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VOLUMETRIC ASSESSMENT OF MANDIBULAR SYMPHYSEAL BONE GRAFT FOR SECONDARY RECONSTRUCTION OF UNILATERAL ALVEOLAR CLEFTS

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ABSTRACT

Purpose: To evaluate the volume of bone graft that can be harvested from the mandibular symphysis and compare it with the bone volume needed for secondary grafting unilateral alveolar clefts using a computer-aided design (CAD) software program based on 3 Dimensional Cone Beam CT Scans. In addition, to study the bone fill of the mandibular symphysis graft in the alveolar cleft.

Subjects & Methods: The subjects were 12 patients with unilateral alveolar clefts who underwent Cone Beam CT Scans 1 week prior to procedure. Using a 3D Analysis Software, the available bone that can be harvested from the mandibular symphysis area was determined using CBCT. Also, the volume of the Alveolar cleft defect was calculated preoperatively to assess the sufficiency of the symphyseal bone graft. All patients underwent secondary alveolar cleft grafting with mandibular symphysis bone. Six months postoperatively, CBCT was used to evaluate the amount of bone fill of the alveolar cleft.

Results: The mean harvestable symphysis bone volume including the lingual cortex was 2.4 cm^3 (range: 1.4–4.3 cm^3). The actual harvested particulate symphyseal bone graft volume was calculated during surgery and was 2.62 cm^3 (range: 1.6–4.0 cm^3). The preoperative mean volume of the unilateral alveolar cleft defects was 1.9 cm^3 (range: 1.1- 2.85 cm^3). The mean postoperative bone fill ratio of the unilateral alveolar cleft was 79% (range 54% to 96%) 6 months postoperatively.

Conclusion: This Study showed that the mandibular symphysis provided sufficient bone volume for secondary unilateral alveolar cleft grafting. Also, the mandibular symphyseal bone graft provided adequate bone fill of the alveolar cleft 6 months postoperatively..

KEYWORDS: Alveolar Cleft – Mandibular symphysis – autogenous bone – Cone beam CT (CBCT) – Bone graft – Volumetric Analysis

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INTRODUCTION

Secondary alveolar cleft grafting is usually performed prior to the eruption of the permanent Canine during mixed dentition phase. However, the ideal bone graft is still debatable. Different bone graft materials have been extensively employed in alveolar cleft grafting: autograft, xenograft, allograft, and alloplastic materials have all been used with great success (Borstlap et al, 1990; Oberoi et al, 2006).

Autogenous bone remains the gold standard for alveolar cleft grafting. Different donor sites for autogenous bone include: iliac crest, tibia, rib, calvarium, and mandibular symphysis. The anterior iliac crest bone graft is the most common autogenous bone graft employed in alveolar cleft reconstruction. The selection of autogenous bone donor site is influenced by the surgeon's preferred technique, his skills, and the amount of bone graft volume needed (Semb, 2012).

In 1980, *Bosker and van Dijk* first reported the use of mandibular symphysis bone graft in Maxillofacial bony reconstruction. Then, abundant studies have established that bone graft from mandibular symphysis to be an ideal bone graft site presenting intramembranous bone but with some limits. The benefits of mandibular symphysis bone graft are being a simple, short procedure using an intraoral site with no obvious scar, patient acceptance and insignificant postoperative complications. It has been documented to have minimal resorption and abundant concentration of bone morphogenetic proteins. On the other hand, its drawbacks include: the lesser volume of bone obtainable from the mandibular symphyseal area and liability of damage to neighboring teeth, and the mental nerve.

Due to the mandibular symphysis offering more cortical bone compared with other donor sites, it was argued that there is high incidence of canine impaction in the alveolar cleft grafting which was debated by *Enemark et al*. in 2001. At present, there is no recognized technique for measuring the available mandibular symphyseal bone and compare it with the alveolar cleft size.

The purpose of this study was to assess the volume of bone graft that can be harvested from the mandibular symphysis in patients requiring secondary unilateral alveolar cleft grafting during mixed dentition phase and compare it with the alveolar cleft volume and also with the actual bone volume harvested using a computer-aided design (CAD) software program. In addition, to evaluate the volume of bone fill 6 months postoperatively in unilateral alveolar clefts using mandibular symphysis bone graft.

