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# Class III orthognathic surgical cases facilitated by accelerated osteogenic orthodontics: a preliminary report

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*Objectives:* To describe a multidisciplinary treatment approach that includes corticotomy, orthodontic force and orthognathic surgery for the management of skeletal Class III surgical cases. The main advantage of the combined techniques is a reduction in treatment time for young adult patients.

*Method:* Accelerated Osteogenic Orthodontics (AOO) was delivered to three young adult patients during their pre-surgical orthodontic treatment. After aligning and levelling the dental arches, a piezosurgical corticotomy was performed to the buccal aspect of the alveolar bone. Bone graft materials were used to cover the decorticated area and soft tissue flaps were replaced.

*Results:* The mean time for extraction space closure was  $5.4 \pm 1.3$  months and the mean time for pre-surgical orthodontic treatment was  $12.0 \pm 0.9$  months. The average total treatment time was  $20.4 \pm 2.4$  months. A pre-existing bony fenestration in the buccal cortex adjacent to the right lateral incisor root apex of Case 1 was corrected.

*Conclusion:* The facial aesthetics of three patients improved following multidisciplinary treatment. This approach may be an efficient method for the orthognathic patient who desires a reduced treatment time, but further clinical research is required.

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## Introduction

Young adults who are diagnosed with a severe maxillo-mandibular discrepancy seek treatment to improve their facial and dental aesthetics in the shortest possible time.<sup>1</sup>

Most severe skeletal Class III patients need orthognathic surgery to correct the dysplasia. Pre-surgical orthodontic treatment may take 1–2 years,<sup>2</sup> or longer in extraction cases. Post-surgical orthodontic treatment may take 0.5–1 year,<sup>3</sup> which extends overall treatment time to over three years. Therefore, the burden of treatment is heavy and a reduction in treatment time that still meets facial aesthetic requirements is a desirable goal.

Accelerated Osteogenic Orthodontic treatment (AOO) was first introduced by Wilcko et al. in 2001.<sup>4</sup> The

procedure involves selective alveolar decortication, alveolar augmentation in conjunction with orthodontic treatment. Distinct disadvantages of the AOO procedure are the additional cost and morbidity related to the invasive periodontal surgery.<sup>5</sup> In 2009, Dibart<sup>6</sup> used minimally-invasive piezocision to achieve rapid orthodontic tooth movement. In order to reduce surgical injury, the present report combines the two operative methods proposed by Wilcko and Dibart respectively, with the aim of augmenting and improving the AOO procedure. A piezocision was used as an alternative to traditional slow-speed drills.

It has been reported that the orthodontic component of AOO treatment may be completed in one-third to one-fourth of the time required for non-surgically assisted orthodontic treatment.<sup>7,8</sup> A similar effect has been reported in rats,<sup>9–12</sup> dogs,<sup>13–15</sup> and humans.<sup>16–19</sup>

Most publications describing the effects in humans are non-extraction case reports.<sup>16-19</sup> Until now, no randomised controlled trial has been performed.

In this preliminary report, an improved accelerated osteogenic orthodontic method has been applied to orthognathic surgical extraction cases to see whether a reduction in treatment time could be achieved.

## Materials and methods

### *Treatment objective*

Accelerated Osteogenic Orthodontics was delivered to three young adult patients during their pre-surgical orthodontic preparation. All patients were provided information about the proposed treatment and signed informed consent. The clinical trial protocol was ethically approved prior to commencement.

The primary treatment goals for each patient were an improvement in facial aesthetics and in their occlusion, and an increase in self-confidence. More specifically, treatment was designed to address the following objectives: to resolve the anterior and posterior crossbites, to correct an A-P skeletal discrepancy, to align the teeth, and to correct the midline and coordinate dental arch forms. The extraction pattern was designed to establish a Class I canine and a Class II molar relationship bilaterally.

