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RESEARCH ARTICLE

OUTCOME OF ALVEOLAR BONE GRAFTING IN CLEFT LIP AND PALATE PATIENTS – THE RECIPIENT SITE ASSESSMENT

***[1]Dr. Nalisha Mohamed Ramli and [2]Dr. Siti Mazlipah Ismail**

[1]Oral and Maxillofacial Surgery, Faculty of Dentistry, Islamic Science University of Malaysia, (USIM)
[2]Department of Oro-Maxillofacial Surgical and Medical Sciences, Faculty of Dentistry, University of Malaya

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ABSTRACT

Purpose of the Study: A retrospective cross sectional study to determine the recipient site outcome of alveolar bone grafting in cleft lip and palate patients.
Material and Method: All patients operated between 1st January 1999 until 31st December 2009 who fulfilled the inclusion and exclusion criteria were included in this study. The recipient sites were the alveolus clefts. Medical records, radiographs, clinical findings and interviews were used as the study instruments.
Result: The overall success rate of alveolar bone grafting is 54.9% with a higher success rate noted in patients between the age of 6 to 8 years old, in unilateral cleft lip and palate patients, before the eruption of maxillary canine, before the completion of maxillary canine root formation. A significant statistical relationship was noted between the type of cleft and the outcome of surgery.
Conclusion: Alveolar bone grafting procedure is an integral component of the management of patients with cleft lip, alveolar and palate in establishing the integrity of the alveolar cleft defect, enabled the alignment of dentition and allowed overall oral rehabilitation. A favourable treatment outcome is achievable with minimal associated postoperative complications that were usually well tolerated and manageable.

INTRODUCTION

Seven hundred children are born each day with cleft lip and/or cleft palate in the world (Lam *et al*., 2007). In Malaysia, one of the earliest data collection reported that the incidence of cleft lip and palate was 1.54 per 1000 live birth among Malaysians (Stevenson *et al*., 1966). A survey done by the Ministry of Health Malaysia, 1997 reported the incidence of cleft lip and palate is 1 per 941 live births (MOH, 1997). Alveolar bone grafting with anterior iliac bone crest harvesting is an accepted procedures in the management of alveolar cleft in many cleft centres. The alveolus cleft contributed to various problems including oronasal fistula, malposition of teeth, loss of periodontal support, abnormal tooth morphology, speech deformity, poor alar base support, nasal crusting and insufficient bone for orthodontic treatment or prosthetic rehabilitation (Chowdhury *et al*., 2006). It may also leads to hypertrophy of the inferior turbinate and septal displacement contributing to airway problems (Mathews *et al*., 1970). The modern concept of bone grafting was pioneered by Axhausen in 1951 (Rosenstein, 2003). An array of bone grafting techniques were then introduced including the secondary alveolar bone grafting at mixed dentition stage introduced by Boyne and Sands in 1972. There are many protocols proposed for the comprehensive management of cleft lip and palate from birth to adulthood. The Oslo Surgical Protocol is one of the examples which is adapted by many cleft centres (Shaw *et al*., 1992). In the University of Malaya we follow the protocol introduced by Ghani SHA *et al*. (1996) with minor modifications over the years. Ideally, alveolar bone grafting is planned to allow the most favourable eruption of the maxillary canines or the maxillary lateral incisors (Abyholm *et al*., 1981, Bergland *et al*., 1986, Craven *et al*., 2007). Primary bone grafting is done during primary lip closure or shortly after in children less than two years of age but the negative impact it poses to the maxillary growth is still debatable (Koberg, 1973, Rosenstein *et al*., 1991, Sadove and Eppley, 1992, Eppley and Sadove, 2000, Rosenstein, 2003, Chowdhury *et al*., 2006, Bayerlein *et al*., 2006). Secondary alveolar bone grafting is done before eruption of lateral incisor and/or canine. Ideally it should be performed between 9 to 11 years of age, before the eruption of maxillary canine and the canine root development is half to one third completed (Boyne and Sands, 1972, Abyholm *et al*., 1981, Turvey *et al*., 1984, Bergland *et al*., 1986, Enemark *et al*., 1987, Amanat and Langdon, 1991, Chow and Yan, 1994, Dempf *et al*., 2002, Hynes and Earley, 2003, Bayerlein *et al*., 2006). Precious in 2009 suggested

