Effects of timing and number of palate repair on maxillary growth in complete unilateral cleft lip and palate patients

Ashok Kumar Jena* / Ritu Duggal** / Ajoy Roychoudhury*** / Hari Parkash**** /

This cross-sectional study was conducted on 40 subjects to investigate the effects of timings and number of palate surgeries on maxillary growth in complete unilateral cleft lip and palate patients. The number of surgeries performed for palate repair was not an important growth inhibiting factor of maxilla, rather the age at which the initial palate surgery was performed for palate repair was an important factor in influencing maxillary growth.

J Clin Pediatr Dent 28(3): 225-232, 2004

INTRODUCTION

Treatment of patients with cleft lip and palate presents a major challenge because clefts cause various anatomical and functional problems and thus involves multidisciplinary and interdisciplinary approach.[1] Attempts to solve the cleft palate problem have been largely surgical, and these procedures have been and still are instituted at various ages- in some cases only days after birth, but usually before the child start school. However, the true appraisal of the results of surgical management can not be made until some stage of maturity has been reached.[2] Ross and Johnston[3] confirmed that surgical repair of cleft palate has a deleterious effect on maxillary growth. Delayed repair of hard palate has less deleterious effect on maxillary growth than repair of hard palate at an early age.[4-6] A short and retrusive maxilla was found in unilateral cleft lip and palate subjects treated and followed up by the Oslo protocol.[7] From the clinical point of view, the impact of surgery on maxillary growth remains a central issue in the controversy surrounding the surgical management of oro-facial clefts. Although attention was drawn to the dramatic effects of surgically induced growth impairment more than 50 years ago[8], how much contemporary surgery interferes with growth and whether lip or palate surgery is more harmful remain matters of dispute.[9]

It has been concluded that standardization of the services and the participation of high volume operators combined with the optimum orthodontic treatment interventions produced best treatment results and the need for the later orthognathic surgery was minimum.[10] In India not only a centralized multidisciplinary approach is lacking, but also there are no definite treatment protocols with regard to timings of surgery and techniques. It is well documented that the surgical technique employed and specific protocol used for surgery are important factors to affect the cranio-facial morphology in cleft patients.[10] However, conflicting views exist regarding the timing of palate repair in patients with cleft palate and subsequent cranio-facial deformities. Information available in the literature regarding the above issue are mostly from European centers. It is unfortunate that no data is available from Indian subcontinent with special references to the effects of timing of palate repair on cranio-facial dimensions in these patients. Hence, this study was designed to evaluate the effects of early, late and multiple palate surgeries on maxillary growth in North Indian complete unilateral cleft lip and palate patients.

MATERIALS AND METHOD

Patients selected for this study were taken from Cleft Lip and Palate Clinic, Department of Dental Surgery, All India Institute Medical Sciences, New Delhi. Total

* Ashok Kumar Jena, MDS (Orthodontics), Senior Resident, Division of Orthodontics, Department of Dental Surgery, All India Institute of Medical Sciences, New Delhi.
** Ritu Duggal, MDS (Orthodontics), Associate Professor, Division of Orthodontics, Department of Dental Surgery, All India Institute of Medical Sciences, New Delhi.
*** Ajoy Roychoudhury, MDS (Oral and Maxillofacial Surgery), Associate Professor, Department of Dental Surgery, All India Institute of Medical Sciences. New Delhi.
**** Hari Parkash, MDS, FIMFT, FICD, MNAMS, FACD, Professor and Head, Department of Dental Surgery, All India Institute of Medical Sciences, New Delhi.

Send all correspondence to Dr. Ritu Duggal, Associate Professor, Department of Dental Surgery, All India Institute of Medical Sciences, New Delhi, India.