SUBJECTS AND METHODS

12 patients with unilateral alveolar cleft were included in this study. All patients undertook Cone beam computed tomography (CBCT) using a Cone Beam computed tomography Machine (Soredex, Finland) 1 week prior to secondary alveolar cleft grafting. Informed consent was obtained from all patients. All patients underwent secondary alveolar bone grafting at the Department of Oral and Maxillofacial Surgery, Cairo University, Egypt.

Treatment Plan

Following internationally recognized Standards of Care, a Maxillofacial Surgeon with an orthodontist assessed the proper timing for alveolar cleft reconstruction, need for teeth extraction: malformed, supernumerary and unsalvageable teeth before secondary alveolar cleft grafting. Surgery was performed after completion of maxillary orthodontic expansion, and eruption of mandibular Canine tooth to allow for sufficient mandibular symphyseal bone to harvest.

Mandibular Symphysis bone Volume Calculation

The available bone that can be harvested from the mandibular symphysis area was determined using CBCT. The scans were taken every 1 mm and the dataset was imported into a 3D analysis software (Mimics 16.0; Materialise Interactive Medical Image Control System, Leuven, Belgium).

The harvest site in the Mandibular symphysis area was outlined, the margins were fixed at: superior border 5 mm apical to the roots of the mandibular anterior teeth, inferior border 5 mm above the inferior border of the mandible and laterally 5 mm anterior to both mental foramens. The bicortical surface area was calculated and multiplied by the thickness to attain the volume.

Alveolar Cleft Volume requiring bone grafting Calculation

Dataset of the axial sections of the CBCT of the maxillary alveolar cleft were imported into the 3D analysis software (Mimics 16.0; Materialise Interactive Medical Image Control System, Leuven, Belgium). Thresholding and 3 dimensional view of the alveolar cleft area was established. The margins of the alveolar cleft was outlined: superior border as the lower margin of the anterior nasal aperture, inferior border as the alveolar ridge adjacent to the cleft area and medio-laterally, it was bordered by neighboring teeth of the cleft. The surface area was calculated on axial CBCT sections and multiplied by the thickness of each section to attain the alveolar cleft volume (Figure 1). According to the attained data, the amount of bone volume that can be harvested from the mandibular symphyseal area was compared with the volume of the alveolar cleft area.1

Surgical procedure:

Harvesting Mandibular Symphysis Graft:

Autogenous bone was harvested from the mandibular symphysis region under general anesthesia. A horizontal vestibular mucosal incision was made from canine to canine. Then an incision is carried out through mentalis muscle fibers. Sub-periosteal dissection is carried out exposing bone and stripping of mentalis muscle and the mental nerves on both sides were localized and protected. The positions of the apices of the mandibular incisors and the tooth germs or roots of the mandibular permanent canines were outlined to determine the site of the bone graft bed. Using trephine bur autogenous bone was collected from the symphysis area, around 2-4 trephines were collected depending on amount of bone needed then milled manually with bone mill (Figure 2). The milled bone was packed into a graduated syringe to determine volume obtained. A resorbable collagen sponge (Helistat sponge, integra co, USA) was used to fill the bony defect. Closure was done in layers starting with mentalis muscle which is reattached

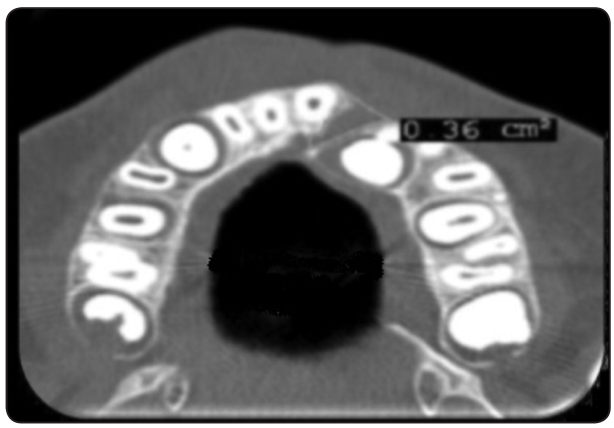

Fig. (1) Surface area of alveolar cleft outlined and calculated on Axial CBCT sections.

