CASE REPORT

The Cortical Boundary Line as a Guide for Incisor Re-positioning with Anterior Segmental Osteotomies

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Abstract Anterior alveolar anatomical constraints involving presurgical orthodontic incisor repositioning are often unrecognized and overlooked during orthodontic-surgical treatment planning. A clear discrimination of this cortical limitation is invaluable during the planning stage as it permits the consideration of alternative approaches like the anterior maxillary osteotomy for effecting the required incisor movement. A simple reference line termed the “Cortical Boundary Line” is introduced to facilitate the clinical translation of this information and through suitable case illustrations, the construction of the reference line using the conventional lateral cephalometric radiograph and its usefulness as an adjunct in aiding decisions on orthodontic incisor decompensation is highlighted.

Introduction

Orthodontic-surgical treatment planning revolves primarily around the presurgical orthodontic repositioning of the incisors. Reducing excessive incisor proclination by restoring its inclination is essential for optimal surgical repositioning of the skeletal bases [1, 2]. In certain instances, the planned incisor decompensatory mechanics can be hindered because of insufficient alveolar width associated with certain types of malocclusions [3–7]. Although, orthodontic movements are possible near and through critical cortical zones, such attempts can potentiate the iatrogenic instability of the tooth [4–13]. A clear discrimination of this cortical limitation is invaluable to treatment planning as it permits the consideration of alternatives such as an anterior maxillary osteotomy, during the planning stage itself. A simple reference line termed the “Cortical Boundary Line (CBL)” is introduced to facilitate the clinical translation of this information and through suitable case illustrations, the construction of the reference line using the conventional lateral cephalometric radiograph and its usefulness as an adjunct in aiding decisions on orthodontic incisor decompensation is highlighted.

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Subject and Methodology

Following the treatment of a series of patients through a combination of orthodontic and orthognathic surgical management at the Department of Orthodontics, we observed root resorption of the anteriors following a post-treatment radiographic evaluation (Fig. 1). A close scrutiny of all relevant pre-treatment records revealed that this iatrogenic sequelae occurred in patients with a narrow

Fig. 1 Post treatment orthopantomograph revealing root resorption of both the upper and lower anteriors following presurgical orthodontics

cortical width of the anterior alveolus. In order to avoid this iatrogenic sequelae, we evaluated and implemented a protocol of assessment that would help ascertain quantitatively the boundary between the root of the anterior and the labial and buccal cortical plate based on Handelman's method. We had determined that cases which showed a cortical boundary within 2 mm or less to the root apex of the incisor when evaluated by the CBL line had an increased likely hood of iatrogenic root resorption as any attempt at a presurgical incisor decompensation would move the root beyond the limiting osseous boundary. This could be avoided by undertaking incisor decompensation with an anterior maxillary osteotomy and our case selection for an AMO was based on a CBL interpretation of the same (i.e. less than 2 mm).

Two patients (Mean age 24.5 years) with Class II division 1 malocclusion on a moderate Class II skeletal pattern

associated with vertical maxillary excess, recessive chin, and increased overjet of 13 and 9 mm respectively, are reported. Case 1 also had mandibular retrognathia (Fig. 2a, b). As both cases required the retraction of the maxillary incisors by 5 mm, their anterior alveolar dimensions were measured using the methodology described below to assess their orthodontic feasibility (Fig. 3).

Pre-treatment lateral cephalometric tracings of the maxillary and mandibular structures are made on acetate paper [3]. Point markings are made to denote the *root apex* of the maxillary and mandibular incisor. Using the palatal plane as reference, a second line is drawn parallel to it, touching the tip of the root of the maxillary incisor. Along this constructed plane, points are marked to denote the anterior and posterior (UA and UP) cortical outlines of the maxilla, to which measurements are made *from the root-apex point*, anteriorly and posteriorly. The mandibular measurement is made similarly by using the occlusal plane [14]; with measurements made to the mandibular cortical outlines (LP and LA) from the root-apex point of the mandibular incisor (Fig. 4a).

The Cortical boundary line (CBL), is now constructed by dropping a perpendicular line from the occlusal plane (Fig. 4b) to the cortical boundary points of the upper and lower anterior alveolus (UA, UP and LA, LP—Fig. 4c, d). An important point to note is that the occlusal plane employed can vary depending on the requirements of the individual patient and that the demarcation of the boundary and subsequent projection is **based primarily on the apical cortical width** of the anterior alveolus, which denotes the limit for root movements [3–6, 14].