Voice: 011-6593231
Fax: 011-26862663
E-mail: rituduggal@rediffmail.com

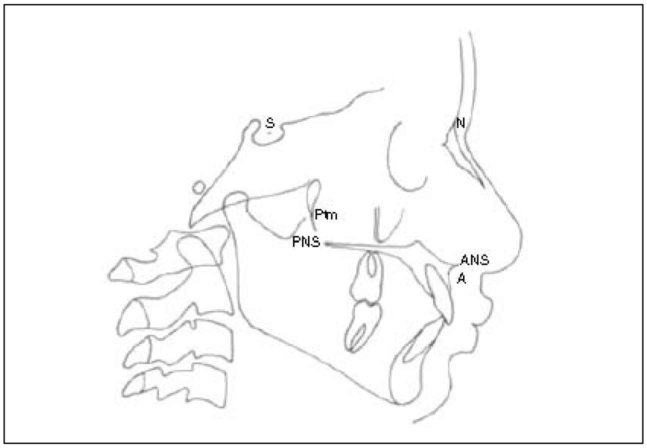

Figure 1. Cephalometric skeletal landmarks: Sella **(S)**. Geometric center of the pituitary fossa located by visual inspection; Nasion **(N)**. The most anterior point on the frontonasal suture in the mid-sagittal plane; Point-A **(A)**. The most posterior midline point in the concavity between the anterior nasal spine and the prosthion; Anterior Nasal Spine **(ANS)**. The anterior tip of the sharp bony process of the maxilla at the lower margin of the anterior nasal opening; Posterior nasal spine **(PNS)**. The posterior spine of the palatine bone constituting the hard palate; Pterygomaxillary Fissure **(Ptm)**. The contour of the pterygomaxillary fissure formed anteriorly by the retromolar tuberosity of the maxilla and posteriorly by the anterior curve of the pterygoid process of the sphenoid bone.

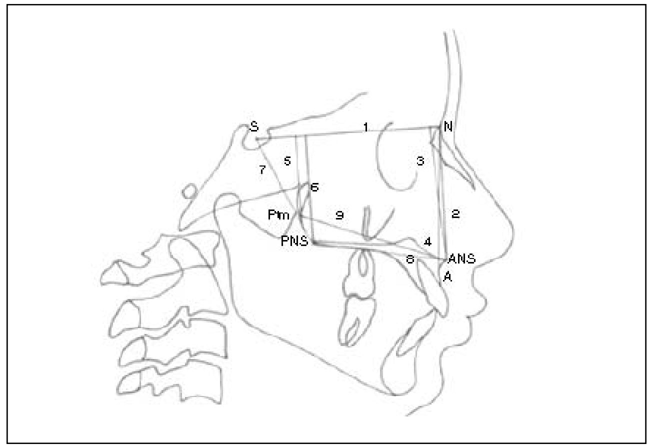

Figure 2. Cephalometric linear parameters: **1.** S-N plane, horizontal plane from sella to nasion; **2.** N-ANS distance, linear distance from nasion to anterior nasal spine; **3.** SN-ANS distance, perpendicular linear distance from anterior nasal spine to S-N plane; **4.** N-A distance, linear distance from nasion to point-A; **5.** SN-ptm distance, perpendicular linear distance from pterygomaxillary fissure point to S-N plane; **6.** SN-PNS distance, perpendicular linear distance from posterior nasal spine to S-N plane; **7.** S-PNS distance, linear distance from sella to posterior nasal spine; **8.** ANS-PNS distance, linear distance from anterior nasal spine to posterior nasal spine; **9.** ANS-Ptm distance, linear distance from anterior nasal spine to pterygomaxillary fissure point.

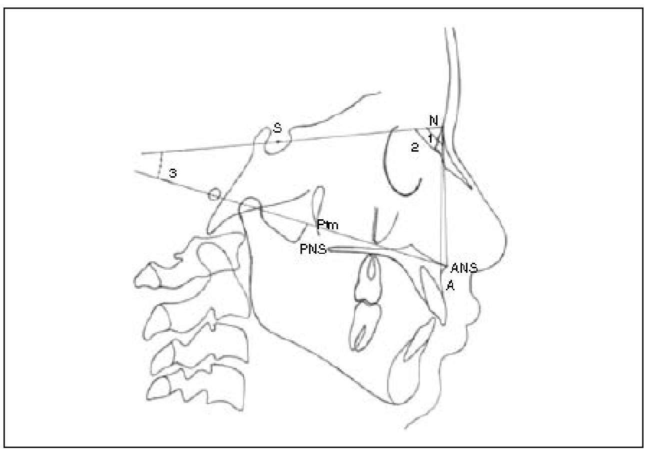

Figure 3. Cephalometric angular parameters: **1.** SNA angle, angle between sella, nasion and point-A; **2.** S N ANS angle, angle between S-N plane and Ptm-ANS plane.

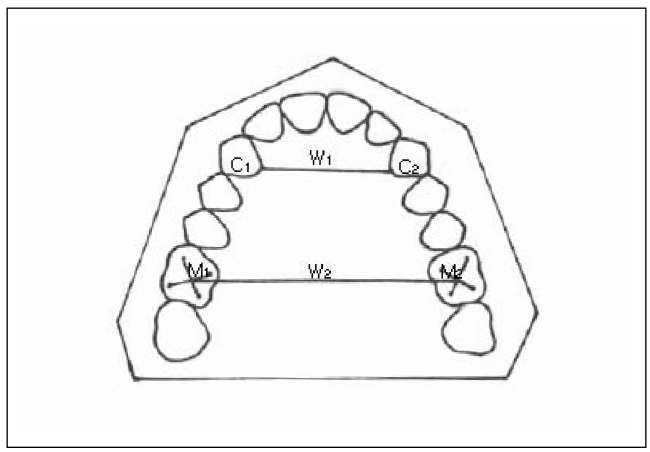

Figure 4. Arch width measurement: Anterior arch width **(W1)** was considered as the linear distance between the deepest point on the palatal gingival margin of right side maxillary permanent canine **(C1)** and left side maxillary permanent canine **(C2)**. Posterior arch width **(W2)** was considered as the linear distance between the intersection of the diagonal lines passing from the cusp tips of the maxillary first molar of right side **(M1)** and left side **(M2)**.