### *Diagnosis and aetiology*

#### *Case 1*

A 19-year-old female with a chief complaint of crossbite presented for treatment. There was no family history of a Class III malocclusion. The patient's occlusion was characterised by an anterior crossbite and a -1.5 mm overjet as well as a posterior crossbite. There was 3 mm of crowding in the lower dental arch, but no crowding in the upper arch. The upper midline had shifted 5 mm to the right and the lower midline was 3 mm to the right. The molar relationship on the right side was a full unit Class III, while on the left side it was a half unit Class III (Figure 1A). The patient had a concave profile. A lateral cephalogram (Figure 1D) and analysis (Table I) indicated a skeletal Class III relationship as a result of maxillary retrusion and mandibular protrusion. The temporomandibular joints were asymptomatic and there was a normal range of mandibular movement. A periodontal probing examination showed normal pocket depths

of 1 to 3 mm in the maxillary anterior region.

#### *Case 2*

A 21-year-old female presented complaining of a long-standing anterior crossbite. She had previously received orthodontic treatment during adolescence, but the crossbite relapsed and returned when she continued to grow. The patient had a concave profile due to a protruding lower jaw.

An intra-oral examination and study casts revealed 2 mm of crowding in the upper arch and lower arch. There was an anterior crossbite with a -0.5 mm overjet and a bilateral posterior crossbite. The molar relationships were a full unit Class III (Figure 2A) and the canine relationships were Class III on both sides. There was no sign or symptoms of TMJ dysfunction or pathology. The lateral cephalogram (Figure 2D) and analysis (Table I) indicated a skeletal Class III relationship with mandibular protrusion. A periodontal probing examination showed pocket depths of 1 to 3 mm in the maxillary anterior region.

