Original Article

Relation of maxillary permanent central incisor rotations with the primary palatal margin and overjet in repaired complete unilateral cleft lip and palate

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ABSTRACT

Objectives: To examine the relation of maxillary permanent central incisor rotation with the primary palatal margin (PPM) and overjet in the mixed dentition in complete unilateral cleft lip and palate (cUCLP).

Materials and Methods: Dental casts and preorthodontic records taken before alveolar bone grafting were examined to exclude patients having permanent teeth distal to the cleft side maxillary central incisor (CS1) and mesial to the cleft. Maxillary central incisor rotation, the angle between PPM and midline, proximity of the lingual surface of the central incisor to PPM, and overjet were measured from standardized occlusal photographs of the dental casts of 54 children with repaired cUCLP (38 M, 16 F; aged 8.7 ± 1.0 years). Descriptive analysis and correlation statistics were performed.

Results: Rotations were noted in 92.6% of the CS1. Their magnitude (111.2 ± 24.2°) was significantly greater than the noncleft side maxillary central incisor (NCS1) rotations (76.7 ± 15.7°). Rotations were predominantly distolabial for the CS1 and distopalatal for the NCS1. The PPM was located within 2 mm of the lingual surface of the CS1 in 35.2% of the sample. Severe CS1 rotation existed in 48.2% of the sample and was significantly correlated with the PPM angle ($r = 0.3$; $P = .046$) and when its proximity to the PPM was within 2 mm ($\varphi = 0.3$; $P = .028$). Overjet was not significantly correlated with the magnitude of rotation.

Conclusions: The angle between PPM and the midline and its proximity to CS1 are associated with the severity of CS1 rotation in repaired cUCLP. Orthodontic implications are discussed. (*Angle Orthod*. 2025;00:000–000.)

KEY WORDS: Tooth rotation; UCLP; Primary palatal margin; Scar

INTRODUCTION

Maxillary incisor rotations are frequently observed in patients with complete unilateral cleft lip and palate (cUCLP) and can pose significant esthetic and functional challenges to affected individuals with difficulties in speech and oral hygiene maintenance.[1–14] They contribute to the visibility of the cleft deformity, which affects patient self-perception and satisfaction with facial appearance and treatment.[15–17] However, the etiology of maxillary incisor rotations remains poorly understood. Several factors have been suggested in the literature as possible explanations of constricted tooth position and arch contraction, including the influence of the periosteal denudation of the bone followed by the surgical scar, presence of crowding at the terminal end of the greater segment and possible influence of asymmetric muscular pull of the soft tissue attachments in this region.[2,3,5,11,18,19] The postsurgical scar near the primary palatal margin (PPM) could introduce changes in the periodontal ligament of the nearby tooth buds and, thus, create irregular shape and position of the teeth even before their emergence.[2,3]

Tooth rotations are frequently reported in the permanent maxillary incisors but not in deciduous incisors, on

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both cleft and noncleft sides.[5,6,11-14] This could imply the etiological time frame to be when permanent teeth are forming (from age 3 months to 5 years) which coincides with the commonly practiced timing of cleft reparative surgeries, lip repair (age 3–6 months), and palatal repair surgery (1–2 years of age). The degree of maxillary central incisor rotation in the mixed dentition has also been correlated with the width of alveolar cleft processes measured prior to lip repair surgery.[20] However, a comprehensive evaluation of the relation of the PPM with the magnitude and severity of maxillary central incisor rotations in patients with repaired cUCLP has not been reported. In this retrospective observational study, we aimed at examining the relation of maxillary permanent central incisor rotations with the PPM and overjet in the mixed dentition in cUCLP.

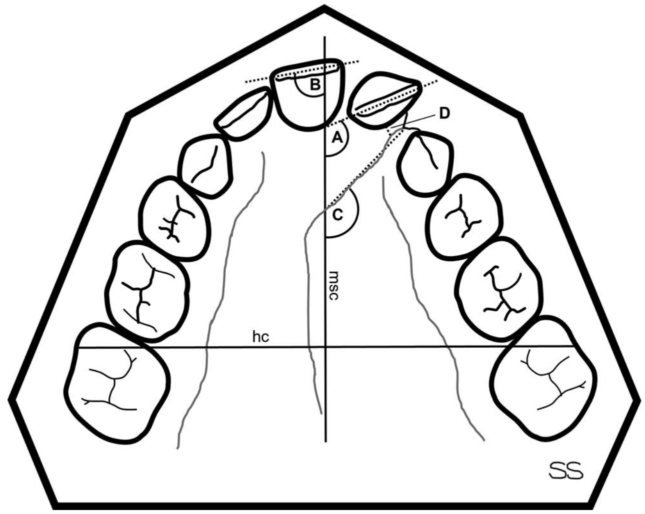

Figure 1. Measurements. (A) Rotation of cleft side maxillary central incisor (CS1). (B) Rotation of noncleft side maxillary central incisor (NCS1). (C) Primary palatal margin (PPM) angle. (D) Distance of PPM from lingual surface of the CS1. msc indicates midsagittal construct; hc, horizontal construct.