40 young North Indian adult subjects were chosen for the study. Among 40 subjects, 10 were normal non-cleft subjects and 30 were repaired complete unilateral cleft lip and palate subjects. The criteria for including a patient in the study were:

- Cleft subjects having repaired complete unilateral clefts of lip and palate.
- Cleft subjects in whom palate was repaired by one stage palatoplasty.
- All cleft and control subjects within the age range of 15-25 years.
- Control subjects having orthognathic facial profile with well-aligned dental arches without history of any orthodontic treatment.

Presence or absence of any palatal fistula was ignored in the patient selection criteria. Cleft subjects who had received alveoloplasty, alveolar bone grafting, two stage palatoplasty, any orthodontic treatment, major orthopedic or orthognathic surgery prior to or after palatal repair and having received any surgical procedure in the oro-facial region other than lip and palate repair were excluded from the study. Ten (10)

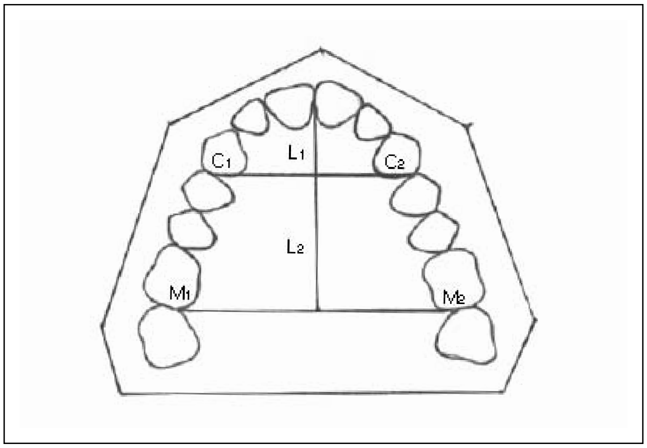

Figure 5. Arch length measurement: Anterior arch length **(L1)** was considered as the linear distance at the midline from a point midway between the central incisors to a tangent touching the distal surfaces of right side maxillary permanent canine **(C1)** and left side maxillary permanent canine **(C2)**. Posterior arch length **(L2)** was considered as the linear distance at the midline from a point midway between the central incisors to a tangent touching the distal surfaces of the right side permanent first molar **(M1)** and left side permanent first molar **(M2)**.

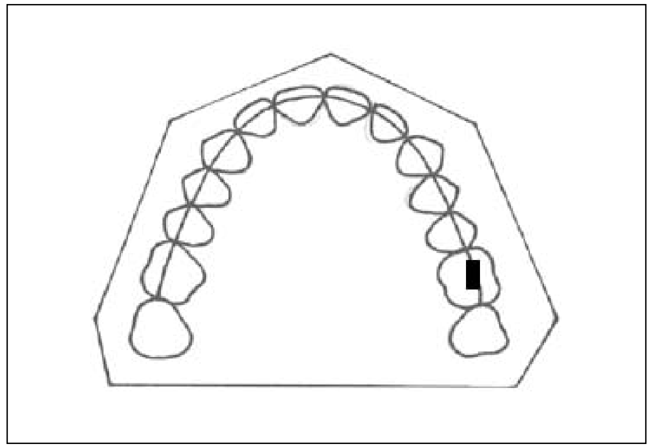

Figure 6. Arch perimeter measurement. It was considered as the linear distance from the distal surface of the right side permanent first molar **(DM1)** around the arch over the contact points and incisal edges in a smoothed curve to the distal surface of the left side permanent first molar **(DM2)**.

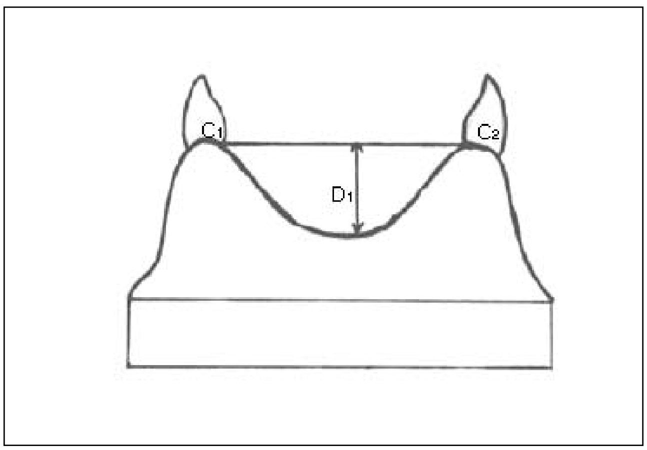

Figure 7. Anterior palatal depth **(D1)** measurement. Anterior palatal depth **(D1)** was considered as the perpendicular distance from a line joining the deepest palatal gingival margin of right permanent canine **(C1)** and left permanent canine **(C2)** to the highest contour of palate.