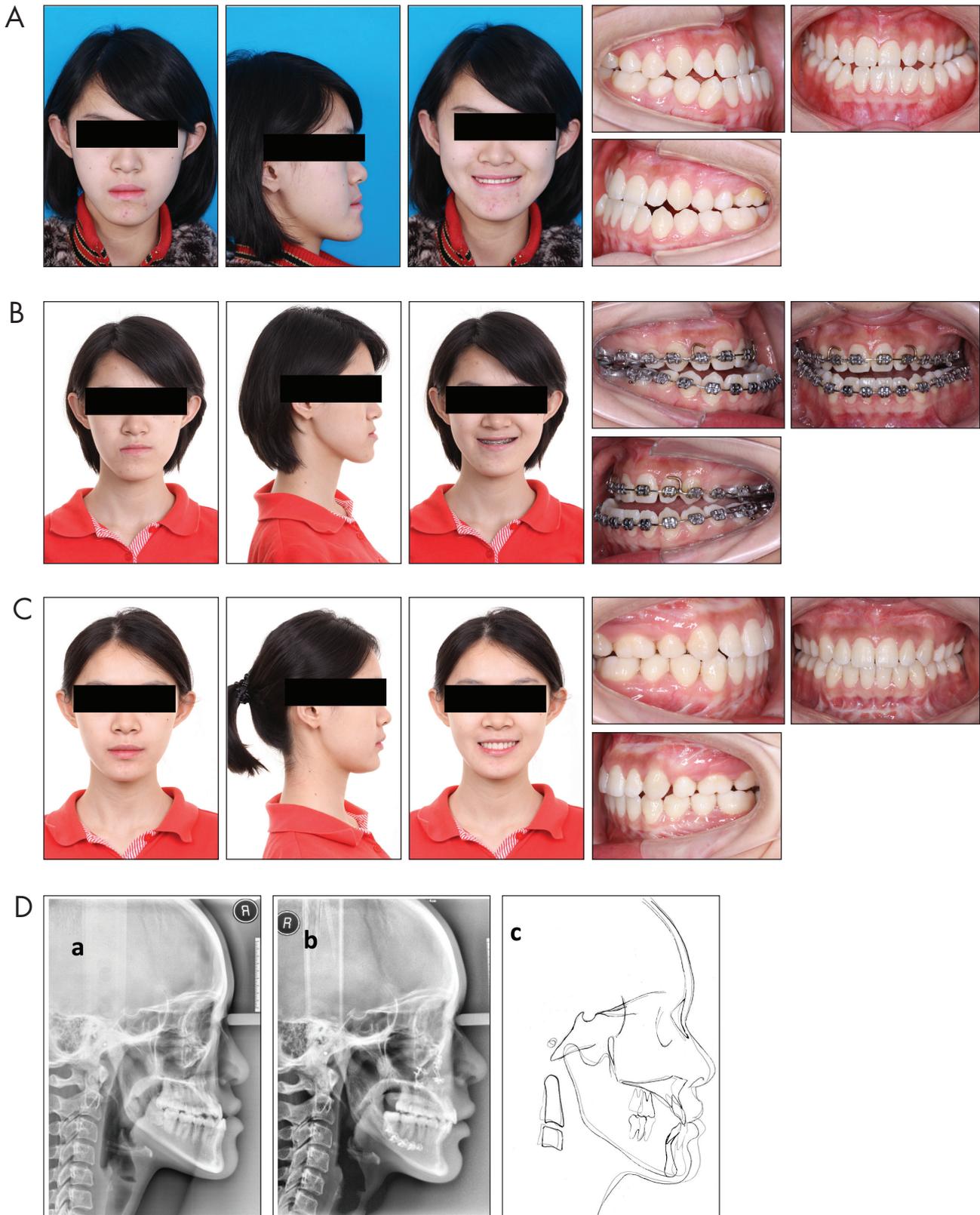
#### *Case 3*

The patient was an 18-year-old male, who complained of an anterior crossbite and an unaesthetic facial and dental appearance. His medical history was unremarkable. The patient had a concave profile with asymmetry.

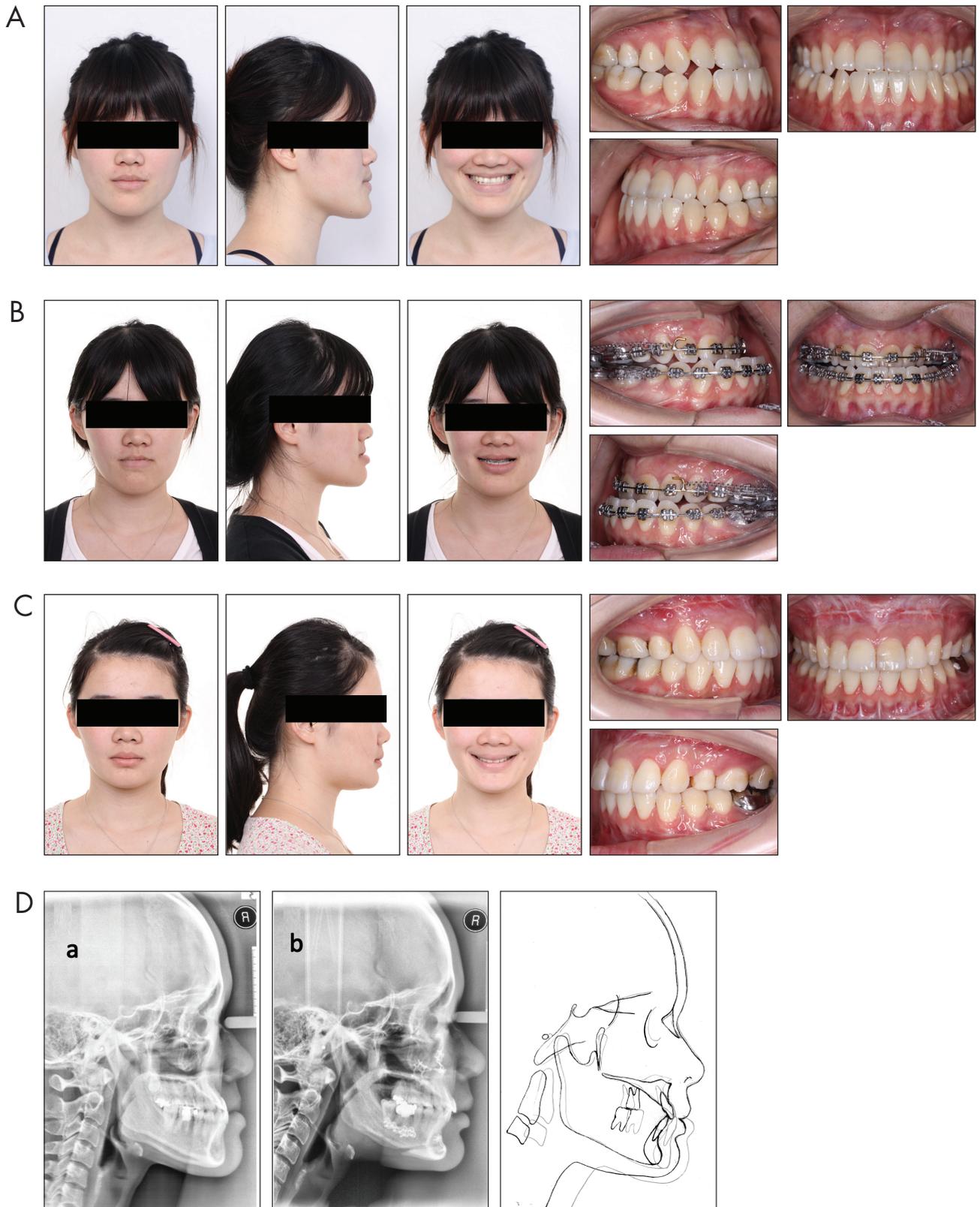
An intra-oral examination and study models showed that there was 3.5 mm of crowding in the upper arch but little in the lower arch. There was an anterior crossbite with a -3.5 mm overjet and a posterior crossbite. The mandible could not be manipulated to an edge-to-edge anterior relationship. The upper midline had shifted 2 mm to the left while the lower midline was also 1 mm to the left. The molar relationships were full unit Class III on both sides (Figure 3A). The lateral cephalogram (Figure 3D) and analysis (Table I) indicated a skeletal Class III relationship with maxillary retrusion and moderate mandibular protrusion. Periodontal probing showed depths of 1 to 3 mm in the maxillary anterior region.

