 doi:10.20944/preprints201809.0086.v1

Review

Maxillary Canine Impaction and Unilateral Cleft Lip and Palate: A Review of the Current Literature

Author

Ali Alqerban[1]

Assistant Professor Department of Preventive Dental Sciences College of Dentistry Prince Sattam Bin Abdulaziz University Alkharj Saudi Arabia

Assistant Professor Department of Preventive Dental Sciences College of Dentistry Dar Al Uloom University Riyadh Saudi Arabia

Email alialqerban123@gmail.com

Corresponding Author:

Ali Alqerban[1]

Assistant Professor Department of Preventive Dental Sciences College of Dentistry Prince Sattam Bin Abdulaziz University Alkharj Saudi Arabia

Assistant Professor Department of Preventive Dental Sciences College of Dentistry Dar Al Uloom University Riyadh Saudi Arabia

Email alialqerban123@gmail.com

Abstract: The present review aims to investigate the effect of alveolar bone grafting in canine impacted unilateral cleft lip and palate patients. The goal of this review is to identify and highlight the factors that may cause maxillary canine impaction, the role of primary and secondary bone graft and dental anomalies that may affect canine impaction in patients with cleft lip and palate.

Keywords: Maxillary canine, Cleft lip, Cleft Palate

 doi:10.20944/preprints201809.0086.v1

1.0 Introduction

Worldwide, UCLP (Unilateral Cleft Lip and Palate) has a prevalence of 0.5 to 3 per 1000 births.[1] Among 10 to 20% of these children, the cleft is part of a syndrome [1]. Strong variations exist according to gender, population, geographic region and maternal characteristics. UCLP is found to be more common in the left than the right side with ratio 2: 1, more often in boys than girls with ratio 2: 1 and more common in the Caucasian population [1-3]. The aetiology of clefts involves both genetic and local factors[2].

1.1 What is Canine Impaction

Canine impaction can be defined as an infra osseous position of the canine after the expected eruption time [4]. Usually a palatal displaced maxillary canine will result in an impaction[5]. Canine impaction in the general population varies from 0.8 to 5.2% [4].

1.2 Theories and etiology related to Canine Impaction

The etiology of canine impaction is summarized in two theories which try to explain the occurrence of palatal displaced canines. The first theory is the guidance theory which states that the canine tooth is insufficiently guided by eruption, by an excess of space in the apical part of the maxilla due to a hypo-plastic or absent lateral incisior or late developing tooth arches with spacing. The second theory is the genetic theory, in which a developmental disorder in the dental lamina is described as the cause for the abnormal angular eruption [4]. Other reasons for retention of the canine is lack of space, persistence of the primary canine and displacement of the canine's germ by the developing maxillary sinus [6]. Commonly, in labial impacted canine crowding is the primary cause. In 83% of the labial impacted canine teeth, there is a lack of space, whereas in palatal impaction this is only in 15 to 18% of the cases [4, 7]. Furthermore, a labially impacted canine tooth will usually erupt naturally high in the labial sulcus, while a palatally impacted canine erupts without intervention. This is probably due to the thick, palatal, cortical bone and the dense, thick and resistant, overlying, palatal mucosa [7].

1.3 Clinical Findings to Predict Canine Impaction:

Clinically, it can be anticipated that a canine can be impacted when: 1. The left and right side are asymmetrical with respect to each other. 2. The primary canine remains intact until 15 years of age. 3. If the canines are not palpable at their normal place (as labial bulge) despite advanced occlusal development and somatic maturity. 4. If the eruption of the lateral incisor is late, with distal or labial inclination or migration and 5. If a palatal bulge is present [7, 8]. Some authors believe that the risk of canine tooth impaction can also be partly predicted on the basis of dentofacial characteristics and by evaluating the transversal maxillary width [4].

 doi:10.20944/preprints201809.0086.v1

Lastly, impaction can also be detected via radiographic evaluation [9]. On a panoramic image, 4 radiographic factors were correlated with predicting the prognosis for an impacted canine. These are the angulation between the tooth axis and the midline, the vertical distance of the crown tip to the occlusal plane, the anteroposterior position of the root point relative to the center line and the degree of overlap between the angle tooth crown tip and the lateral incisor [4, 10]. Warford et al.,[11] investigated the mesiodistal location of the canine crown with respect to the neighboring teeth (sector) and the angulation with respect to a horizontal reference line as predictors for angle tooth impaction. They concluded that if the sector was more mesially localized, the risk of impaction is greater. The angulation, however, did not contribute significantly in predicting angular tooth impaction. Similarly, Katsnelson et al.,[12] attempted to determine the palatal or buccal position of an impacted canine tooth by measuring the angle between tooth axis and occlusal plane. Their results showed that if the angle was greater than 65°, the probability is 26.6 times greater that the canine is situated buccally [12]. Similarly, Sajnani and King [13] noted that from the age of 5 there is a significant difference in distance from the canine cuspid to the occlusal plane between the canine that will be impacted and its contralateral side. From the age of 9, the impacted canine tooth is more located in mesial sector and is increasingly tilted towards mesial with increased canine angle to the midline, in contrast to the non-impacted contralateral which is respectively located just above the primary canine and which is almost vertically angulated[13].