CBL and Treatment Summary of Case Reports

The CBL construction for Case 1 (Fig. 2) revealed the alveolar cortex to be in direct proximity to the root of the maxillary incisor and in Case 2 the posterior cortical boundary was less than 2 mm away; indicating limited orthodontic feasibility in both cases. The case 2 diagram illustrates the hypothetical possibility of a 5 mm retraction, within the CBL boundary, by

Fig. 2 Case report 1 pre and post treatment records with CBL simulation

Fig. 3 Case report 2 pre and post treatment records with CBL simulation

Fig. 4 **a** Cortical boundary demarcation [1]. **b** Cortical boundary lines of the maxillary and mandibular alveolus. **c** Maxillary cortical boundary lines (CBL-Mx) related to the occlusal plane. **d** Mandibular cortical boundary lines (CBL-Mn) related to the occlusal plane

a controlled tipping movement of only the crown (Fig. 3c). Such precise orchestrations are unrealistic in cortically limited zones due to mechanical insufficiencies in effecting three-dimensional control [15, 16]. However, the required alteration to the axial inclination of the incisor can be efficiently addressed with an anterior maxillary osteotomy as the surgical mobilization permits the planned posterior movement of the incisor precisely [17–21]. A similar assessment was also made for mandibular incisor movements but the current discussion has been limited to treatment planning involving the maxillary incisor alone.

Although, both cases were ideally suited for an anterior maxillary segmental osteotomy, it was taken up only in the second case. Case I had the incisor proclination addressed through presurgical extraction orthodontics. The final treatment plan included a LeFort 1 impaction, BSSO advancement and genioplasty for Case 1; Case 2 had LeFort 1 impaction, anterior segmental osteotomy and genioplasty. Both cases had satisfactory clinical outcomes. The post treatment radiological evaluation revealed a violation of the cortical boundary in case 1 (Fig. 2d) and its preservation in case 2 (Fig. 3d, e).

Table 1 Pre and post treatment cephalometric analysis of cases with reduced cortical width^a treated by amo (blue) and presurgical orthodontics (green) with root resorption grading (Malmgren 1983)

CEPH PARAMETER	PATIENT 1 AMO		PATIENT 2 AMO		PATIENT 3 AMO		PATIENT 4 AMO		PATIENT 5 AMO		PATIENT 6 AMO		PATIENT 7 AMO		PATIENT 8 AMO		PATIENT 9 PSO		PATIENT 10 PSO	
	PRE	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST
SNA	82.8	80.3	87.3	81.7	89.5	85.5	84.7	78.8	86.3	81.8	84.2	79.9	85.9	80.4	83.6	77.9	85.4	80.5	83.4	79.9
SNB	74.7	76.9	80.5	80.6	83.9	84.7	79.7	78.0	80.5	79.0	77.0	78.8	78.2	77.0	78.6	77.0	75.7	74.5	75.0	74.6
ANB	8.1	3.4	6.8	1.1	5.6	0.8	5	0.8	5.8	2.8	7.2	1.1	7.7	3.4	5	0.9	9.7	6	8.4	5.3
UPPER INCISOR TO MAXILLARY PLANE	123.2	114.2	104.4	106.2	109.1	110.0	102.2	105.7	107.0	108.6	108.6	109.5	127.1	118.8	106.5	110.4	111.4	106.5	107.4	103.7
UPPER INCISOR TO NA	32.7	26.2	20.6	23.1	22.8	23.6	18.0	21.9	20.9	23.5	21.3	22.0	39.6	34.9	20.4	22.3	23.8	20.7	21.7	19.9
LOWER INCISOR TO NB	36.7	30.4	38.0	32.8	40.7	35.2	36.3	33.2	37.5	30.6	36.8	34.9	38.7	35.2	40.4	36.2	37.8	30.1	35.0	31.9
GRADE OF RESORPTION	0	0-1	0	0-1	0	0-1	0	0-1	0	0-1	0	0-1	0	0-1	0	0-1	0	2	0	2

^a Cortical boundary <2 mm as verified by CBL construction

A series of 10 patients treated at our department following an assessment using the CBL methodology is listed in Table 1, with their pre and post-treatment cephalometric observations. Incisor decompensation by anterior maxillary osteotomy for incisor decompensation was undertaken in eight patients and two patients were managed by presurgical orthodontics. An assessment of the integrity of the root was also made before treatment as well as after, with the degree of resorption *if present* represented on a scale from 0 to 3 (Malmgren 1982); where 0 represented no resorption Grade 1—minimal resorption, Grade 2—representing resorption upto 1/3rd of the root and Grade 3—representing severe root resorption beyond 1/3rd of the root length [22].

Conclusion

The importance of recognizing the boundary constraints of the alveolar cortex has been highlighted by numerous authors with descriptions of anatomical variations in differing facial types as well as its influence on the characteristics of the dentition and surrounding structures [3–7]. However, the clinical translation of this information has been unspecific especially in scenarios involving orthodontic-surgical planning with regard to incisor movements; and this lacunae becomes apparent only with the occurrence of an iatrogenic consequence [4–13]. As highlighted through these case

reports the CBL reference provides a simple yet valuable clinical translatory tool in critical cortical zones. The methodology proposed, though limited by its two-dimensional nature, permits the clinical translation of the cortical characteristics that dictates orthodontic-surgical treatment planning. Its use in scenarios associated with moderate to severe anterior dental protrusion, especially in critical cortical zones, facilitates treatment decisions like the anterior segmental maxillary osteotomy not just for its effectiveness in addressing anterior dental protrusion [17–19] but importantly because it preserves the integrity of the tooth.

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