIME FOR CANINE ERUPTION THROUGH GRAFT: The mean length of time required for all test canines to erupt through the graft (i.e., move from stage A to stage E) was 3.4 years ± 1.6 S.D. In the unilateral cleft group, the mean length of time for this movement was 3.3 years ± 1.5 S.D. for the test canines and 2.2 years ± 1.9 S.D. for the controls. This difference was statistically significant ($p < 0.05$).

POST GRAFT TOOTH MANAGEMENT: A summary of post-graft canine management is shown in Table 4. Spontaneous eruption of 17 test canines occurred (27% of sample), 11

TABLE 4. Management of Test Canines Subsequent to Maxillary Alveolar Cleft Grafting

Distribution of Canines	*Treatment Required to Accomplish Eruption*		
	None	*Surgical Uncovering*	*Surgical Uncovering and Orthodontic Assistance*
Unilateral (28)	5	4	19
Bilateral (36)	12	7	17
Total (64)	17	11	36

(17%) required surgical covering (either of bone or soft tissue), and 36 (56%) required surgical uncovering and orthodontic assistance to accomplish eruption. A considerably greater proportion of canines in unilateral cleft cases required both surgical uncovering and orthodontic assistance to accomplish eruption than in bilateral cases. All of the control canines erupted through the alveolar bone without assistance.

Discussion

A retrospective study based on radiographic and clinical records clearly suffers a number of disadvantages. Since the post-surgical films were taken annually, the recording of root development stages and progression of eruption are at best only estimates. Since photographic records were not taken, as would be possible in a prospective study, verification of the radiographic and written clinical records was not possible. In addition, the use of radiographs taken under similar conditions but not standardized for each film and each patient introduces further error into the magnification distortion already recognized as occurring in orthopantomographic films (Lund and Manson-Hing, 1975). Nevertheless, the study represents a unique opportunity to collate longitudinal clinical data on a number of patients all receiving the same surgical management prior to completion of the permanent dentition.

The identification of dental calcification from radiographs has been used by others (Nolla 1960; Moorrees *et al* 1963; and Liliequist and Lundberg 1971). The disadvantage of dependence on such radiographic standards is the inherent magnification and distortion of radiographic images. In order to overcome the nonstandardization of radiographs and the magnifications, the crown of the same tooth was used as the reference point since it was reasoned that the crown and root would be subject to the same distortion, with a similar distortion on the contralateral tooth occurring in the bilateral cases.

Recording the progress of the test canine through the bone graft poses similar problems of subjectivity. In the radiographs taken immediately post-grafting and at one year afterwards, the superior border of the graft was radiographically discernible but thereafter was indistinguishable from surrounding bone. It is of interest that, without exception, all test canines had entered the graft (i.e. achieved at least stage C) within one year of grafting.

Based on the radiographic evaluation of all the test and control canines, neither the crowns nor the roots were affected morphologically by the surgical procedures. The calcification of teeth in the alveolar cleft line may be influenced by the surgical procedure or by the bone graft (Trusler *et al* 1957, Dixon 1968).

The present findings suggest a tendency for canines on the cleft side to be somewhat slower in eruption than teeth on the non-cleft side. This supports the observations of Fishman (1970). He also stated that the bilateral cleft lip and palate group demonstrated the highest incidence of delayed eruption of teeth, followed in order by posterior clefts, unilateral lip and palate clefts and lip and alveolar clefts. Delayed eruption in both dentitions on the side of the cleft was also noticed by Ranta (1971).

On the other hand, Haring (1976) reported no difference between eruption of individual teeth and their antimeres in a sample of cleft palate and non-cleft palate patients. Delayed eruption may reflect the lack of eruptive direction for teeth in cleft areas due to disruption of the normal gubernacular epithelial relationship to the primary predecessor (Carollo *et al*, 1971), by either the defect or the surgical intervention. The findings in the present study, however, suggest that the delay is

slight and support the observations of Boyne and Sands (1972).

While recognizing the best time for grafting will vary from patient to patient, we consider that the age range of 9 to 12 years, when the canine root is ¼ to ½ formed, has an excellent prognosis for tooth eruption. In the present study in this age range no marked differences were seen between test and control canines in the extent of root-development at the time of grafting and all test canines proceeded to complete root development. This opinion supports that of Boyne and Sands (1972), who suggested closing the anterior alveolar cleft when the patient is between 9 and 11 years of age. Matthews et al (1970), however, considered the optimum age for later bone grafting to be 18 years, since post operative occlusal changes are less likely in the mature patient. We believe that if surgery is performed after the age of 18 years, this may lead to the loss of those teeth adjacent to the alveolar defects, especially the canine and lateral incisor teeth. In addition, a periodontal defect may develop in adults with increasing loss of bone next to the osseous margins of the cleft (Boyne and Sands, 1976). Thus, the ability to graft bone successfully in the alveolar cleft defect in adults becomes more complicated.

Using the autogenous hip graft as donor site at this age does not appear to predispose towards the formation of residual alveolar notches. Such notches have been reported subsequent to the use of a rib graft as a donor site for closing 25 cases of alveolar cleft defects at age of 2 and 6 months by Pickrell *et al* (1968) and by Epstein *et al* (1970). In their opinion, rib grafts do not form a true alveolus; proliferation of the alveolar process does not occur until eruption of the secondary dentition and early grafting may leave a permanent notch in the maxilla. Schmid (1964) is of the opinion that implanted bone graft in the alveolar cleft tends to atrophy in infants because of functional disuse. Longacre (1966) stated that a rib graft maintains its original structure embedded in an overlay of new bone similar to that of the host site, so that subsequently teeth may not erupt through the rib graft because it contains excessive cortical bone.

In this study, teeth erupted spontaneously through an autogenous hip graft. It is of particular interest 27% erupted without surgical or orthodontic intervention. This may well be an underestimate of unassisted eruption since early surgical and orthodontic assistance was readily available to accomplish tooth positioning when it appeared appropriate to do so, rather than wait for delayed eruption.

Conclusions

On the basis of the present study it is concluded that:

1. The ideal time for performing alveolar bone grafting to patients with a cleft alveolus varies from patient to patient. Grafting is highly successful in the age range 9 to 12 years when the canine root is ¼ to ½ formed.
2. Canine teeth can migrate and erupt spontaneously through autogenous iliac crest bone grafting.
3. Canines in the cleft area will subsequently have a normal root development provided there were no developmental disturbances.
4. Canines will erupt later than normal into grafted alveolar defects and a longer time will be required for their eruption through the bone graft.
5. Surgical and orthodontic intervention is often required for complete eruption.

Acknowledgment: The authors wish to acknowledge the highly valuable contributions made towards this study by the following individuals and University of Minnesota departments: the Chairman, Dr. Michael Speidel, and the faculty members of the Department of Orthodontics for the orthodontic treatment of the cases studied; the Chairman, Dr. Karlind Moller, and the members of the teams of the Cleft Palate Clinic, and to the Pediatric and Plastic surgeons for assisting in obtaining the bone for these surgical procedures and Farida Tawfik for the statistical analysis of the data in this study.

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