1.4 Adverse effects of Canine Impaction with interceptive treatment modalities

Adverse effects of an impacted canine were the migration of adjacent teeth and loss of arch length, internal resorption, dentogenic cyst formation, external tooth/root resorption of the impacted canine, infection (mainly in case of partial impaction), pain and combinations of the above[4, 7]. Furthermore, patients with an impacted canine tooth require a longer treatment period and the orthodontic treatment should be started early to avoid ankylosis of the canine or resorption on the roots of the incisors [8, 14] The interceptive treatment for a displaced or impacted maxillary canine is extraction of the primary canine with maxillary expansion. Combining primary canine extraction with a cervical pull headgear would significantly increase the success of treatment according to Leonardi et al.,[15] and Bacetti et al.,[16]. The possible treatments options when the canine is effectively impacted are: 1. No treatment and follow-up 2. surgical release, which is also the most desirable solution 3. auto-transplantation of the canine 4. the prosthetic replacement, 5. extracting the canine and the first premolar into this position and 6. extracting the canine and posterior segmental osteotomy to move the buccal segment to mesial and thus closing the space. One must avoid extraction of the canine at all times because of its aesthetic and functional importance [17].

 doi:10.20944/preprints201809.0086.v1

Extraction is only exceptionally indicated as in the case of ankylosis, internal or external root resorption, root dilatation, pathological changes such as infection or cyst formation[7].

1.5 Canine eruption and UCLP (Unilateral Cleft Lip and Palate) Patients

All maxillary canines move incisally, buccally and mesially on both cleft and non-cleft sides [17]. If the lateral incisor is present, it is usually located on the side of the bone defect. The canine tooth, on the other hand, is usually located at the distal edge of the gap or is superior to the bony defect[18]. Russell and McLeod.,[19] stated that the canine teeth get more vertical angulation during eruption. Lindauer et al.,[20] had established that in UCLP patients aged 9-10 years, the risk of impaction is higher when the canine tooth overlaps more than half the root of the lateral incisor.

The maxillary canines at the cleft side erupt slower with delayed root development compared to those at the contralateral side [19]. This may increase the risk of impaction. In addition, the amount of root development does not affect the outcome in terms of canine eruption [19]. In the split-mouth study of El Deeb et al.,[21] it was found that the canine on the contralateral side (mean age of eruption 12.3 ± 1.2 SD) erupts faster than the canine on the cleft side (mean age of eruption 13.4 ± 1.9 SD). Enemark et al.,[22] found that contra-lateral canines erupt spontaneously. However, the risk of angular tooth impaction on the contralateral side would still be greater than the risk in the general population.

In UCLP patients who did not have a bone graft, there was a significant difference in the canine angle before and after eruption. After eruption, this angle is much more vertical, most likely because of conduction through the cortical bone (unless the canine can just erupt through in the alveolar ridge, then there is no difference in eruption angle[17]. In children receiving a bone graft, there are no changes in the angle of eruption of the canine[18]. This means that these canines will erupt in the same inappropriate angle as they were before SABT (secondary bone grafting transplantation). From this it can be concluded that surgical exposure will be necessary to correct this inappropriate angle of eruption [18, 19]

1.6 The Nomenclature of Bone Transplantation and Canine impaction UCLP patients

There is primary, secondary and tertiary bone transplantation. Primary bone transplantation is performed in the primary dentition and the bone graft done before age of 2 years. It has been found it may compromise midfacial growth [23]

In secondary bone grafting transplantation (SABT), there is a choice between early and late secondary bone transplantation. In an early SABT, the bone graft is placed at 5-7 years of age when the root formation of the lateral incisor reaches 1/3^{r} to1/2 of its final length[24, 25].

Late SABT occurs at 9-11 years of age where the root formation of the final canine is 1/4th to 2/3rd of its final length [26, 27]. Orthodontic expansion of the maxillary arch will often be required before to improve access to the alveolar cleft and the closure of the nasal floor [28]. The choice between early and late SABT is done by evaluating advantages and disadvantages against each other. In patients with a healthy lateral incisor, the procedure can be done earlier so that the lateral incisors can be maintained. In patients with agenesis of the lateral incisor or where maxillary growth problems would be detrimental, the surgery can be scheduled later [29, 30].