Corresponding author: Dr. Nalisha Mohamed Ramli
Oral and Maxillofacial Surgery, Faculty of Dentistry, Islamic Science University of Malaysia, (USIM).

performing alveolar bone grafting at the age of 5.5 to 6 years old prior to eruption of the permanent central incisor to provide an acceptable clinical crown length of maxillary central incisor adjacent to the cleft area. Alveolar bone grafting done after the eruption of permanent maxillary canine at the cleft site is termed as late secondary alveolar bone grafting (Enemark *et al*., 1987). Tertiary alveolar bone grafting is done after the completion of growth which may be technically challenging (van der Meij *et al*., 2003, Hogan *et al*., 2003). One of the objectives of alveolar bone grafting is to allow eruption of teeth into the cleft site (Dempf *et al*., 2002, Hogan *et al*., 2003, Jia *et al*., 2006). It will also enable orthodontic movement of teeth into the grafted cleft alveolus (Hynes and Earley, 2003, Hogan *et al*., 2003, Jia *et al*., 2006). Besides that, alveolar bone grafting will help in oronasal fistulas closure (Enemark *et al*., 1987, Salyer, 2001, Dempf *et al*., 2002).

This procedure is needed to achieve a non prosthetic space closure of the alveolar cleft defect and assist dental implant placement (Bergland *et al*., 1986, Jia *et al*., 2006, Amanat and Langdon, 1991, Hynes and Earley, 2003). It provides stabilization of the dental maxillary arch, continuity of the arch and provide bony support for the teeth (Boyne and Sands, 1972, Turvey *et al*., 1984, Enemark *et al*., 1985, Bergland *et al*., 1986, Hynes and Earley, 2003, Hogan *et al*., 2003). Radiographic assessment is preferable to determine the success rate of alveolar bone grafting as highlighted by Clinical Standards Advisory Group Cleft Lip and Palate audit cleft services in the United Kingdom (Bergland *et al*., 1986, Enemark *et al*., 1987, Collins *et al*., 1998, Sandy *et al*., 1998, Witherow *et al*., 2002, Hynes and Earley, 2003). The Bergland Grading system used in measuring bone formation post grafting is still considered the gold standard in evaluating the radiographical outcome (Bergland *et al*., 1986). (Table 1)

Table 1. The Bergland's Criteria

Classification	Explanation	Interpretation
Type I	Normal interdental septal height	Success
Type II	Interdental septal height is more than ¾ of normal interdental septal height	Success
Type III	Interdental septal height is less than ¾ of normal interdental septal height	Failure
Type IV	No bony bridge achieved	Failure

Hynes and Earley (2003) modified the Bergland's grading system by evaluating the occlusal and basal bone level from periapical dental radiograph to enable precise measurement of the graft success. The Clinical Standards Advisory Group Study in 1998 suggested that Type I and II of the Bergland's Criteria (achieving at least 75% of the normal interalveolar septum height) as a successful outcome.The ability of canine to erupt spontaneously into the grafted site has also been used as an indicator for success (Newlands, 2000). Kokkinos *et al*. (1997) considered the facial aesthetic as the outcome determinant of alveolar bone grafting while Tan *et al*. (1999) used the periodontal status and ability of the teeth to erupt as the determinant of the success. Patient should have a sound dentition with healthy periodontium prior to bone grafting with proper maintenance of optimum oral hygiene (Horswell and Henderson, 2003). Table 2 listed the combined success rate of alveolar bone grafting in all cleft types reported in various literatures over the years.It is agreed by many literature that the failure of bone grafting is greater in patients with bilateral clefts due to shortage of surrounding tissue (Hall and Posnick, 1983, Collins *et al*., 1998, Jia *et al*., 1998). Patients grafted late is said to have significantly worse bone level due to extensive absorption of the graft (Newlands, 2000). The success rate of alveolar bone grafting diminishes with increasing age due to compromised healing ability but they might benefit from an improved lip support (Enemark *et al*., 1987, Jia*et al*., 1998,Amanat and Langdon, 1999, Chowdhury *et al*., 2006). Adequate soft tissue coverage of the grafted bone is an imperative factor for success (Craven *et al*., 2007). A cautious attention should be given to the manipulation of palatal and nasal floor mucoperiosteal flaps. A sufficient quantity of bone graft must be condensed basally to the level of the piriform aperture to restore the width and height of the alveolar ridge (Hynes and Earley, 2003). A two layered repair of the oronasal fistula is less prone to breakdown with incorporation of a bone graft (Chowdhury *et al*., 2006).