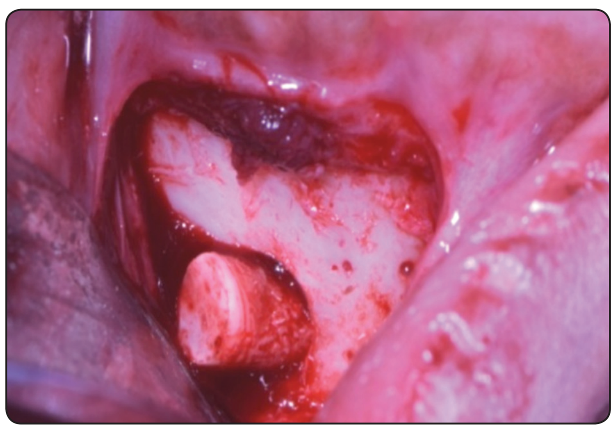

Fig. (2) Showing the symphyseal bone harvest using trephine back using PGA 3-0 sutures to prevent chin ptosis. This was followed by closure of the mucosa using PGA 3-0 sutures. In order to reduce edema, an elastic bandage was applied to the chin for 48 hours. Intraoperatively, the harvested bone was measured after bone milling by using a graduated syringe. Preoperative and intraoperative bone volumes were evaluated and compared.

Alveolar Cleft Grafting Procedure:

Articaine 4% local anesthetic solution with vasoconstrictor (epinephrine 1:100,000) was infiltrated along the cleft surgical site for hemostasis. An intraoral lateral sliding labial flap was made starting with a sulcular incision on the labial side of the alveolar cleft extending to about 2 teeth on either side of the cleft or non-cleft side. A releasing incision was made on each side of the flap extending to the depth of the mucobuccal fold. On the palatal side, a sulcular incision was completed extending about 2 teeth on either side of the cleft or non-cleft side. Mucoperiosteal flaps were elevated exposing the alveolar bony defect and surrounding bone. Labial flaps were dissected from the nasal mucosa up to the nasal spine. Also, the Palatal flaps were reflected and separated from the nasal mucosa. The nasal fistula was outlined and closed using 4/0 vicryl, then the nasal mucosa was elevated upward creating the bed for the bone graft (Figure 3).

Then the harvested symphyseal bone graft was packed into the alveolar cleft area (figure 4) and it was determined if it was sufficient or not. The actual volume of bone graft was calculated by subtracting remaining particulate bone from the harvested bone volume.

Scoring of the periosteum of the labial flaps to allow advancement of the flaps without tension to cover the bone graft in alveolar cleft area. The labial and palatal flaps were sutured with 4/0 Vicryl (Figure 5).