Tertiary bone grafting is a bone graft when all permanent teeth have erupted. In UCLP alveolar bone graft can also be performed after eruption of the permanent canine[31]. The canine tooth has already erupted through the fissure. The bone graft only serves to restore the continuity of the alveolar crest, to close a persistent bucco-nasal fistula, to retract the canine orthodontically or to place an implant at later stage[32]. A bone graft at this older age is less successful and would lead to more frequent problems [33]. According to Enemark et al.,[34] the risk of root resorption of the canine is greater when bone grafting is performed when the canine tooth has already erupted. This could be avoided by covering the canine with lyophilized (freeze-dried) bone during the operation. The failure of a bone graft in the form of wound dehiscence and / or bone sequestration is also more common[35]. This is because with aging the healing potential decreases and the integration of the bone graft is no longer ideal, partly because the bone marrow is older and therefore contains less regenerative capacity.

The optimal time for alveolar bone transplantation (ABT) has been long discussed in the literature. There is growing consensus that secondary bone grafting at 9-11 years of age, where the root development of the canine is 1/2e to 1/3rd, gives the best result [27, 36] although other factors may also be of interest as:

1. Age [37] According to Ozawa et al.,[38] it was not good to perform the bone transplantation too early. Maturation and migration of the canine would then take a long time in which resorption of the graft would occur as a result of un-used. On the other hand, they emphasized that if the bone graft was delayed for too long, the canine could abnormally erupt and the subsequent orthodontic treatment becomes more difficult.

2. The presence or absence of the lateral incisor as discussed above[26].

3. The crown eruption phase has received a bone graft if only the root formation had been observed [27, 33].

4. The height of the intermediary formed septa [37]

 doi:10.20944/preprints201809.0086.v1

5. The width of the cleft. However, Jabbari et al. found the width of cleft has no effect either on the success or failure of the SABG [22, 39]

6. The classification of malocclusion [39, 40]

7. The canine position relative to the gap in its pre-eruptive phase [39, 41]. Enemark et al., stated that if the canine tooth was impacted in the palate, bone height and orthodontic treatment can be postponed until or after the eruption of the canine tooth. The advantage of this postponing is that the operation can then immediately be combined with an orthognathic surgical treatment [22].

8. The canine inclination. A study found that if the canine inclination increased, there will be a negative impact on SABG [39]

There are many other variables that influence the outcome of a bone transplant of the cleft, such as the timing of the procedure [26] the type of cleft,[37] surgeon's experience, donor site, inter-operator differences [33] and the pre-surgical status of the alveolar gap, for example, the pre-surgical amount of supporting bone for the mesial and distal teeth that abut against the gap. Moreover, the timing of the bone graft was also more critical in unilateral and bilateral cleft patients than in patients with only a cleft lip and alveolar ridge [41]

2.0 Study Selection

An electronic search was carried out via the PubMed (Medline) and ISI web of knowledge databases using various keywords including “cleft lip,” “cleft palate,” “canine impaction,” “unilateral cleft lip,” and “maxillary canine,” in combination. Papers published in English language in last 40 years were carefully examined and scrutinized. The studies significant to our review were critically analysed and summarized in Table 1. Duplicate studies found were removed

200 **Table 1.** Review of studies that have reported the frequency of maxillary canine exposure on
201 Cleft lip and palate patients

Authors	Year	Type Cleft		N	Gender		Age of Bone graft	Spontaneous Eruption	Surgical Exposure
		BC	UC		Male	Female			
Kwon et al. [42]	1981	35	64	99	62	37	7-11	73%	27%
El Deeb et al. [21]	1982	18	28	46	32	14	7-14	17.9%	82% (14% exposed, 67.9% exposed + orthodontic traction)
Troxell et al. [43]	1982	4	26	30	14	16	7-26	95%	0%
Turvey et al. *[36]*	1984	9	15	24	13	11	7. 3 – 25.4	95%	5%
Hinrichs et al. [44]	1984	-	18	18	10	8	7.3 - 13.9	44%	56% (11.1% exposed, 44.4% exposed + orthodontic traction)
Enemark et al. *[34]*	1985	-	62	62		/	8.6 - 15.11	50%	8.1%
El Deeb et al. [45]	1986	18	8	26	17	9	7-13	41%	59%
Bergland et al. [46]	1986	49	291	340	218	122	8-17	85%	15%
Bergland et al. [37]	1986 b		BC:41	41	25	16	8.9 – 17.4	95%	5%
Enemark et al. [47]	1987	44	151	224	153	71	Canine not erupted 10 Canine erupted through: graft 13.10	-	30%