MATERIALS AND METHODS

Following Research Ethics Board approval at The Hospital for Sick Children, Toronto, Canada, a retrospective chart review was undertaken to select patients with nonsyndromic cUCLP who had their lip and palate reparative surgeries at The Hospital for Sick Children, Toronto, Canada. Orthodontic records taken prior to beginning prealveolar bone grafting orthodontic preparation were screened to select study models of patients who did not receive any previous orthodontic treatment and had both maxillary central incisors erupted. Further inclusion criteria required that none of the patients had mandibular skeletal or dental asymmetry, as verified from chart notes and photographs. A pair of dividers was used to measure linear distances from the mesial-cervical margin of the mandibular central incisors to the mesial contact points of each mandibular permanent first molar. Models in which the difference was less than 1 mm were selected. Because incisor rotations have been shown to be associated with the presence of permanent teeth (lateral incisor or supernumerary permanent teeth) distal to the cleft side maxillary central incisor (CS1)[11], radiographic records were reviewed to assess tooth presence in the maxilla. Cases that had a lateral incisor or supernumerary tooth in the greater hemimaxilloalveolar (HMA) segment, mesial to the cleft were excluded. However, if a lateral incisor or supernumerary tooth was present in the lesser segment distal to the cleft, the model was allowed to be included in the study. No other exclusion criteria were applied.

Applying these criteria, the included sample comprised dental models from 54 children in the mixed dentition stage of dental development. Lip repair techniques included Millard, Tennison, or Fisher anatomic subunit techniques. Palate repair techniques included von Langenbeck, Wardill-Killner pushback, or hybrid techniques, methods that are commonly followed around the world, thus representing typical surgical treatment in UCLP.

A straight line was drawn, using a 0.5-mm-thick pencil, from the buccal groove of each mandibular permanent first molar to the bucco-occlusal surface of each maxillary permanent first molar, with the dental models in occlusion. Overjet was measured at the most protruded point of the central incisor to its antagonistic tooth with a scale. The dental models were then separated, and maxillary models were mounted on a stand with the occlusal plane parallel to the floor, and the occlusal surfaces of teeth facing upward. A 12.3-megapixel digital single lens-reflex camera using a 90-mm macro lens was set at ISO 200, 1/30 sec at f13, and secured perpendicular to the occlusal plane. Occlusal photographs of the maxillary dental arch were acquired, with the resolution set at 4032×3024 pixels. Each image was calibrated using a 10-mm plastic scale placed at the correct depth of field and parallel to the lens of the camera. The images were processed using Photoshop CS4 and Adobe Illustrator 4 (Adobe Systems Inc., San Jose, Calif), using which, a horizontal construct (hc) was drawn connecting the right and left marks that had been made on the bucco-occlusal surface of the maxillary molars prior to photographing the models. A perpendicular line drawn at the midpoint of this horizontal construct was referred to as the midsagittal construct (msc) of the maxillary arch (Figure 1).

Maxillary central incisor rotation was measured as the internal angle formed between a line connecting the mesial and distal line angles of the

Table 1. Directions and Magnitudes of Permanent Maxillary Central Incisor Rotation Patterns

Direction of Rotation	Cleft Side No. (%)	Cleft Side Magnitude, Mean ± SD (°)	Noncleft Side No. (%)	Noncleft Side Magnitude, Mean ± SD (°)
Distolabial	41 (75.9)	120 ± 20.8	8 (14.8)	99.7 ± 6.5
Distopalatal	9 (16.7)	80.3 ± 4.7	45 (83.3)	72.4 ± 13
No rotation	4 (7.4)	90	1 (1.8)	90

incisal edge and the msc. For quantitative and qualitative assessment, taking perpendicular (90°) from the msc as representative of no rotation, CS1 and noncleft side maxillary central incisor (NCS1) rotations were categorized as mild (0–10° from 90°), moderate (10–20° from 90°), or severe (>20° from 90°). The PPM angle was measured as the internal angle formed between the msc and the line of best fit along the surgical scar on the anterior palate in the incisor region of the primary palate. The distance from the center of the lingual contour of the CS1 to the PPM was measured and categorized as less or more than 2 mm. The variables measured are shown in Figure 1.