### *Treatment process*

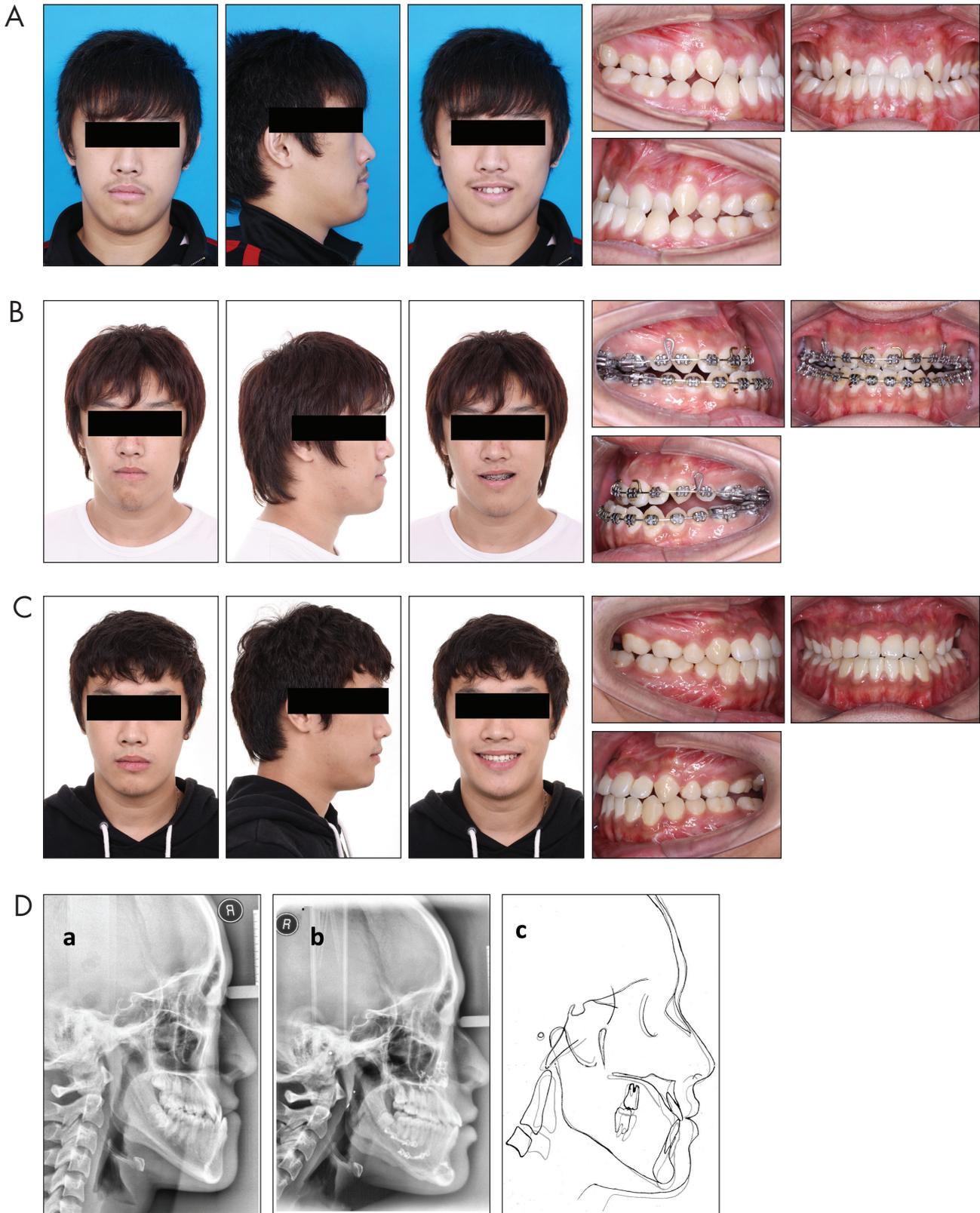
The extraction pattern for the three cases involved the removal of the upper first premolars and all erupted third molars. The molars were subsequently