Table 2. Combined success rate in all types of cleft

Year	Author	Success rate	Outcome Determinant
1986	Bergland	90%	Radiograph - Bergland
1995	Long *et al.*	95%	Radiograph – Own Method
1996	Tan *et al.*	95%	Periodontal Status and Radiograph
1996	Kalaaji *et al.*	81%	Radiograph – Own Method
1997	Kindelan	73%	Radiograph – Kindelan
1998	Collins *et al.*	86%	Radiograph – Bergland
1998	Sandy *et al.*	58%	Radiograph – Bergland
1998	Jia*et al.*	83%	Radiograph – Bergland
1999	Kindelan	81%	Radiograph – Kindelan
1999	Denny *et al.*	83%	Radiograph – Own Method
2000	Newlands	94%	Radiograph – Bergland
2000	Da Silva Filho*et al.*	72%	Canine Eruption
2000	Lilja *et al.*	94%	Radiograph – Own Method
2002	Witherow *et al.*	84%	Radiograph – Chelsea
2002	Dempf *et al.*	80%	Radiograph – Own Method
2003	Hynes and Earley	92.5%	Radiograph – Modified Bergland
2003	Schultze-Mosgau *et al.*	88%	Radiograph - Kindelan
2003	Nightingale *et al.*	83.5%	Radiograph – Bergland, Kindelan & Chelsea
2005	Trindade *et al.*	86%	Radiograph – Chelsea &Bergland's
2005	Clarkson *et al.*	81%	Radiograph - Bergland
2006	Bayerlain *et al.*	76%	Radiograph – Bergland's
2006	Chowdhury *et al.*	94%	Radiograph – Own Method
2006	Rawashdeh& al Nimri	74%	Radiograph - Kindelan

Surgical wound infection will results in exposure and contamination of the grafts that will increase the risk of graft loss (Kortebein *et al*., 1991, Hynes and Earley, 2003, Chowdhury *et al*., 2006). Maintenance of good oral hygiene post operatively is essential to minimize infection. Craven *et al*. (2007) kept their patients admitted for 48 hours post surgery with strict clear liquid diet.The aim of this study is to evaluate the recipient site (alveolar cleft) of alveolar bone grafting with autogenous particulate cancellous bone marrow harvested from the anterior iliac crest in cleft lip and palate patients.

The objectives of the study are as follows

1) To determine the success rate of alveolar bone grafting done in the Oral and Maxillofacial Surgery Department, University of Malaya using the Modified Bergland's Criteria.

2) To calculate the success rate of alveolar bone grafting according to age, type of cleft, eruption and stage of root formation of maxillary canine.
3) To determine association of age, type of cleft, eruption and stage of root formation of maxillary canine with the treatment outcome.
4) To assess the clinical outcome of the recipient site post operatively.

MATERIALS AND METHODS

Study Design

This was a retrospective cross sectional study design involving cleft lip and palate patients who had underwent alveolar bone grafting. The recipient site refers to the alveolus cleft area which received the autologous particulate cancellous bone marrow graft during the alveolar bone grafting procedure.

Study Samples

Subjects of this study were the cleft lip and palate patients who had underwent alveolar bone grafting of the alveolus cleft in the Department of Oral and Maxillofacial Surgery, Faculty of Dentistry, University of Malaya from the 1st January 1999 until 31st December 2009

Inclusion Criteria

1. Patients with unilateral or bilateral cleft lip, alveolus and palate.
2. All patients must have undergone alveolar bone grafting procedure in University Malaya Medical Centre performed by the members of Oral and Maxillofacial Surgery Department, Faculty of Dentistry, University of Malaya.
3. The source of bone graft was the autologous particulate cancellous bone marrow harvested from the anterior iliac crest via open surgical approach.
4. All cases selected must have completed the surgical procedure at least 6 months prior to assessment.

Exclusion Criteria

1. Patients with incomplete medical and operative records available.
2. Patients who were unable to attend clinical assessment.
3. Patients with serious medical condition or disorders that may affect the healing potential or contribute to the possible post operative complications.
4. Patients with other associated craniofacial deformities or syndrome.