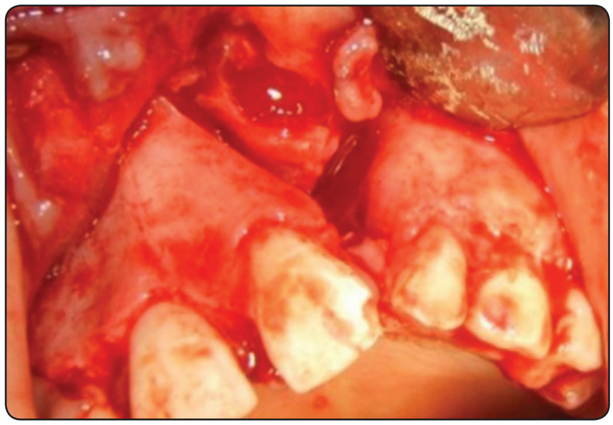

Fig. (3) Nasal fistula elevated and closed using 4-0 Vicryl

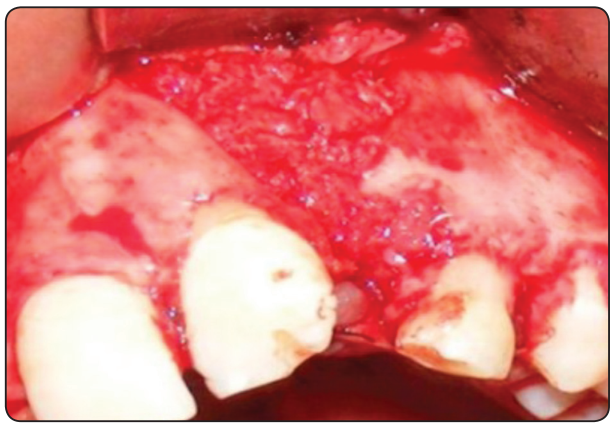

Fig. (4) Mandibular Symphyseal bone packed into alveolar defect

Fig. (5) Showing flap sutured back in place

Radiographic Assessment:

CBCT was performed 6 months postoperatively to evaluate amount of bone formation, bony bridging and eruption of the permanent canine. The volume of remaining alveolar defect around bone graft at 6 months was measured and subtracted from the actual alveolar defect volume to calculate Volume of bone fill. The actual volume of alveolar bone graft is represented as a percentage of bone fill of the alveolar defect volume (Preoperative alveolar Defect Volume – Postoperative residual defect volume / Preoperative Alveolar defect volume X 100).

Statistical analysis

Statistical analysis was implemented using SPSS (Statistical package for the social sciences) version 16, Echosoft corp., U.S.A. Data were represented as mean ± standard deviation. Paired Student t-test was used to compare variables within the same group. Results were considered statistically significant if the P-value was equal or less than 0.05.

RESULTS

A total of 12 patients with unilateral cleft lip and palate underwent alveolar cleft reconstruction using mandibular symphyseal bone graft. A Mean age was 12.7 years and included 7 males and 5 females. All Surgeries had successful postoperative period with no complications. At 6 months postoperatively, there was adequate fill of the alveolar defect and good bone bridging the gap (figure 6). The mean harvestable symphyseal bone volume was calculated Preoperatively, from analyzing CBCT scans of the mandible using Mimics 3D analysis software for all 12 patients. The mean harvestable symphysis