Intraexaminer reliability was assessed by intraclass correlation coefficient analysis applied to repeated measurements made 45 days apart and showed excellent reliability of the method. Descriptive statistics followed by a χ^2 test, Pearson's (r), Spearman's (ρ), and phi (φ) correlation coefficient calculations were conducted according to normality assessments of the data. The association of severe CS1 rotation with its proximity of being within 2 mm of the PPM was studied by the φ coefficient. The significance level for statistical tests was set at 5%.

RESULTS

In the 54 dental casts that were included in this study, there were 33 left-sided repaired clefts and 21 right-sided repaired clefts. The models were from 38 males and 16 females, and the mean age at which the models had been taken was 8.7 ± 1.0 years. While no lateral incisors or supernumerary teeth were present in the HMA segment mesial to the cleft, a lateral incisor or supernumerary tooth was present in the lesser segment distal to the cleft in 27.8% (N = 15) of the sample. The lateral incisor on the noncleft side was present in 100% of the study sample.

The frequency of maxillary central incisor rotation exceeded 90% in this sample (Table 1). The CS1 showed a large distolabial rotation as the predominant pattern with 75.9% (N = 41) having distolabial rotation, 16.7% (N = 9) distopalatal rotation, and 7.4% (N = 4) no rotation, while the NCS1 showed a distopalatal rotation as the most frequent pattern with 83.3% (N = 45) showing distopalatal rotation, 14.8% (N = 8) distolabial rotation, and 1.8% (N = 1) no rotation. The CS1 was more frequently distolabially rotated than the NCS1, and the likelihood was highly significant (χ^2 [1, N = 54] = 48.02, $P < .001$). The magnitude of rotation of the CS1 (111.2 ± 24.2°) was greater than that of the NCS1 (76.7 ± 15.7°). The difference in magnitudes of rotation of the CS1 and the NCS1, assessed by paired t-test, was significant (mean = 34.4 ± 29.2°; $P < .001$; Table 2). Almost half (48.2% [N = 26]) CS1 were observed to have severe magnitudes of rotation (Figure 2; Table 3) followed by 27.8% (N = 15) having moderate and 24.1% (N = 13) having mild rotation. On the other hand, only 27.8% (N = 15) NCS1's were observed to have severe, 38.9% (N = 21) moderate, and 33.3% (N = 18) mild rotations. When distopalatal rotations were observed in the CS1, they were never severe. Conversely, when distolabial rotations were observed in the NCS1, only 1 patient (1.8%) had severe rotation.

The magnitude of the PPM angle was 129.2 ± 18.2° (Table 3). The PPM was located within 2 mm of the lingual surface of the CS1 in 35.2% (N = 19) and farther than 2 mm in 64.8% (N = 35) of the sample, whereas it was located farther than 2 mm from the NCS1 in the entire sample. A negative overjet was seen on the cleft side with the mean overjet measured at the CS1 being −1.9 ± 2.9 and 0.7 ± 2 mm at the NCS1 (Table 3).

A modest but statistically significant ($r = 0.3$; $P = .046$) correlation was observed between the CS1

Table 2. Magnitudes of Permanent Maxillary Central Incisor Rotation

Rotation	Cleft Side No.	Cleft Side Magnitude, Mean ± SD (°)	Noncleft Side No.	Noncleft Side Magnitude, Mean ± SD (°)	Difference (Paired Measurements) Magnitude, Mean ± SD (°)	P Value
Permanent central incisor rotation	54	111.2± 24.2	54	76.7± 15.7	34.4 ± 29.2	<.001*

* $P < .001$.

Figure 2. Variations in rotation pattern and severity of cleft side maxillary central incisor (CS1) rotations seen in repaired complete unilateral cleft lip and palate (cUCLP). Clockwise from top left to bottom right: mild, severe, and very severe distolabial rotation. Bottom left: No significant rotation.

rotation and the PPM angle, while no significant correlation of the NCS1 rotation with the PPM was observed ($r = 0.1$; $P = .616$). Magnitudes of CS1 and NCS1 rotations were not significantly correlated ($P = -.03$; $P = .852$). Severe CS1 rotation was significantly correlated with the proximity of the lingual surface of this tooth being within 2 mm distance from the PPM ($\varphi = 0.3$; $P = .028$). The overjet did not correlate significantly with magnitude of CS1 rotation ($P = -.1$; $P = .445$) or NCS1 rotation ($P = .03$; $P = .806$).