A standardized data collection form was used to record information retrieved during medical and operative record assessment as well as the clinical findings. Every patient who agreed to participate was briefed regarding the aim and objective of this study. The patient or the legal guardian was then required to read the patient's information sheet given and then signed the written consent. The selected patient's medical and operative records were obtained from the Dental Records Unit of Faculty of Dentistry, University of Malaya. Pre operative radiograph assessment was based on the Orthopantomogram (OPG), upper occlusal and periapical radiograph films to evaluate the presence of tooth or teeth in the cleft area. A special attention was also given to the permanent maxillary canine adjacent or directly related to the alveolus cleft, whereby the state of eruption and presence of the tooth were recorded. The stage of its root formation during the alveolar bone grafting procedure was also assessed. The evaluation of root formation is divided into four categories as listed in Table 3.

Table 3. Stages of root formation of maxillary canine

Stage of root formation	Measurement
Less than 50%	Root length is less than the crown height
50%	Root length is equal to crown height
More than 50%	Root length is more than crown height
Completed / 100%	Complete root formation either with open or closed apex

(modified from Boyarskiy *et al*., 2006)

Post operative radiographical assessment was made on the upper anterior occlusal radiograph film taken 60° to cleft area taken at least six months post operatively. All of the post operative radiographs were viewed in a standardized condition, using the same radiograph viewing box. The specific landmark is identified on each radiograph and traced onto an acetate tracing paper. (Figure 1)

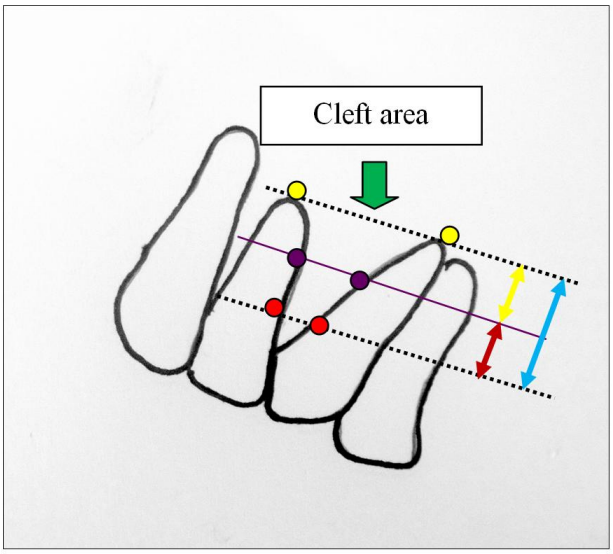

Figure 1. Landmark for tracing of upper occlusal radiograph

● Cementoenamel junction of teeth adjacent to cleft
● Apical region of teeth adjacent to cleft
● Mid of root of teeth adjacent to cleft
↔ Basal bone level of alveolus cleft (measured from mid of root)
↔ Occlusal bone level of alveolus cleft (measured from mid of root)
↔ Total bone graft level

A technique adapted from the Modified Bergland's Grading System was used to evaluate the success of the grafted alveolus

(Hynes and Earley, 2003). This method estimated the occlusal and basal bone level of the grafted site. Both the occlusal and basal bone level will enabled the measurement of the total bone graft level at the mid region of the cleft. The total bone graft heights are then categorized into Type I, Type II, Type III or Type IV as depicted by the original Bergland's Scale (Bergland *et al*., 1986) (Table 1).Clinical examination of the recipient site included the assessment of the status of upper lateral incisor and canine post bone grafting. The periodontal health of the adjacent teeth to cleft area was also evaluated. Periodontal assessment comprised of the evaluation of periodontal pocketing, tooth mobility and presence of gingival recession of the teeth in vicinity of the alveolus cleft. The presence of residual fistula associated with cleft alveolus is recorded as well. Besides that, other related complications of the recipient site post operatively were also recorded if present. The Statistical Programme for Social Science (SPSS) Version 17.0 (SPSS Inc., 1999) was used for data entry and analysis. The distribution and frequencies were examined. Descriptive statistics were used to describe the variables. Means and standard deviations or median were calculated for all continuous variables. Categorical variables were calculated as frequency and percentages.To investigate the association of age of patient, type of cleft, eruption status of canine and root formation of canine to outcome of alveolar bone grafting, Mann-Whitney and Kruskal Wallis statistical test were employed.