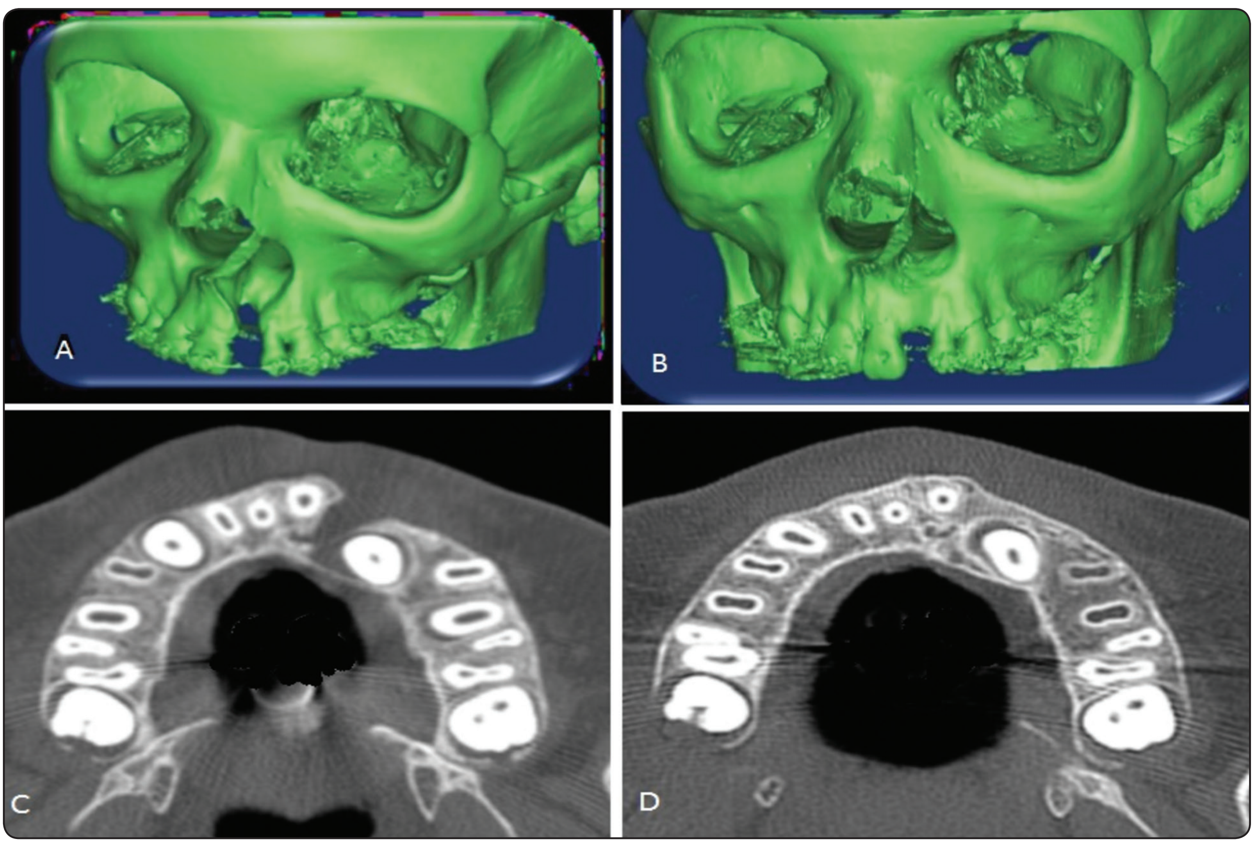

Fig. (6) A,B showing 3 D scan of the alveolar cleft preoperatively and Postoperatively. C,D: Showing axial view of alveolar cleft preoperatively and postoperatively the bone fill and the bridging of the gap is evident.

bone volume including the lingual cortex was 2.4 cm^3 (range: 1.4–4.3 cm^3). The actual harvested particulate symphyseal bone graft volume was calculated during surgery and was 2.62 cm^3 (range: 1.6–4.0 cm^3). There was no statistical significant difference between calculated mean harvestable bone and actual bone volume harvested (P>0.05).

TABLE (1)

	Mean	Range
Harvestable symphysis bone volume (CBCT)	2.4 cm^3	1.4–4.3 cm^3
actual harvested particulate symphyseal bone	2.62 cm^3	1.6–4.0 cm^3
Preoperative mean volume of the unilateral alveolar cleft	1.9 cm^3	1.1- 2.85 cm^3

The preoperative mean volume of the unilateral alveolar cleft defects was 1.9 cm^3 (range: 1.1- 2.85 cm^3) compared with actual harvested particulate symphyseal bone graft volume 2.62 cm^3 (range: 1.6–4.0 cm^3). Thus the harvestable symphyseal bone graft was sufficient for secondary unilateral alveolar cleft grafting. There was statistical significant difference between the harvestable bone graft and the alveolar cleft volume. P<0.05). The mean postoperative bone fill ratio of the unilateral alveolar cleft was 79% (range 54% to 96%) 6 months postoperatively (Table 1).

DISCUSSION

Alveolar cleft grafting is an essential phase in the management of patients with cleft lip and palate. Various donor sites exist for autogenous bone graft harvest, which includes the iliac crest, cranium, mandibular symphysis, rib and ramus. The most commonly uses donor site is the anterior iliac crest due to abundant cancellous bone and accessibility. However, disadvantages of iliac crest bone graft such as skin incision and gait disturbance remains. Intra oral bone graft sources such as mandibular symphysis and ramus are viable alternatives with advantages such as lack of skin incision and ease of bone harvest; however the sufficiency of the bone graft from these sites could present a disadvantage Van der Mejj et al, 2003, Amirlak et al, 2013).

Autogenous graft obtained from intra-membranous bone has been demonstrated to be more resistant to resorption than bone grafts obtained from endochondral bones. Currently, the mandibular symphysis represents an ideal bone graft donor site clinicians for augmenting atrophic alveolar ridges prior to implant placement. Thus volumetric assessment of both the mandibular symphysis and alveolar cleft is important to determine if it is adequate enough for bone grafting of alveolar defects (Hoppenreijs et al, 1992, Shirzadeh et al., 2018).