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 5 September 2018 doi:10.20944/preprints201809.0086.v1

Paulin et al. [48]	1988	13	54	67		-	37 patients, Canine not erupted at ABT: 8-14 30 patients, Canine erupted through at ABT: 10-20	93%	7%
Amanat & Langdon [35]	1991	13	21	34	23	11	7-24	-	2.1%
McCanny & Roberts-Harry [49]	1998	12	17	29	7 group A 8 group8	9 group A 5 group B	Group A: 9 – 39 Group B: 7 - 25	Group A: 43.5% Group B: 44.5%	Group A: 8.7% Group B: 5.5%
Da Silva Filho et al. [32]	2000	-	UCL: 12	50	32	18	-	72%	6%
Enemark et al. [22]	2001	-	UCL P:101	101	72	29	Mandibulair bone: 8.10-11.8	68%	32%
							Hip bone 8.8 – 12.4	65%	35%
van der Wal & van der Meulen [6]	2001	11	51	62	-	-	8.6-12.8	77%	20%
Dempf et al. [50]	2002	49	UC:42	91	-	-	SABT: 10.6 Tertiary graft: 21.3	100%	0%
Hogan et al. [28]	2003	11	UC:23	34	19	15	8.5-18.4	92%	8%

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 5 September 2018 doi:10.20944/preprints201809.0086.v1

Matsui et al. [51]	2005		UC:340	340	98	142	Canine not erupted at SABT: 9.1	78.9%	Canine not erupted at SABT: 18.9%
Russel & McLeod [19]	2008	48	UC:53	101	-	-	78 early SABT: 5-8.9 23 late SABT: 9.3-16.9		20 time higher risk compared to general population
Tortora et al. [52]	2008	29	UC:87	116	-	-	UCLP: 18 -55 months BCLP: 20- 63 months	80%	4.4%
Oberoi et al. [18]	2010	4	UC:12	21	12	9	10. 6	88%	12%

BC= bilaterale clefts, UC= unilaterale clefts, CLA= cleft lip and alveolar ridge, CLAP= cleft alveolar ridge and palate

2.1 Surgical Exposure of Impacted Canine in UCLP

Surgical exposure is required when radiographically clear deviation from direction or location of the permanent canine can be demonstrated after SABT and when there is resorption of adjacent teeth or cystic radiolucency around the canine tooth [51]

Maxillary canine impaction in UCLP patients is still under investigation and to date there is few split-mouth studies. The occurrence of surgical exposure is already reported by several authors (Table 1). A strong variation in results exists and can be explained by various reasons. First, are the procedures and surgical techniques. A study by Enemark et al.,[22] attributed the effect of primary surgical procedure to high percentage in impacted canines i.e. (35%) requiring surgical release. Similarly, El Deeb., [45] presented high percentage of surgically exposed canines (73%). Both of the authors admits that this percentage is an underestimation of the number of spontaneous eruption because they easily chose for surgical exposure as it seemed appropriate, instead to wait for a spontaneous delayed eruption. A study by Tortora et al.,[52] investigated the success of Early Secondary Gingival Alveoloplasty (ESGAP) at 2-3 years of age, with closure of the hard palate simultaneously. 15.5% of the canine teeth showed impaction, of which 4.4% were exposed surgically. This number was found to be higher than other studies after SABT [28, 49, 50], which implies that the early closing of the alveolar ridge may be responsible for less space for the canine to erupt spontaneously. There

 doi:10.20944/preprints201809.0086.v1

are authors who reported a higher impaction percentage, as a result of which Tortora et al.,[52] in the study stated that ESGAP does not have an adverse effect on angle eruption.

In another study by Hinrichs et al.,[53] and Bergland et al.,[37] stated that the reason for tooth impaction is the anatomy of the alveolar ridge that muco-buccal and muco-labial patches do not satisfy, in contrast to a mucogingival patch. They persist as soft and red tissue that forms a resilient obstacle to the erupting tooth [37, 44]. Damage to the periodontal ligament during the surgical procedure leads to necrosis, resulting in resorption and ankylosis of the tooth [54]. Secondly, each sample is unique with individual characteristics, just as each CLP (Cleft lip palate) is unique. For example, it has been shown that surgical exposure was more frequent in patients with both a cleft alveolar ridge and palate (CLAP) compared to patients with only cleft alveolar ridge (CLA) [19], more often with bilateral cleft than with unilateral and that also the width of the defect plays a role[51]. In addition, alveolar cleft width has been found increased significantly in patients who undergo surgical exposure than in those who had spontaneous eruption[55].