Table 3. Measured Study Variables[a]

Study Variable	Cleft Side	Noncleft Side
Maxillary central incisor rotation	111.2 ± 24.2°	76.7 ± 15.7°
PPM angle	129.2 ± 18.2°	
Frequency of lingual surface of maxillary central incisor being < 2 mm distance from PPM	35.2%	0%
Frequency of severe maxillary central incisor rotation	48.2%	27.8%
Overjet at maxillary central incisor	−1.9 ± 2.9 mm	0.7 ± 2 mm

[a] PPM indicates primary palatal margin.

DISCUSSION

In this study, we aimed at investigating if any association of the PPM with the frequently observed rotation of the maxillary central incisor in repaired cUCLP existed to assess if the cleft reparative surgical interventions and consequent scar tissue were associated with this dental malocclusion. The sample was drawn from patients who were in the mixed dentition and had not received orthodontic treatment or an alveolar bone graft yet and did not have any teeth located distal to the CS1 and mesial to the cleft in the greater HMA segment. This allowed investigating the study aim without any confounding effects of orthodontic treatment, alveolar bone graft surgery,

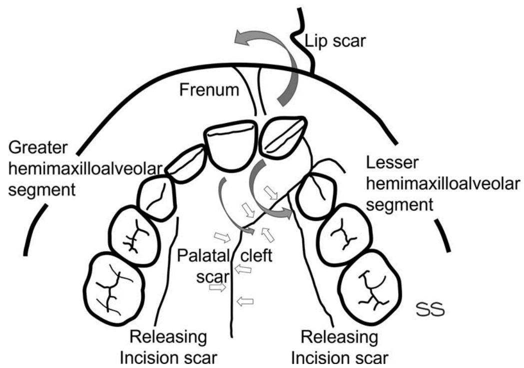

Figure 3. A composite representation of multiple factors that likely contribute to incisor rotation in complete unilateral cleft lip and palate (cUCLP), including asymmetric pull of lip musculature, scar tissue, and the presence or absence of teeth near the incisor. Directions of rotations are shown by curved arrows (adapted from Suri et al. 2018[11]).

as well as dental crowding at the terminal end of the greater HMA segment, which may be associated with maxillary incisor rotation in individuals with cUCLP.[3,5,11] Due to the asymmetry that may exist in the maxillary segments in repaired cUCLP, only patients without mandibular skeletal or dental asymmetry were included in the study. The method of analysis using standardized, oriented photographs of dental casts of included patients avoided limitations imposed by maxillary asymmetry and surgical alterations of the palatal soft tissues.

Associations of the PPM with the CS1 rotations were significant although modest, indicating that, while the scar tissue and the regional anatomy of the PPM were associated with the CS1 rotation and its severity in repaired cUCLP, other factors may also be associated. Most rotations of the NCS1 were distopalatal, the same direction as the distolabial rotations of the CS1 (or anticlockwise when observing their relation to the msc, if all maxillary dental casts were observed from the occlusal view and oriented as if they had left-sided clefts). Although the distance of the NCS1 from the PPM was greater than 2 mm in all cases and no significant correlation was detected between them, 83.3% of these teeth were rotated distopalatally. This could have been due to the influence of the palatal repair surgical flaps as well as the gingival circumferential and interdental attachments of the adjacent CS1, 75.9% of which showed distolabial rotation. It is also likely that the generally less severe NCS1 rotations reflected the stabilizing effect of the noncleft side maxillary lateral incisors on the NCS1 through the interdental gingival attachments, as these teeth were present on the noncleft side and absent on the cleft side in the entire sample.