Shirzadeh et al in 2018 measured the volume of bone that can be harvested from mandibular symphysis and demonstrated it to be an average of 2.1 cm^3 (range 1.6-2.3 cm^3). However, the volume of the alveolar cleft defect was not measured preoperatively to determine sufficiency.

Botel et al in 1993 measured the volume of the alveolar cleft utilizing bone wax impressions and producing resin models to determine the bone volume. They determined that alveolar cleft defect volume ranged from 1 -3.5 cm^3 and a median of 1.5 cm^3. In this study, CBCT was utilized to measure the volume of the possible symphyseal bone graft with a safety margin from the lower anterior teeth and inferior border of the mandible as described by Borstlap et al and Hoppenreijs et al. The actual harvestable symhyseal bone graft in this study was in the range of 1.4 to 4.3 cm^3 with an average of 2.4 cm^3 including outer and inner cortex. While the actual harvested particulate bone had an average of 2.62 cm^3 with a range of 1.6–4.0 cm^3.

CT scans are used to correctly measure the volume of mandibular symphyseal bone graft and the alveolar defect size. Lately, there has been a shift towards the utilization of CBCT for preoperative and postoperative volumetric assessment of alveolar cleft defects (Choi et al., 2012; Zhang et al., 2012; Amirlak et al., 2013). Oberoi et al in 2009 in cases of unilateral and bilateral clefts grafted with iliac crest bone graft at a mean age of 10.6 years revealed 84% bone fill 1 year postoperative, while Zhang et al in 2012 in cases of unilateral alveolar clefts treated with autogenous iliac crest bone graft showed 71% bone fill at 6 months postoperative. Numerous studies exist that assess alveolar cleft defects using CT scans, Van der Meij et al in 2003 demonstrated 64 % bone fill in unilateral alveolar cleft cases, Feichtinger et al in 2007 showed a bone fill of 50% 1 year postoperative. Thus a large variation of bone fill in alveolar cleft defects exists in different studies and range between 50 % t0 84%. This variation can be attributed to different measurement techniques, segmentation process or in outlining the alveolar defect as area of interest. However, our current study may designate that the bone fill following Symphyseal bone grafting is not significantly different from that attained utilizing anterior iliac crest bone grafts. This study showed an overall bone fill of 79% (range 54% to 96%) 6 months postoperatively. Albuquerque et al. in 2011 compared the utilization of CBCT and CT scans for volumetric measurement of alveolar cleft defects. They proved that both techniques were effective and attained high efficacy for volume measurement.

Alveolar cleft size remains to be one of the most critical factors leading to the success of the bone graft. Long et al in 1995 and Van Der Meij in 2003 indicated in their studies that the wider the clefts, the more the bone graft is prone to resorption. Contrary to this Oberoi et al in 2009 showed that the size of Preoperative Cleft Defect did not have an effect on the amount of bone fill.

Similar to our study, Feichtinger et al. in 2006; Kim et al. in2008 and Oberoi et al. in 2009 all indicated that the volumetric size of the preoperative defect did not appear to affect the outcome in terms of bone fill. All the cases in this study received presurgical expansion, the effect of presurgical Maxillary expansion on bone resorption relative to cleft width has not been proven (Oberoi et al. in 2009).

The factors attributed to resorption of the bone graft in alveolar clefts were tension of the mucoperiosteal flap resulting in bone dehiscence, lack of dental hygiene, and periodontal problems (Bergland et al., 1986; Keese and Schmelzle, 1995 and Semb, 2012). In this study, oral hygiene and periodontal condition were well sustained. Other factors that seems more qualitative but are still crucial to the successful outcome of alveolar cleft grafting are: bone bridging between the alveolar segments, the condition of the neighboring teeth, and orthodontic alignment (Rosenstein et al., 1997; Tai et al., 2000).