2.2 Radiographic Interpretation of Canine Impaction and UCLP patients

One of the main disadvantage of a panoramic image is that the reliability in the anterior region is limited because structures are blurred. Furthermore, the horizontal deformation is not linear, so the angle of the crown and distance from the crown to the centre line is overestimated on a panoramic radiography. Due to this magnification, distortion, overlap of important structures, limited number of identifiable landmarks and positioning problems with two-dimensional panoramic image is a hassle, which may influence the quality of interpretation [56]. The only way to be certain of resorption on the lateral incisor and of the buccal or palatal position of the impacted canine is by means of two-dimensional images such as CBCT. A study by Ericson and Kurol.,[8] interprets the resorption of neighbouring teeth by the impacted canine tooth on a two-dimensional image taking in consideration three factors 1. The degree of overlap, 2. The occurrence of the lamina dura (interrupted or not) and 3. The occurrence of the root contour. However, they concluded the interrupted lamina dura is a sign of resorption. According to Ericson and Kurol.,[8] peri-apical image showed a better relation to the lateral incisor compared to a panoramic image. Panoramic images are found unreliable for 1 finding the position of the canine relative to the tooth arch or the lateral incisor and 2 for detecting resorption of neighbouring teeth.

However, there are authors who argue that panoramic images are reliable for geometric measurements. Linear vertical measurements, ratios and angles can be determined with consistent accuracy through a panoramic image [13]. Further, the bucco palatal position of

the canine can be easily determined [57] Angles measured on a panoramic show a combination of the angle tooth slope both in the frontal and sagittal plane [57]

2.3 Skeletal relation in UCLP Patients

In UCLP patients mid-facial retrusion frequently occurs with a Class III skeletal relationship due to inherited growth limitations or post-surgical scar tissue[58]. The occlusion classifications have no effect in development of canine impaction [59]. In UCLP with impacted canines at the cleft side the occlusion is found more Class II malocclusion, while in non-cleft side had significantly more Class III malocclusion [59].

3.0 Conclusion

In today's rapidly advancing medical field, one optimal treatment plan to adhere to when treating canine impaction in patients with cleft lip and Palate is not possible. In accordance to the available evidence in the present study every patient is different and treatment options vary according to the characteristics, subjective response and variability of the malformation.

Acknowledgement and Funding

This project was supported by the Deanship of Scientific Research at Prince Sattam Bin Abdulaziz University under the research project 2016/03/5678.

Conflict of interest statement: The author declares that there is no conflict of interest and the author have read and approved the final draft.

References

1. Derijcke A, Eerens A, Carels C. The incidence of oral clefts: a review. Br J Oral Maxillofac Surg. 1996;34(6):488-94. Epub 1996/12/01. PubMed PMID: 8971440.
2. Akcam MO, Evirgen S, Uslu O, Memikoğlu UT. Dental anomalies in individuals with cleft lip and/or palate. The European Journal of Orthodontics. 2010;32(2):207-13.
3. Dewinter G, Quirynen M, Heidbuchel K, Verdonck A, Willems G, Carels C. Dental abnormalities, bone graft quality, and periodontal conditions in patients with unilateral cleft lip and palate at different phases of orthodontic treatment. Cleft Palate Craniofac J. 2003;40(4):343-50. Epub 2003/07/09. doi: 10.1597/1545-1569_2003_040_0343_dabgqa_2.0.co_2. PubMed PMID: 12846599.
4. Litsas G, Acar A. A review of early displaced maxillary canines: etiology, diagnosis and interceptive treatment. Open Dent J. 2011;5:39-47. Epub 2011/05/14. doi: 10.2174/1874210601105010039. PubMed PMID: 21566691; PubMed Central PMCID: PMCPMC3091288.
5. Power SM, Short MB. An investigation into the response of palatally displaced canines to the removal of deciduous canines and an assessment of factors contributing to favourable eruption. British Journal of Orthodontics. 1993;20(3):215-23.
6. Van der Wal K, van der Meulen B. Eruption of canines through alveolar bone grafts in cleft lip and palate. Nederlands tijdschrift voor tandheelkunde. 2001;108(10):401.
7. Bishara SE. Impacted maxillary canines: a review. Am J Orthod Dentofacial Orthop. 1992;101(2):159-71. Epub 1992/02/01. doi: 10.1016/0889-5406(92)70008-X. PubMed PMID: 1739070.
8. Ericson S, Kurol J. Resorption of maxillary lateral incisors caused by ectopic eruption of the canines. A clinical and radiographic analysis of predisposing factors. Am J Orthod Dentofacial Orthop. 1988;94(6):503-13. Epub 1988/12/01. PubMed PMID: 3195514.
9. Alqerban A, Storms AS, Voet M, Fieuws S, Willems G. Early prediction of maxillary canine impaction. Dentomaxillofac Radiol. 2016;45(3):20150232. Epub 2015/12/20. doi: 10.1259/dmfr.20150232. PubMed PMID: 26683426; PubMed Central PMCID: PMCPMC4846145.
10. Fleming PS, Scott P, Heidari N, Dibiase AT. Influence of radiographic position of ectopic canines on the duration of orthodontic treatment. Angle Orthod. 2009;79(3):442-6. Epub 2009/05/06. doi: 10.2319/042708-238.1. PubMed PMID: 19413390.
11. Warford JH, Jr., Grandhi RK, Tira DE. Prediction of maxillary canine impaction using sectors and angular measurement. Am J Orthod Dentofacial Orthop. 2003;124(6):651-5. Epub 2003/12/11. doi: 10.1016/S0889540603006218. PubMed PMID: 14666077.
12. Katsnelson A, Flick WG, Susarla S, Tartakovsky JV, Miloro M. Use of panoramic x-ray to determine position of impacted maxillary canines. Journal of Oral and Maxillofacial Surgery. 2010;68(5):996-1000.