RESULTS

43 patients with cleft lip and palate were involved in this study with 51 recipient sites assessed. Majority (32) of the study populations had unilateral complete cleft lip and palate. There were 16 bilateral alveolus cleft and 35 unilateral alveolus cleft evaluated as recipient sites.The mean age of patients during alveolar bone grafting was 14.4 years old. The youngest patient was 6 years of age and the oldest was 27 years of age. From 51 cleft sites examined, majority (29 sites) were first alveolar bone grafting surgery. Majority of the first surgery were done for patients below 14 years old. The status of maxillary canines and its root formation adjacent to cleft defect during alveolar bone grafting are summarizes in Table 4.

Table 4. Status of maxillary canines in 51 cleft sites

Status of upper maxillary canine	Frequencyn (%)
Eruption status	
Erupted	24 (47.1)
Unerupted	18 (35.3)
Congenitally Missing	8 (15.7)
Extracted	1 (2.0)
Stage of root development	
Less than 50% formed	8 (15.7)
50% formed	6 (11.8)
More than 50% formed	12 (23.5)
Completed	16 (31.4)
Congenitally Missing / Extracted	9 (17.6)

Out of 51 cleft sites, 60.8% achieved satisfactory occlusal bone level, 58.8% had adequate basal bone level and 54.9% can be categorized as a successful alveolar bone grafting based on a sufficient total bone height measured. Table 5 illustrates the comparison between the three bone levels measured with the outcome of the surgery. The mean age of patients with success of alveolar bone grafting is 13.1 and the average age of patient with failure is 16 years old. It is identified that 83.3% of children in between six to eight years of age had successful alveolar bone grafts.

Table 5. Comparison of outcome of alveolar bone grafting

Total Bone Level	Basal Bone Level	Occlusal Bone Level	Outcome	
			Success	Failure
Type I	Type I	Type I	14	
Type II	Type I	Type II	4	
	Type II	Type I	5	
	Type II	Type II	5	
Type III	Type I	Type III		1
	Type II	Type III		1
	Type III	Type I		1
		Type II		1
		Type III		15
		Type IV		3
	Type IV	Type II		1

The least percentage of success rates was found for patients aged more that fourteen years old, where less than half managed to retain enough bone post operatively (35%). Cases of unilateral alveolus cleft showed a higher success rate (65.8%) compared to cases of bilateral alveolus cleft. 66.7% of cases done before the eruption of maxillary canine were successful and only 50% of cases done after the eruption of canine succeeded. The success rate of alveolar bone grafting done after completion of canine root is 37.5%, much lower than 75% success rate if it is done before half of the root was formed. (Table 6)

Table 6. Success rate of alveolar bone grafting according to age, type of cleft, status of eruption and root formation of canine

Associated Factors	Outcome(N = 51)		Success Rate (%)
	Success (frequency)	Failure (frequency)	
Age of patients			
6 – 8 years old	5	1	83.3
9 – 11 years old	8	4	66.7
12 – 14 years old	8	5	61.5
More than 14 years old	7	13	35.0
Type of cleft alveolus			
Bilateral	5	11	31.3
Unilateral	23	12	65.8
Status of upper canine			
Erupted	12	12	50.0
Unerupted	12	6	66.7
Missing / Extracted	4	5	44.4
Root formation			
Less than 50%	6	2	75.0
50%	4	2	66.7
More than 50%	8	4	66.7
100%	6	10	37.5
Missing canine	4	5	44.4

Statistical analysis of the factors associated with the outcome of alveolar bone grafting is done using the non parametric test (Mann Whitney and Kruskal Wallis) with p value defined at <0.05. A significant relationship can be seen between the type of cleft (either unilateral or bilateral alveolus cleft) with the outcome of surgery ($p = 0.02$)

Clinical outcome of alveolar bone grafting at the recipient site

It was noted that post operatively, apart from eight missing maxillary canine and one extracted canine, 30 or 58.8% of the canine have erupted, 12 remains unerupted. Six of the previously unerupted upper canine prior to alveolar bone grafting, managed to erupt at the time of review. All the cases with unerupted canine were below 12 years of age and 5 of them were below the eruption age of canine that is less than 9 years old. Most of the cleft sides had a congenitally missing upper lateral incisor with the percentage of 60.8%. Seven of the maxillary lateral incisors managed to erupt to a functional occlusion with normal tooth morphology. Six of them erupted with abnormal morphology. The maxillary lateral incisor remained unerupted in 2 cases and five teeth were extracted in view of caries or abnormal position and shape.8 cleft sides had residual fistula at the anterior part of the hard palate adjacent to the alveolus cleft area. Another two cleft sides presented with a fistula each at the bucconasal area and the junction of hard and soft palate. Patient with fistula of the bucconasal area failed the procedure. Only three cases with persistent fistula at the anterior of hard palate had enough bone formation to be considered as successful alveolar bone grafting.