CONCLUSION

Thus, preoperative evaluation of alveolar cleft volume and determining the maximum volume of bone graft to be harvested from mandibular symphysis is a precise method for unilateral Alveolar cleft reconstruction. The results showed that the mandibular symphysis provided sufficient bone volume for secondary unilateral alveolar cleft grafting. However, as a result of variability among different individuals of both the cleft volume and the bone graft volume harvested from the mandibular symphysis, it would be of greater accuracy to perform these preoperative volume evaluations to guarantee adequacy of the bone graft on each individual case.

REFERENCES

1. Bergland O, Semb G, Abyholm FE. Elimination of the residual alveolar cleft by secondary bone grafting and subsequent orthodontic treatment. Cleft Palate J. 1986; 23:175–205.
2. Borstlap W, Heidbuchel K, Freithoffer H, Kuijpers-Jagtman A. Early secondary bone grafting of alveolar cleft defects. J Cranio-Max-Fac Surg 1990: 18: 201-5.
3. Bosker HL, van Dijk L. Het bottransplantaat uit de mandibula voor herstel van de gnathopalatoschisis. Ned Tijdschr Geneeskd. 1980;87:383–388.
4. Botel U, Fleiner B, Steckeer S. Beckenspanentnahme bei 172 Kieferspaltosteoplastiken: eine retrospective Studie. Fortschr Kiefer Gesichtschir
5. Boyne PJ, Sands NR. Secondary bone grafting of residual alveolar and palatal clefts. J Oral Surg. 1972;30:87–92.
6. Enemark H, Jensen J, Bosch C. Mandibular bone graft material for reconstruction of alveolar cleft defects: long-term results. Cleft Palate Craniofac J. 2001;38:155–163.
7. Feichtinger M, Mossbock R, Karcher H. Evaluation of bone volume following bone grafting in patients with unilateral clefts of lip, alveolus and palate using a CT-guided three-dimensional navigation system. J Craniomaxillofac Surg. 2006; 34:144–149.
8. Hoppenreijs T, Nudam E, Freihofer H. The chin as a donor site in early secondary osteoplasty: a retrospective clinical and radiological evaluation. J Cranio-Max-Fac Surg 1992: 20:119-24.
9. Kim KR, Kim S, Baek SH. Change in grafted secondary alveolar bone in patients with UCLP and UCLA. A three-dimensional computed tomography study. Angle Orthod. 2008;78:631–640.
10. Kilinc A, Saruhan N, Ertas U, Korkmaz IH, Kaymaz I. An Analysis of Mandibular Symphyseal Graft Sufficiency for Alveolar Cleft Bone Grafting. Journal of Craniofacial Surgery 2017; 28: 147-50.
11. Long RE Jr, Spangler BE, Yow M. Cleft width and secondary alveolar bone graft success. Cleft Palate Craniofac J. 1995;32:420– 427.
12. Oberoi S, Chigurupati R, Gill P, Hoffman WY, Vargervik K. Volumetric assessment of secondary alveolar bone grafting using cone beam computed tomography. Cleft Palate Craniofac J. 2009;46:503–511.
13. Rosenstein SW, Long RE Jr, Dado DV, Vinson B, Alder ME. Comparison of 2-D calculations from periapical and occlusal radiographs versus 3-D calculations from CAT scans in determining bone support for cleft-adjacent teeth following early alveolar bone grafts. Cleft Palate Craniofac J. 1997;34:199–205.
14. Semb G. Alveolar bone grafting. Front Oral Biol. 2012; 16:124–136.
15. Shirzadeh A, Rahpeyma A, Khajehahmadi S. A Prospective Study of Chin Bone Graft Harvesting for Unilateral Maxillary Alveolar Cleft During Mixed Dentition. J Oral Maxillofac Surg. 2018 ;76:180-188.
16. Tai CC, Sutherland IS, McFadden L. Prospective analysis of secondary alveolar bone grafting using computed tomography. J Oral Maxillofac Surg. 2000;58:1241–1249, discussion 1250.
17. Van der Meij A, Baart JA, Prahl-Andersen B, Kostense PJ, van der Sijp JR, Tuinzing DB. Outcome of bone grafting in relation to cleft width in unilateral cleft lip and palate patients. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2003;96:19–25.