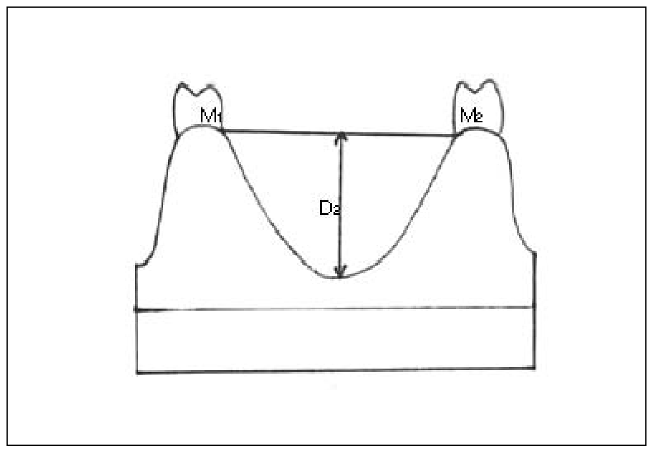

Figure 8. Posterior palatal depth **(D2)** measurement. Posterior palatal depth **(D2)** was considered as the perpendicular distance from a line joining the deepest palatal gingival margin of right side permanent first molar **(M1)** and left side permanent first molar **(M2)** to the highest contour of palate.

normal non-cleft subjects (5 males and 5 females) were included in the control group and 30 cleft subjects were divided into three groups each containing 10 subjects (5 males and 5 females), according to the age at which initial palate repair was performed and number of surgeries performed for palate repair.

Group I: Control group.
Group II: Early repair group, subjects who had undergone palate repair before 2 years of age.
Group III: Late repair group, subjects who had undergone palate repair after 2 years of age.
Group IV: Multiple repair group, subjects who had undergone multiple surgeries for palate repair irrespective of age at which the initial palate repair was performed.

In subjects of group II and group III palate was repaired by single surgery, but in subjects of group IV more than one surgery was performed to repair palate, but all surgeries were performed before five years of age. Left lateral cephalometric radiographs and dental study models were made for all studied subjects. Lateral cephalogram and study models were

Table 1. Cephalometric parameters among different groups

Parameters	Group-I (n=10)		Group-II (n=10)		Group-III (n=10)		Group-IV (n=10)		
	Mean±SD	95% Confidence Interval for Mean	Mean±SD	95% Confidence Interval for Mean	Mean±SD	95% Confidence Interval for Mean	Mean±SD	95% Confidence Interval for Mean	p value
N-ANS Distance	51.39±2.81	49.37-53.40	51.53±7.23	46.36- 56.71	53.29±3.98	50.43-56.14	52.23±2.71	50.28- 54.17	.782 NS
SN-ANS Distance	51.21±2.84	49.18- 53.24	50.05±6.76	45.21- 54.89	52.79±3.85	50.03- 55.55	51.38±2.78	49.39- 53.37	.581 NS
N-A Distance	56.00±3.10	53.79- 58.22	58.45±7.27	53.24- 63.66	58.82±3.15	56.56- 61.07	57.25±3.71	54.60- 59.91	.528 NS
SN-Ptm Distance	33.04±2.58	31.19- 34.88	35.01±4.25	31.97- 38.05	34.24±3.41	31.80- 36.68	35.47±2.71	33.53- 37.41	.389 NS
SN-PNS Distance	43.39±2.18	41.82-44.95	44.74±5.64	40.70-48.78	42.37±3.11	40.14- 44.59	43.75±4.66	40.42- 47.09	.641 NS
S-PNS Distance	47.06±2.35	45.37- 48.74	46.12±5.42	42.24- 50.00	45.46±3.10	43.24- 47.68	45.89±4.41	42.73- 49.05	.837 NS
ANS-PNS Distance	47.73±3.44	45.27- 50.19	47.30±3.27	44.95-49.64	50.61±3.50	48.10-53.12	50.86±5.39	47.00-50.46	.106 NS
ANS-Ptm Distance	54.21±2.60	52.35-56.08	49.51±3.78	46.80-52.2154.70 (3.40		52.26-57.13	52.71±3.93	49.89-55.52	.008 **
SNA Angle	82.15±3.84	79.39-84.90	70.45±3.47	67.96-72.93	78.80±3.48	76.30-81.29	76.90±4.64	73.57-80.22	.000 ***
S N ANS Angle	86.65±3.65	84.03-89.24	75.35±3.27	73.00-77.69	83.00±2.81	80.98-85.01	81.20±4.06	78.29-84.10	.000 ***
S-N ANS-Ptm Angle	19.25±3.40	16.81-21.68	17.20±4.89	13.69-20.70	18.25±4.72	14.86-21.63	17.55±3.13	15.31-19.78	.696 NS

NS = Non-significant, * = p < 0.05, ** = p < 0.01 and *** = p < 0.001.

analyzed separately for each group and than compared among themselves.