Gingival recessions were found in five teeth adjacent to the grafted alveolus cleft and all were bilateral clefts (LAHSAL). All the recessions measured were associated with tooth surface facing the alveolus cleft. The gingival recessions were ranged between 1mm to 4mm. Apart from that, it was noted that all teeth adjacent to the alveolus cleft area were firm with no periodontal pocketing present. No other complications such as hematoma, wound infection, or flap dehiscence or breakdown were recorded and reported in all our patients.

DISCUSSION

A minimum 6 months post operative duration was chosen for evaluation of the patients as complete bony healing of the grafted cleft area can only be achieved at least 6 months postoperatively (Johanson *et al*., 1974, Jia *et al*., 2006). Majority of alveolar bone grafting surgery in our centre were performed as a tertiary bone grafting which were done after the age of 14 years old (39.2%) and more than half underwent revision bone grafting. The mix nature of procedures and age of patients seen in our centre is because of the referral cases for revision grafting from other centres as well as late presentation for alveolar bone grafting (tertiary alveolar bone grafting). Our centre has just recently adapted to the new recommendation of early secondary alveolar bone grafting since the year 2009 to concentrate on the eruption of lateral incisor and to maintain the clinical crown height of the upper central maxillary incisor as well as assisting eruption of the upper canine later in the development (Precious, 2009). The outcome of alveolar bone grafting in this study was determined by post operative upper anterior occlusal radiograph analysis of the cleft site (Witherow *et al*., 2002, Nightingale *et al*., 2003, Jia *et al*., 2006). Recently, there has been a trend towards the use of Computed Tomography Imaging for assessing the outcome of alveolar bone grafting to enable a more accurate estimation (Honma *et al*., 1999, Tai *et al*., 2000, Hynes and Earley, 2003, Feichtinger *et al*., 2006), its application still is somewhat debatable. Rosenstein *et al*. (1997) have shown that the intraoral dental radiograph is as effective as computed tomography scans images for evaluating the interalveolar bone post grafting. The method to determine the success rate of alveolar bone grafting in this study was adapted from The Modified Bergland's Grading System established by Hynes and Earley (2003). It involves measurement of the occlusal, basal and total interalveolar bone level instead of only the total interalveolar bone height calculated in the original Bergland's Grading System. This method enable a more exact prediction of the availability of the bone post surgery. This is important in decision making as well as treatment planning regarding repetition of surgery.

Hynes and Earley (2003) claimed that the basal bone level plays an important role for orthodontic manipulation, but in this study, it was found that patient with inadequate basal bone level (Type III) still can achieve orthodontic alignment of teeth providing that enough bone are present occlusally (Type I or Type II). Therefore, the basal bone can be considered to play an even more important role in achieving a symmetrical alar base and providing a strong platform for secondary correction of the nose later in life. It may also contribute if an invasive prosthetic rehabilitation such as insertion of endosseous implants is needed. Hence, a failed basal bone level may not need instant revision unless a secondary correction surgery is planned at a later stage. The occlusal bone level, on the other hand is considered more beneficial in maintaining stability of the teeth adjacent to the cleft as well as ensuring a continuity of the alveolar arch and periodontal health of adjacent teeth. It is needed for eruption of teeth and to allow orthodontic movement of teeth across the cleft site. Most of our patients with Type III or IV occlusal bone level still managed to have eruption of canine and lateral incisor teeth into the grafted cleft area.The success rate determined from this study is slightly lower but comparable to the work of many other authors in the past years which ranges from 58% - 95% (Table 2). These authors have used different criteria in assessing the outcome of alveolar bone grafting but majority preferred radiographical analysis. The original Bergland's criteria were nevertheless the standard of radiographical analysis of alveolar bone grafting (Bergland *et al*., 1986). One patient with Type I basal bone level is interpreted to have failure of the bone grafting because less than 75% bone formed occlusally but patient has successfully completed orthodontic treatment with erupted canine and well aligned dentition even though the lateral incisor is missing. In this patient, the repetition of the bone grafting is still necessary in the future for further secondary cleft surgery particularly the secondary nose surgery as the symmetry of the alar base is yet to be achieved. On the other hand, 1 patient failed alveolar bone grafting by having a Type II basal bone level but Type III occlusal bone level. Orthodontic treatment managed to close the cleft space with acceptable alignment of the upper canine tooth. In this particular patient, as the periodontal support of the tooth was not compromised and space closure achieved with quite a symmetrical nose and alar base, repetition of surgery was unnecessary.Total bone loss of the occlusal bone height was noted in 3 patients, while total bone loss of the basal bone height was noted in 1 patient and in all these cases repetition of