Distolabial rotation of the CS1 has also been reported in individuals with unoperated clefts[21,22] and clefts of the lip only,[6] and the width of the cleft prior to lip repair has been shown to be positively correlated with the degree of CS1 rotation,[20] implying that asymmetric muscle pull of the orbicularis oris[23–25] could be an additional factor that can influence maxillary incisor rotation patterns in individuals with clefts (Figure 3). It is possible that the asymmetric muscular pull seen in infancy prior to lip repair manifests to a variable extent on the dental lamina and the dental arch during early and middle childhood. The findings are also useful for the clinician to better inform the affected patients and their caregivers about CS1 rotation and to develop clinical strategies for managing this very frequent and visible feature of the patient's cleft-related malocclusion. Rotated maxillary central incisors can have significant psychosocial and functional effects on the affected child, and these visible teeth should be derotated and aligned prior to alveolar bone graft surgery. Orthodontic biomechanical strategies should be optimized to derotate the maxillary central incisors carefully to maintain tooth roots within the surrounding bone, such as by angulating the bracket to the axis of the root and by applying gentle forces during tooth derotation (Figure 4). In addition to derotation, the labiolingual inclination of the maxillary incisors should also be improved during tooth alignment to prevent traumatic occlusion with the opposing arch. The maxillary archform should be preserved while correcting severely rotated incisors (Figure 5). Derotation and alignment of these teeth with light forces prior to alveolar bone grafting does not induce root exposure or poorer bone grafting outcomes but is associated with better bone fill when three-dimensional volumetric measurements are assessed[10,26] and promotes better oral hygiene that could contribute to improving alveolar bone grafting outcomes.[8]

CONCLUSIONS

- The angle between the PPM and the midline and its proximity to the CS1 are associated with severity of CS1 rotation in repaired cUCLP.
- The overjet does not correlate significantly with the magnitude of CS1 or NCS1 rotation.
- Other factors, such as asymmetric lip muscular pull on the soft tissue attachment, may also play a role and warrant investigation.
- Orthodontic biomechanical strategies should be optimized to derotate the CS1 carefully.

Figure 4. A flexible multistranded archwire is useful to allow gentle derotation before alveolar bone grafting while monitoring that the periodontal support and bony coverage of the cleft side maxillary central incisor (CS1) is adequate (orthodontic treatment provided by Dr Sunjay Suri).

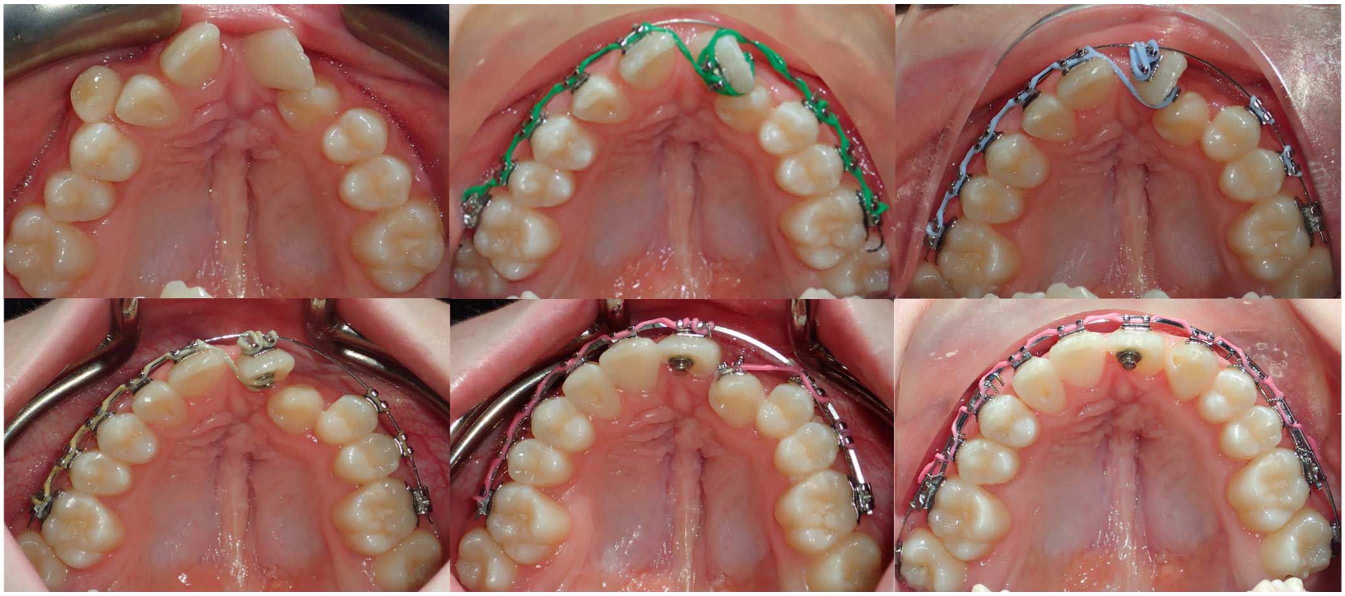

Figure 5. In cases of severe cleft side maxillary central incisor (CS1) rotation, orthodontic derotation with first-order couple mechanics, while stabilizing the overall maxillary archform with a rigid archwire, may be indicated (orthodontic treatment provided by Dr Sunjay Suri).

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