Cephalometric films were obtained using the cephalometric equipment available at the respective study center. The cephalometric films were obtained with the teeth in occlusion and all cephalometric films were obtained from a single machine. The cephalometric landmarks, linear parameters and angular parameters used in the study are shown in Figures 1, 2 and 3 respectively. All the cephalograms were traced manually and analyzed by a single investigator.

In maxillary study model, the mid-palatal raphe and the cusp tips of permanent first molar were defined by tracing with a 0.5mm pointed drawing pencil. Model photocopies were obtained as described by Champagne.[11] On photocopies, a midline was drawn along mid-palatal raphe. Two diagonal lines were drawn between the cusp tips of permanent first molars and their point of intersection was marked.[12] On the occlusal photocopies, measurement of arch width, arch length and arch perimeter were carried out as shown in Figures 4, 5 and 6 respectively. After recording the occlusal photocopies of maxillary study models, they were sectioned at the deepest palatal gingival margin of permanent canine and first molar region. Then the cross-sectional photocopies were obtained for palatal depth measurement as shown in Figure-7 and 8 respectively. The arch width, arch length, arch perimeter and palatal depth were measured by using an electronic digital caliper.

By using Goslon Yardstick,[13] dental study models of cleft subjects were arranged into five groups from the excellent (Goslon group 1) dental arch relationships to the worst (Goslon group 5) dental arch relationship. In general, models falling into group 1 and group 2 were considered as excellent and good dental arch relationship and models falling into group 4 and group 5 were considered as poor or very poor dental arch relationship.

STATISTICAL METHOD

A master file was made and the data was statistically analyzed on a computer using 'SPSS' computer software. A data file was created under dBase and converted into microstat file. The data were subjected to descriptive analysis for mean, range, frequency and standard deviation of all variables. One way ANOVA

Table 2. Arch width, Arch length, Arch perimeter and Palatal depth among four different groups (in millimeters)

Parameters	Group-I (n=10)		Group-II (n=10)		Group-III (n=10)		Group-IV (n=10)		
	Mean±SD	95% Confidence Interval for Mean	Mean±SD	95% Confidence Interval for Mean	Mean±SD	95% Confidence Interval for Mean	Mean±SD	95% Confidence Interval for Mean	p value
Anterior arch width	24.50±1.47	23.44-25.55	16.50±4.29	13.42-19.57	24.07±4.03	21.18-26.96	23.02±2.75	21.05-24.99	.000 ***
Posterior arch width	47.22±2.07	45.74-48.70	41.00±6.71	36.20-45.80	43.54±6.97	38.55-48.53	44.84±3.86	42.07-47.61	.085 NS
Anterior arch length	9.31±0.87	8.69-9.94	6.23±2.33	4.56-7.90	8.61±2.64	6.72-10.51	7.18±2.92	5.09-9.27	.024 *
Posterior arch length	33.10±1.29	32.17-34.02	24.58±2.55	22.75-26.40	31.50±4.52	28.26-34.73	31.16±3.68	28.53-33.79	.000 ***
Arch perimeter	98.56±3.26	96.23-100.90	76.16±7.21	71.00-81.32	91.77±8.66	85.58-97.97	92.50±9.56	85.65-99.34	.000 ***
Anterior palatal depth	4.34±0.91	3.68-4.99	3.17±0.90	2.52-3.82	4.32±1.08	3.55-5.10	4.08±1.90	2.72-5.44	.152 NS
Posterior palatal depth	14.59±1.71	13.36-15.82	10.48±3.27	8.13-12.82	13.20±2.92	11.11-15.29	12.17±2.92	10.08-14.26	.016 *

NS = Non-significant, * = p < 0.05, ** = p < 0.01 and *** = p < 0.001.

Table 3. Percentage of Goslon scores in different groups

Score	Group-II	Group-III	Group- IV
1	0%	10%	0%
2	10%	70%	60%
3	30%	20%	40%
4	30%	0%	0%
5	30%	0%	0%

was used for analysis of variance and multiple test range (LSD) was used for multiple comparisons. Probability value (p-value) 0.05 was considered as statistically significant level.

RESULTS

The mean age of studied subjects from groups I to IV was 17.03(1.63yrs, 19.69(3.59yrs, 17.74(2.92yrs and 19.41(3.29yrs respectively and the mean age of initial palate repair for group-II to IV was 1.16(0.33yrs, 3.68(1.52yrs and 2.37(0.80yrs respectively. The mean number of surgeries done in subjects of group IV was 2.7(0.82 with range of 2 to 4.