13. Sajnani AK, King NM. Early prediction of maxillary canine impaction from panoramic radiographs. Am J Orthod Dentofacial Orthop. 2012;142(1):45-51. Epub 2012/07/04. doi: 10.1016/j.ajodo.2012.02.021. PubMed PMID: 22748989.

14. Ericson S, Kurol J. Radiographic examination of ectopically erupting maxillary canines. Am J Orthod Dentofacial Orthop. 1987;91(6):483-92. Epub 1987/06/01. PubMed PMID: 3473928.

15. Leonardi M, Armi P, Franchi L, Baccetti T. Two interceptive approaches to palatally displaced canines: a prospective longitudinal study. Angle Orthod. 2004;74(5):581-6. Epub 2004/11/09. doi: 10.1043/0003-3219(2004)074<0581:TIATPD>2.0.CO;2. PubMed PMID: 15529490.

16. Baccetti T, Leonardi M, Armi P. A randomized clinical study of two interceptive approaches to palatally displaced canines. Eur J Orthod. 2008;30(4):381-5. Epub 2008/06/06. doi: 10.1093/ejo/cjn023. PubMed PMID: 18524761.

17. Alqerban A, Jacobs R, Lambrechts P, Loozen G, Willems G. Root resorption of the maxillary lateral incisor caused by impacted canine: a literature review. Clinical oral investigations. 2009;13(3):247-55.

18. Oberoi S, Gill P, Chigurupati R, Hoffman WY, Hatcher DC, Vargervik K. Three-dimensional assessment of the eruption path of the canine in individuals with bone-grafted alveolar clefts using cone beam computed tomography. The Cleft palate-craniofacial journal. 2010;47(5):507-12.

19. Russell KA, McLeod CE. Canine eruption in patients with complete cleft lip and palate. Cleft Palate Craniofac J. 2008;45(1):73-80. Epub 2008/01/25. doi: 10.1597/07-049.1. PubMed PMID: 18215104.

20. Lindauer SJ, Rubenstein LK, Hang WM, Andersen WC, Isaacson RJ. Canine impaction identified early with panoramic radiographs. J Am Dent Assoc. 1992;123(3):91-2, 5-7. Epub 1992/03/01. PubMed PMID: 1545064.

21. El MD, Messer L, Lehnert M, Hebda TW, Waite D. Canine eruption into grafted bone in maxillary alveolar cleft defects. The Cleft palate journal. 1982;19(1):9-16.

22. Enemark H, Jensen J, Bosch C. Mandibular bone graft material for reconstruction of alveolar cleft defects: long-term results. Cleft Palate Craniofac J. 2001;38(2):155-63. Epub 2001/04/11. doi: 10.1597/1545-1569_2001_038_0155_mbgmfr_2.0.co_2. PubMed PMID: 11294543.

23. Fudalej P, Janiszewska-Olszowska J, Wedrychowska-Szulc B, Katsaros C. Early alveolar bone grafting has a negative effect on maxillary dental arch dimensions of pre-school children with complete unilateral cleft lip and palate. Orthodontics & craniofacial research. 2011;14(2):51-7.

24. Sindet-Pedersen S, Enemark H. Comparative study of secondary and late secondary bone-grafting in patients with residual cleft defects. Short-term evaluation. International journal of oral surgery. 1985;14(5):389-98.

25. Kleinpoort F, Ferchichi H, Belkhou A, Tramini P, Bigorre M, Captier G. Early secondary bone grafting in children with alveolar cleft does not modify the risk of maxillary permanent canine impaction at the age of 10 years. Journal of Cranio-Maxillofacial Surgery. 2017;45(4):515-9.