surgery is inevitable. It can be concluded that the need for repetition of surgery even in cases which were categorized as failure of the alveolar bone grafting must be evaluated individually. The Type III interalveolar bone level does not always need revision. Patient may have sufficient bone to achieve a functional and aesthetic objective of alveolar bone grafting even with a deficiency of bone at the cleft alveolus.

The failure of bone grafting in this study was found to be more at the basal region. This may be related directly to a challenging surgical technique to ensure a sufficient amount of bone condensed at the basal level of the cleft up to the level of piriform aperture. Our centre had been practicing secondary alveolar bone grafting initially until recently where we have adopted an earlier timing of secondary alveolar bone grafting in our young patients of 6 to 8 years old. So far, 83.3% of the bone grafting done between the ages of 6 to 8 years old is successful. The better healing potential in children of younger age and the higher chances of graft resorption in older age groups particularly in a long standing none treated cleft may explain this occurrence (Abyholm *et al*., 1981, Sindet-Pedersen and Enemark, 1985). It was also found that patients with unilateral cleft alveolus had a higher success rate compared to those with bilateral alveolus cleft. A significant statistical relationship was found between the outcome of surgery and type of cleft. These findings could be correlated to the results published in previous literatures (Abyholm *et al*., 1981, Sindet-Pedersen and Enemark, 1985, Collins *et al*., 1998, Newlands, 2000, Jia *et al*., 2006). Limited availability of the surrounding normal soft tissue causes inability to achieve water tight seal that cause contamination of the surgical site (Kortebein *et al*., 1991). Amanat and Langdon (1981) suggested that timing of surgery in bilateral cleft cases is crucial to ensure a better success rate. Patients with bilateral clefts often had a higher incidence of oronasal fistula after the primary repair that required repeated attempts of surgical closure that will create abundant scar tissue (Long *et al*., 1995, Denny *et al*., 1999, van Der Meij *et al*., 2003). The success rate calculated for our unilateral cleft cases (which includes the cases of bilateral cleft lip with unilateral cleft alveolus) was 65.7%, higher than the bilateral cases and thus comparable to previous reported success rate (Abyholm *et al*., 1981, Hall and Posnick, 1983, Bergland *et al*., 1986, Paulin *et al*., 1988, Collins *et al*., 1998, Denny *et al*., 1999, Newlands, 2000, Lilja *et al*., 2000, Dempf *et al*., 2002, Schultze-Mosgau *et al*., 2003, Trindade *et al*., 2005, Rawashdeh and al Nimri, 2007). Our success rate was calculated to be better if the surgery was done before the eruption of maxillary canine (66.7%). This is in agreement with cases reported by many previous authors (Boyne and Sands, 1972, Abyholm *et al*., 1981, Sindet-Pedersen and Enemark, 1985, Berglan*det al*., 1986, Amanat and Langdon, 1991, Kalaaji *et al*., 1996, Jia *et al*., 1998, Collins *et al*., 1998). Patients with missing maxillary canine at cleft site however exhibited a lower success rate than both groups (44.4%). This might be related to the fact that presence of teeth and eruption forces create a positive benefit in inducing better stability and growth of the grafted bone (Arangio *et al*., 2008).