The descriptive statistics for cephalometric linear and angular parameters are described in Table-1. The linear cephalometric parameters representing anterior maxillary height (N-ANS, SN-ANS and N-A distance) and posterior maxillary height (SN-Ptm and SN-PNS distance) for all groups were essentially identical. The length of maxilla (ANS-PNS distance) was also identical for all groups. The depth of maxilla (ANS-Ptm distance) in group II differed significantly from group I ($p<0.01$), group III ($P<0.01$) and group IV ($P<0.05$). The posterior position of maxilla (S-PNS distance) for all groups was similar. With regards to the antero-posterior position of maxillary base (SNA angle) and maxilla (S N ANS angle), group II differed significantly ($p<0.001$) from other groups. For rotation of maxilla, the angle between S-N plane and ANS-Ptm plane was essentially identical in all groups.

The descriptive statistics of study model analysis for each individual group are described in Table-2. The subjects in group II had less anterior arch width as compared to the subjects of other groups and this reduction was statistically significant ($p<0.001$) among groups. However, the posterior arch width was essentially identical between groups. Both anterior arch length and posterior arch length were significantly deficient in subjects of group II. Anterior arch length showed statistically less significant ($p<0.05$) difference among groups than posterior arch length ($p<0.001$). There was a significant reduction of 22.40mm arch perimeter in group II from control group, 15.61mm from group III and 16.34mm from group IV. This difference between four groups was statistically significant ($p<0.001$). There was no significant difference among four groups for anterior palatal depth.

There was also no difference in posterior palatal depth among groups except between group I and group II (P<0.05).

The mean Goslon score for group II to IV was 3.80±1.03, 2.10±0.56 and 2.40±0.51 respectively. Comparison of Goslon scores among cleft groups showed that there was significant difference between group II and III (P<0.001) and between group II and IV (p<0.001), however no significant difference was there between group III and IV. The distribution of Goslon scores among each group are described in Table-3. Distribution of Goslon score showed severe maxillary growth inhibition in subjects of group II than subjects of group IV and group III.

DISCUSSION

The timing and number of surgeries for palate repair had a significant effect on subsequent maxillary growth. The anterior vertical growth of maxilla was more (though not statistically significant) in cleft subjects than the control subjects. This was probably due to elevated anterior cranial fossa[7,14] or due to downward rotation of maxilla.[15,16] Repair of hard palate between 4 years to 9 years of age resulted in greater anterior vertical development of maxilla than repair of hard palate at an early age.[4] However, delayed repair of hard palate (at 8.5 years) resulted in most satisfactory anterior vertical development of maxilla.[16]

Posterior vertical growth of maxilla was essentially equal in all groups. However, repair of hard palate caused decreased posterior maxillary vertical development[17,18] and the important factor for severity of this reduction was timing of hard palate repair.[17]

The length of maxilla in early repair group was comparable to the control group, but was less (statistically not significant) when compared with late and multiple repair group. The early surgical trauma and resistance of scar tissue were probably responsible for such minor differences. Palatoplasty had no adverse effect on length of maxilla.[19] However, the length of maxilla appeared to be most affected when palatoplasty was done before 18 months of age[20]. A decreased length of maxilla was found when palate was repaired by two stage palatoplasty[18].

Timing and number of palate repairs had a significant effect on depth of maxilla. Surgical trauma to the growing maxilla and restraining effect of scar tissue by early palate repair caused maxillary depth reduction. The depth of maxilla in late repair group and in multiple surgery group was comparable with control group. Thus, timing of initial palate repair was more important factor for maxillary growth inhibition than the number of attempts to repair palate.

One of the most significant cephalometric findings was maxillary retrusion in all repaired cleft subjects. Severity of maxillary retrusion was directly related to the age of initial palate repair. Severe reduction in SNA and S N ANS angle revealed the disturbance that the palate repair caused maxillary retrusion. Thus, the present study confirms the clinical aspect seen regularly in cleft lip and palate patients operated on at conventional timings and according to the current concepts in the literature, that show a retrusion of maxilla in patients operated on when compared to non-cleft subjects.[17-19,21]

In the present study, the timing and number of palate repairs had no adverse effect on inclination or rotation of maxilla. In unilateral cleft lip and palate subjects, palate repair caused maxillary downward inclination with center of rotation near posterior nasal spine.[15] However, early repair of hard palate caused less downward inclination of maxilla than delayed repair of hard palate.[16]