26. Lilja J, Kalaaji A, Friede H, Elander A. Combined bone grafting and delayed closure of the hard palate in patients with unilateral cleft lip and palate: facilitation of lateral incisor eruption and evaluation of indicators for timing of the procedure. Cleft Palate Craniofac J. 2000;37(1):98-105. Epub 2000/02/12. doi: 10.1597/1545-1569_2000_037_0098_cbgadc_2.3.co_2. PubMed PMID: 10670897.

27. Boyne PJ, Sands NR. Secondary bone grafting of residual alveolar and palatal clefts. J Oral Surg. 1972;30(2):87-92. Epub 1972/02/01. PubMed PMID: 4550446.

28. Hogan L, Shand J, Heggie A, Kilpatrick N. Canine eruption into grafted alveolar clefts: a retrospective study. Australian dental journal. 2003;48(2):119-24.

29. Kuijpers-Jagtman A. The orthodontist, an essential partner in CLP treatment. B ENT. 2006:57.

30. Shashua D, Omnell ML. Radiographic determination of the position of the maxillary lateral incisor in the cleft alveolus and parameters for assessing its habilitation prospects. Cleft Palate Craniofac J. 2000;37(1):21-5. Epub 2000/02/12. doi: 10.1597/1545-1569_2000_037_0021_rdotpo_2.3.co_2. PubMed PMID: 10670885.

31. Lorenzoni DC, Janson G, Bastos JC, Carvalho RM, Bastos JC, Lauris RdCMC, et al. Evaluation of secondary alveolar bone grafting outcomes performed after canine eruption in complete unilateral cleft lip and palate. Clinical oral investigations. 2017;21(1):267-73.

32. da Silva Filho OG, Teles SG, Ozawa TO, Filho LC. Secondary bone graft and eruption of the permanent canine in patients with alveolar clefts: literature review and case report. Angle Orthod. 2000;70(2):174-8. Epub 2000/06/01. doi: 10.1043/0003-3219(2000)070<0174:SBGAEO>2.0.CO;2. PubMed PMID: 10833007.

33. Long Jr RE, Paterno M, Vinson B. Effect of cuspid positioning in the cleft at the time of secondary alveolar bone grafting on eventual graft success. The Cleft palate-craniofacial journal. 1996;33(3):225-30.

34. Enemark H, Krantz-Simonsen E, Schramm JE. Secondary bonegrafting in unilateral cleft lip palate patients: indications and treatment procedure. International journal of oral surgery. 1985;14(1):2-10.

35. Amanat N, Langdon JD. Secondary alveolar bone grafting in clefts of the lip and palate. J Craniomaxillofac Surg. 1991;19(1):7-14. Epub 1991/01/01. PubMed PMID: 2019659.

36. Turvey TA, Vig K, Moriarty J, Hoke J. Delayed bone grafting in the cleft maxilla and palate: a retrospective multidisciplinary analysis. Am J Orthod. 1984;86(3):244-56. Epub 1984/09/01. PubMed PMID: 6383059.

37. Bergland O, Semb G, Abyholm F, Borchgrevink H, Eskeland G. Secondary bone grafting and orthodontic treatment in patients with bilateral complete clefts of the lip and palate. Ann Plast Surg. 1986;17(6):460-74. Epub 1986/12/01. PubMed PMID: 3548551.

38. Ozawa T, Omura S, Fukuyama E, Matsui Y, Torikai K, Fujita K. Factors influencing secondary alveolar bone grafting in cleft lip and palate patients: prospective analysis using CT image analyzer.

Cleft Palate Craniofac J. 2007;44(3):286-91. Epub 2007/05/05. doi: 10.1597/06-054. PubMed PMID: 17477757.

39. Jabbari F, Reiser E, Thor A, Hakelius M, Nowinski D. Correlations between initial cleft size and dental anomalies in unilateral cleft lip and palate patients after alveolar bone grafting. Upsala journal of medical sciences. 2016;121(1):33-7.

40. Gereltzul E, Baba Y, Ohyama K. Attitude of the canine in secondary bone-grafted and nongrafted patients with cleft lip and palate. Cleft Palate Craniofac J. 2005;42(6):679-86. Epub 2005/10/26. doi: 10.1597/04-016.1. PubMed PMID: 16241181.

41. Jia Y, Fu M, Ma L. Long-term outcome of secondary alveolar bone grafting in patients with various types of cleft. British Journal of Oral and Maxillofacial Surgery. 2006;44(4):308-12.

42. Kwon HJ, Waite DE, Stickel FR, Chisholm T, McParland F. The management of alveolar cleft defects. J Am Dent Assoc. 1981;102(6):848-53. Epub 1981/06/01. PubMed PMID: 7028838.