Patients with less than 50% of the canine root formed achieve 75% success rate. It has been generally agreed that alveolar bone grafting should be commenced when the root formation of the upper canine is 1/4th – 3/4th formed (Hall and Posnick, 1983, Eppley, 1996, Ochs, 1996, Dempf *et al*., 2002, Chowdhury *et al*., 2006, Lilja *et al*., 2009). Clinical evaluation of the grafted alveolar cleft defect at the time of study, revealed that 6 out of 18 unerupted canine prior to the surgery have managed to erupt to a functional occlusion. Meanwhile, another twelve cases still remained unerupted with 5 of the cases involving children less than 9 years of age increasing the possibility of eruption anytime soon. The remaining 7 cases of unerupted canine might not erupt into a functional occlusion without further combined surgical and orthodontic intervention or might be considered for surgical removal and replacement with other available methods if eruption is still impossible later. Eruption of the maxillary canine post alveolar bone grafting ranges from 52% to 96.4% (Jia *et al*., 1998, Collins *et al*., 1998, Newlands, 2000, Olekas and Zaleckas, 2003). The incidence of canine eruption post surgery in our centre is therefore comparable with other centres. None of the patients included in this study require a surgical exposure and orthodontic traction to assist eruption of canine.Most of our patients have congenitally missing lateral incisors (60.8%). Congenital absence of the lateral incisor was quite common at the region of cleft alveolus as stated to be more than 50% by Dewinter *et al*. (2003) and varied between 70.8% to 97.1% by Akcam *et al*. (2010). Only 13.7 % of our patients managed to have the upper lateral incisor to erupt with normal tooth morphology. 2 patients, still have an unerupted lateral incisor with 1 patient is 7 years of age and still waiting for the eruption of the tooth. Meanwhile another patient is already 17 years of age making the natural eruption of the tooth impossible. The alveolar bone grafting should generally provide an adequate bony environment for tooth eruption (Boyne and Sands, 1972, Bergland *et al*., 1986, Stoelinga *et al*., 1990, Long *et al*., 1995, Geraedts *et al*., 2007). As our centre now is going for the early secondary bone grafting at the age between 6 to 8 years old, it is hoped that apart from the effect to the maxillary central incisor, the possibility of better survival and function of the lateral incisor tooth at the cleft site can be achieved. This new timing of alveolar bone grafting is also expected to develop arch continuity before eruption of the upper lateral incisor at the age of 7 to 8 years old.80.4% still have fistula at the anterior hard palate with two subjects had a functionally relevant problems that renders further surgical intervention. The occurrence of fistula at the anterior part of the hard palate might not indicate the failure of alveolar bone grafting alone as it may portrayed the inadequate closure of primary palatoplasty. The fistula present at the more posterior part of the palate including the soft palate is considered not related to the alveolus cleft defect. 66.7% cases with fistula either at the bucconasal or anterior part of the hard palate were noted to have failure of the alveolar bone grafting, supporting the suggestion that the presence of fistula can compromise the success rate of this important surgical intervention (Enemark *et al*., 1985).

None of the teeth adjacent to cleft defcet were noted to have periodontal pocketing and tooth mobility, but a small number of patients (5) were found to develop gingival recession of the tooth surface adjacent to the cleft area. This can be attributed by the lack of bone support of the teeth adjacent to the cleft as 3 of them had less than 75% bone identified occlusally. 2

subjects with gingival recession managed to achieve more than 75% of bone formation post bone grafting. This phenomenon might be a direct consequence of periodontal tissue destruction secondary to poor maintenance of oral hygiene at the region of alveolus cleft. Alveolar bone grafting should be aimed towards providing a continuous and stable maxillary alveolar arch to allow eruption and orthodontic movement of teeth into the cleft site with elimination of oronasal fistula while maintaining the periodontal support of teeth as well as the symmetry of the alar base. It should also provide enough bone to enable sufficient bone for prosthodontic rehabilitation including implant placement if needed later in life and at the same time avoiding any negative impact to the facial growth.

Recommendation

A larger population based study should be made in the near future to investigate the treatment outcome of alveolar bone grafting of the Malaysian population as many other centres across the country has been actively involved in the management of cleft lip and palate patients.Furthermore, a prospective study should be initiated to comprehensively assess the long term outcome of alveolar bone grafting procedure performed in this centre with a more standardized protocol of data collection, radiographical and clinical assessment of the recipient and donor site.The application of computerized tomography scan (CT Scan) might be considered as part of future research involving alveolar bone grafting for a more accurate evaluation of the bone availability at the grafted cleft sites as well as its related structure. However, the usefulness of using this method must be weighed accordingly to the cost, radiation and benefits involved.A computer based data recording of the clefts patients should be available in the near future in order to enable auditing of the comprehensive multidisciplinary treatment involving them. It is recommended that a national database of cleft patients' information be developed and a free exchange of this information is available within each cleft centre. More educational programme for the public should be initiated, so that patients will come forward and the untreated cleft alveolus can be managed accordingly aiming towards full rehabilitation of the oral health for a better quality of life generally.

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