Anterior arch width was significantly affected by an early repair of palate. This repair after 2 years of age and multiple attempts to repair palate had no effect on anterior portion of the maxillary dental arch. Early surgical trauma to the young maxilla and abnormal palatal inclination of canines by the surgical scar resulted in decreased transverse growth of anterior maxillary arch.[22] Absence of median palatal suture and bridging of the new bone over the nasal septum by palatoplasty inhibited transverse maxillary growth.[23] Timing of initial palate repair and number of attempt for palate repair had no influence on posterior arch width. Thus, it can be concluded that the anterior part of the dental arch was affected more commonly by the malformation and by the early surgical correction of palate than the posterior part. In repaired cleft subjects, the pull of the scar tissue caused decreased dental arch width.[24]

Anterior arch length in all cleft groups was less than the control group. The amount of anterior arch length reduction was directly related to the age of initial palate repair. Thus, anterior arch length was affected by timing of initial palate repair. However, posterior arch length was affected severely by the early palate repair. Medial collapse of the dental arch at the premolar region by the early palatal repair caused the posterior arch length to be decreased. Thus, delaying the repair of palate had a favorable effect on the arch length. Arch perimeter was reduced by palate repair in all cleft subjects. Age of initial palate repair played a major role for severity of arch perimeter reduction. Backward path of eruption of maxillary permanent incisors resulted in deficient antero-posterior dimension of the upper arch and a more retrusive position of maxilla counted for the remaining part of the impairment.[25] However, the skill of surgeon was more important for later maxillary growth and occlusal development than the timing of hard palate repair.[17] Dimension of maxillary dental arch was found to be smaller in repaired cleft subjects at the age of 3 years and timing of hard palate repair had no effect on dental arch dimension.[26]

Timing and number of surgeries had no effect on depth of palate at the canine region. However, repair of palate at very young age reduced the vertical growth of the palate at the first molar region. Thus, the present study suggested that repair of palate during rapid growth period can inhibit palatal growth in depth.

Goslon index showed that the timing of the initial palate repair had a significant effect on dental arch relationship. In late and multiple repair groups, dental arch relationship was much better than the early repair group. Subjects who had delayed palate repair showed a potential for normal maxillary growth. Thus, the result supports the view that palatal closure was likely to cause maxillary hypoplasia and the severity of hypoplasia was related to the age at which palate was initially repaired. Patients who had palatal repair in infancy showed high Goslon score indicating unfavorable dental arch relationship.[27,28] In a six center International study of treatment outcome, the timings of hard palate repair had significant effect on dental arch relationship.[29] They also concluded that centers with uniform and organized approach in treating cleft lip and palate patients had best maxillary growth. However, the timings of hard palate closure had no effect on dental arch relationships.[30]

It has been confirmed that standardization, centralization and the participation of high volume operators were associated with good treatment outcomes.[10] In India, there is neither a centralized multidisciplinary approach nor a definite treatment protocol for the management of cleft patients. Thus, for the best treatment outcome, refinement of the present treatment standard is required in India. All cleft patients of India should be treated in cleft care center, all center should be centralized and should follow a standard treatment protocol.

CONCLUSION

The following conclusions were drawn from the study.

Timings and number of surgeries had no influence on maxillary vertical growth and on maxillary length. Repair of palate before 2 years of age inhibited growth of maxilla in depth where as repair of palate after 2 years of age and multiple surgery performed for palate repair had no effect on maxillary growth in depth. The most evident surgical sequels occurred was an accentuated maxillary retrusion without any rotation or inclination of maxilla.

Anterior arch width was severely affected by early palatal repair. Timing and number of surgeries for palate repair had no effect on posterior arch width in repaired unilateral cleft lip and palate subjects. Posterior arch length was affected more than anterior arch length by palate repair and timing of palatal repair played a significant role for this. The degree of reduction of arch perimeter in repaired cleft subjects was related to the age at which palate repair was performed. Timing of palate repair had no effect on anterior palatal depth but had significant effect on posterior palatal depth.

Goslon index showed better dental arch relationship in subjects in whom repair of palate was performed after 2 years of age. Repair of palate at an early age had more inhibiting effect on antero-posterior maxillary growth than repair of palate at a later age.

Thus number of surgeries performed for palatal repair was not an important growth inhibiting factor of maxilla, rather the age which the initial surgery was performed for palate repair is an important factor influencing maxillary growth.