43. Troxell JB, Fonseca RJ, Osbon DB. A retrospective study of alveolar cleft grafting. J Oral Maxillofac Surg. 1982;40(11):721-5. Epub 1982/11/01. PubMed PMID: 6752358.

44. Hinrichs JE, el-Deeb ME, Waite DE, Bevis RR, Bandt CL. Periodontal evaluation of canines erupted through grafted alveolar cleft defects. J Oral Maxillofac Surg. 1984;42(11):717-21. Epub 1984/11/01. PubMed PMID: 6387071.

45. Eldeeb ME, Hinrichs JE, Waite DE, Bandt CL, Bevis R. Repair of alveolar cleft defects with autogenous bone grafting: periodontal evaluation. Cleft Palate J. 1986;23(2):126-36. Epub 1986/04/01. PubMed PMID: 3516455.

46. Bergland O, Semb G, Abyholm FE. Elimination of the residual alveolar cleft by secondary bone grafting and subsequent orthodontic treatment. Cleft Palate J. 1986;23(3):175-205. Epub 1986/07/01. PubMed PMID: 3524905.

47. Enemark H, Sindet-Pedersen S, Bundgaard M. Long-term results after secondary bone grafting of alveolar clefts. J Oral Maxillofac Surg. 1987;45(11):913-9. Epub 1987/11/01. PubMed PMID: 3312537.

48. Paulin G, Astrand P, Rosenquist JB, Bartholdson L. Intermediate bone grafting of alveolar clefts. J Craniomaxillofac Surg. 1988;16(1):2-7. Epub 1988/01/01. PubMed PMID: 3276737.

49. McCanny CM, Roberts-Harry DP. A comparison of two different bone-harvesting techniques for secondary alveolar bone grafting in patients with cleft lip and palate. Cleft Palate Craniofac J. 1998;35(5):442-6. Epub 1998/10/07. doi: 10.1597/1545-1569_1998_035_0442_acotdb_2.3.co_2. PubMed PMID: 9761565.

50. Dempf R, Teltzrow T, Kramer F-J, Hausamen J-E. Alveolar bone grafting in patients with complete clefts: a comparative study between secondary and tertiary bone grafting. The Cleft palate-craniofacial journal. 2002;39(1):18-25.

51. Matsui K, Echigo S, Kimizuka S, Takahashi M, Chiba M. Clinical study on eruption of permanent canines after secondary alveolar bone grafting. Cleft Palate Craniofac J. 2005;42(3):309-13. Epub 2005/05/04. doi: 10.1597/03-113.1. PubMed PMID: 15865467.

52. Tortora C, Meazzini MC, Garattini G, Brusati R. Prevalence of abnormalities in dental structure, position, and eruption pattern in a population of unilateral and bilateral cleft lip and palate patients. Cleft Palate Craniofac J. 2008;45(2):154-62. Epub 2008/03/13. doi: 10.1597/06-218.1. PubMed PMID: 18333651.

53. Hinrichs J, Novak M. Classification of diseases and conditions affecting the periodontium. Carranza's Clinical Peridontology,(11thedn), Reed Elsevier India Private Limited, New Delhi. 2012;41.

54. Andreasen J, Ravn J. Epidemiology of traumatic dental injuries to primary and permanent teeth in a Danish population sample. International journal of oral surgery. 1972;1(5):235-9.

55. Nishihara K, Nozoe E, Maeda A, Hirahara N, Okawachi T, Miyawaki S, et al. Outcome following secondary autogenous bone grafting before and after canine eruption in patients with unilateral cleft lip and palate. The Cleft Palate-Craniofacial Journal. 2014;51(2):165-71.

56. Alqerban A, Jacobs R, Fieuws S, Willems G. Comparison of two cone beam computed tomographic systems versus panoramic imaging for localization of impacted maxillary canines and detection of root resorption. Eur J Orthod. 2011;33(1):93-102. Epub 2011/01/29. doi: 10.1093/ejo/cjq034. PubMed PMID: 21270321.

57. Chaushu S, Chaushu G, Becker A. The use of panoramic radiographs to localize displaced maxillary canines. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology. 1999;88(4):511-6.

58. Seo Y-J, Park J-W, Kim YH, Baek S-H. Initial growth pattern of children with cleft before alveolar bone graft stage according to cleft type: unilateral cleft lip and alveolus, unilateral cleft lip and palate, and cleft palate. The Angle orthodontist. 2011;81(6):1103-10.

59. Hereman V, Cadenas De Llano-Pérula M, Willems G, Coucke W, Wyatt J, Verdonck A. Associated parameters of canine impaction in patients with unilateral cleft lip and palate after secondary alveolar bone grafting: a retrospective study. European Journal of Orthodontics. 2018.