**Figure 1.** Case 1: (A) Pretreatment appearance and intra-oral view. (B) Appearance and intra-oral view after closing upper extraction space and prior to orthognathic surgery. (C) Post-treatment appearance and intra-oral view. (D) (a) Pretreatment lateral cephalogram, (b) Post-treatment lateral cephalogram, (c) Superimposition of pretreatment (grey) and post-treatment (black) cephalometric tracings.



**Figure 2.** Case 2: (A) Pretreatment appearance and intra-oral view. (B) Appearance and intra-oral view after closing upper extraction space and prior to orthognathic surgery. (C) Post-treatment appearance and intra-oral view. (D) (a) Pretreatment lateral cephalogram, (b) Post-treatment lateral cephalogram, (c) Superimposition of pretreatment (grey) and post-treatment (black) cephalometric tracings.



**Figure 3.** Case 3: (A) Pretreatment appearance and intra-oral view. (B) Appearance and intra-oral view after closing upper extraction space and prior to orthognathic surgery. (C) Posttreatment appearance and intra-oral view. (D) (a) Pretreatment lateral cephalogram, (b) Post-treatment lateral cephalogram, (c) Superimposition of pretreatment (grey) and post-treatment (black) cephalometric tracings.

banded and the remaining teeth were bonded with pre-adjusted edgewise fixed appliances employing a 0.022-inch slot.

After aligning and levelling the upper arch and inserting a 0.019" × 0.025" stainless steel wire, a corticotomy was performed on the buccal side of the alveolus using piezosurgery (Piezo Ultrasonic Surgery Unit, SATELEC, Bordeaux, France). Initially, a full thickness muco-periosteal flap was reflected from the upper left second premolar to the upper right second premolar. Parallel vertical incisions were performed in the inter-radicular spaces and through the entire thickness of the buccal cortical plate. The corticotomy cuts were extended gingivally to a height 2 mm above the apices of the teeth and occlusally to 2 mm below the level of the alveolar crestal bone. No horizontal corticotomy cuts were made. Subsequently, bone grafting materials (CERASORB curasan AG, 150–500µm, 0.5 g) were applied to selectively cover

the decorticated area and the flap was replaced and sutured (Figure 4). Following the raising of a muco-periosteal flap in Case 1, a bony fenestration was noted in the buccal cortex at the level of the root apex of the upper right lateral incisor (Figure 5A, B). The fenestration was covered with grafting material before the soft tissue flap was replaced (Figure 4C).