REFERENCES

1. Albery EH, Hathorn IS, Pigott RW. Cleft lip and palate – a team approach. 1st ed. Wright Bristol, Great Britain, 8-9, 1986.
2. Bernstein L. The effect of timing of cleft palate operations on subsequent growth of the maxilla. Laryngoscope 78: 1510-1565, 1968.
3. Ross RB, Johnston MC. Cleft lip and palate. Baltimore; Williams and Wilkins. 1987.
4. Friede H, Lilja J, Johanson B. Cleft lip and palate treatment with delayed closure of the hard palate. Scand J Plast Reconstr Surg 14: 49-53, 1980.
5. Friede H, Moller M, Lilja J, Lauritzen C, Johanson B. Facial morphology and occlusion at the stage of early mixed dentition in cleft lip and palate patients treated with delayed closure of the hard palate. Scand J Plast Reconstr Surg 21: 65-71, 1987.
6. Smahel Z. Treatment effects on facial development in patients with unilateral cleft lip and palate. Cleft Palate-Craniofac J 31: 437-445, 1994.
7. Semb G. A study of facial growth in patients with unilateral cleft lip and palate treated by Oslo CLP Team. Cleft Palate-Craniofac J 28: 1-21, 1991.
8. Graber TM. Cranio-facial morphology in cleft palate and cleft lip deformities. Surg Gynec Obst 88: 359-369, 1949.
9. Ross RB. Treatment variables affecting facial growth in complete unilateral cleft lip and palate. Part 1: Treatment affecting growth. Cleft Palate J 24: 5-23, 1987.
10. Shaw WC, Dhal E, Asher-McDad C, Brattstrom V, Mars M. A six-center International study of treatment outcome in patients with clefts of the lip and palate. Part 5. General discussion and conclusions. Cleft Palate-Craniofac J 29: 413-418, 1992.
11. Champagne M. Reliability of measurements from photocopies of study models. J Clin Orthod 26: 648-650, 1992.
12. Keles A, Sayinsu K. A new approach in maxillary molar distalization: Intraoral bodily molar distalizer. Am J Ortho Dentofac Ortho 117: 39-48, 2000.
13. Mars M, Plint DA, Houston WJB, Bergland O, Semb G. The Goslon Yardstick: A new system of assessing Dental arch relationships in children with unilateral clefts of lip and palate. Cleft Palate J 24: 314-322, 1987.
14. Aduss H. Cranio-facial growth in complete unilateral cleft lip and palate. Angle Orthod 41: 202-213, 1971.
15. Normando ADC, Filho OGS, Filho LC. Influence of surgery on maxillary growth in cleft lip and / or palate patients. J Craniomaxillofac surg 20: 111-118, 1992.
16. Friede H, Enemark H. Long-term evidence for favorable midfacial growth after delayed hard palate repair in UCLP patients. Cleft Palate-Craniofac J 38: 323-329, 2001.
17. Ross RB. Treatment variables affecting growth in unilateral cleft lip and palate. Part 5: Timing of palate repair. Cleft Palate J 24: 54-63, 1987.
18. Ozturk Y, Cura N. Examination of cranio-facial morphology in children with unilateral cleft lip and palate. Cleft Palate-Craniofac J 33: 32-36, 1996.
19. Dahl E. Cranio-facial morphology in congenital clefts of the lip and palate. Acta Odonto Scan 28: supp.57, 1970.

20. Horswell BB, Levant BA. Cranio-facial growth in unilateral cleft lip and palate: Skeletal growth from eight to eighteen years. Cleft Palate J 25: 114-121, 1988.
21. Bishara SE, Sierk DL, Huang KS. A longitudinal study on unilateral cleft lip and palate subjects. Cleft Palate J 16: 59-71, 1979.
22. Graber TM. A cephalometric analysis of developmental pattern and facial morphology in cleft palate. Angle Orthod 19: 91-100, 1949.
23. Prydso U, Holm PCA, Dahl E, Fogh-Andersen P. Bone formation in palatal clefts subsequent to palatovomeroplasty. Scand J Plast Reconstr Surg 8: 73-78, 1974.
24. Trotman CA, Collett AR, McNamara JA(Jr), Cohen SR. Analysis of cranio-facial and dental morphology in monozygotic twins discordant for cleft lip and unilateral cleft lip and palate. Angle Orthod 63: 135-139, 1993.
25. Bergland O, Sidhu SS. Cranio-facial pattern in boys with unilateral complete clefts at 10-12 years of age. Trans Europ Orthodont Soc 48: 159-166, 1972.
26. Nystrom M, Ranta R. Effect of timing and method of cleft palate repair on dental arches at the age of three years. Cleft Palate J 27: 349-353, 1990.
27. Mars M, Houston WJB. A preliminary study of facial growth and morphology in unoperated male UCLP subjects over 13 years of age. Cleft Palate J 27: 7-10, 1990.
28. Hathorn I, Roberts-Harry D, Mars M. The Goslon yardstick applied to a consecutive series of patients with unilateral clefts of the lip and palate. Cleft Palate-Craniofac J 33: 494-496, 1996.
29. Mars M, Brattstrom V, McWilliam J, Plint DA, Semb G. A six-center International study of treatment outcome in patients with clefts of lip and palate: Part 3. Dental arch relationships. Cleft Palate J 29: 405-408, 1992.
30. Noverraz AEM, Jagtman AMK, Mars M, Hof MAV. Timing of hard palate closure and dental arch relationships in unilateral cleft lip and palate patients: A mixed-longitudinal study. Cleft Palate J 30: 391-396, 1993.