The patients were reviewed after two weeks for orthodontic adjustments and, thereafter, seen every four weeks. En masse retraction of the anterior teeth was commenced on the 0.019" × 0.025" stainless steel archwires and, following completion, a maxillary Le Fort I osteotomy and a mandibular bilateral sagittal split osteotomy combined with a mentoplasty were performed for each patient. Rigid internal fixation was applied by four microplates and 16 microscrews in the maxilla, two miniplates and eight microscrews in the mandible and two microplates and six microscrews in the chin. Following orthognathic surgery,

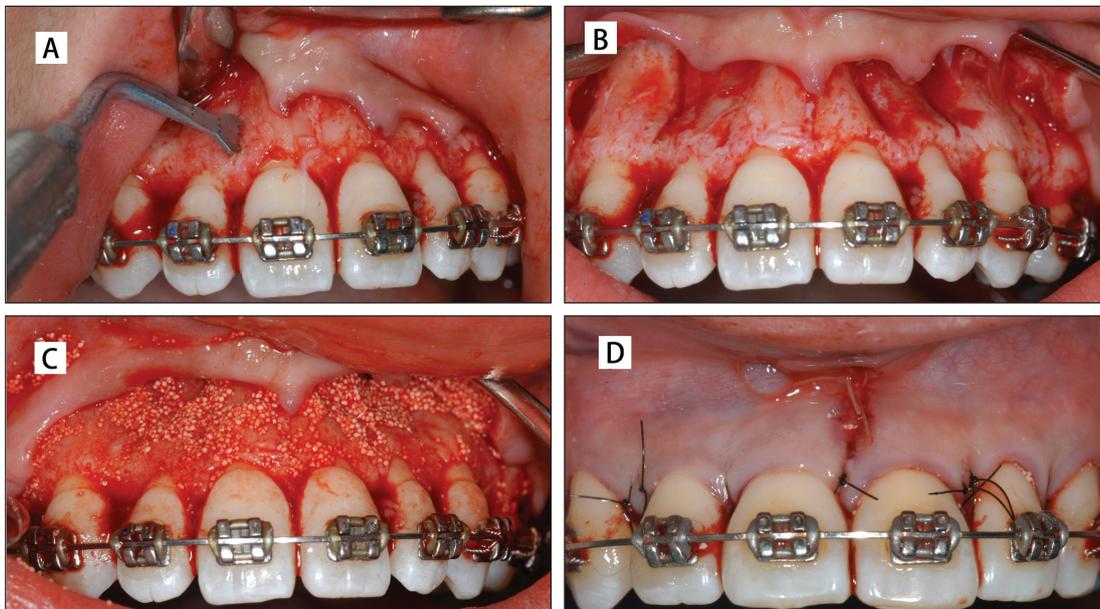


Figure 4. (A) Piezosurgery performed on maxillary anterior alveolar bone. (B) Vertical incisions performed in inter-radicular spaces. (C) Bone graft material covered the decortication area. (D) Suture.



Figure 5. Case 1: (A, B) Bony fenestration detected in buccal cortex near the middle of right lateral incisor root during corticotomy. (C) CBCT image after the treatment.

postoperative orthodontic treatment was continued to achieve a solid occlusion, after which the appliances were removed and retention initiated.

### Treatment results

The time involved in closing the extraction spaces after AOO for the three cases was 4.0 months, 5.6 months and 6.5 months, respectively (Table II). The mean time was  $5.4 \pm 1.3$  months. The duration of preoperative orthodontic treatment, which involved arch alignment and levelling and space closure, was 11.1 months, 11.3 months and 12.9 months, respectively. The mean time for the surgical

intervention, including preoperative preparation in the orthognathic department, the surgical procedure and postoperative recovery, was  $3.7 \pm 0.6$  months. Postoperative orthodontic treatment time was 4.1 months, 4.2 months, and 5.9 months respectively, which produced a mean period of  $4.7 \pm 1.0$  months. Therefore, the average time for preoperative orthodontics was  $12.0 \pm 0.9$  months, and the overall treatment time was  $20.4 \pm 2.4$  months (Table II). After active treatment, the skeletal and dental objectives had been achieved (Figures 1C, 2C, 3C). The crossbites had been corrected as a result of the forward movement of the maxilla and the backward movement of the mandible. Superimpositions of

Table I. Cephalometric analysis of three Class III orthognathic surgical cases.

Variable	Mean	SD	Case 1		Case 2		Case 3	
			Pretreatment	Post-treatment	Pretreatment	Post-treatment	Pretreatment	Post-treatment
SNA (°)	82.80	4.00	78.51	79.94	83.23	86.76	77.27	79.12
SNB (°)	80.10	3.90	85.66	78.63	88.10	83.93	80.42	78.12
ANB (°)	2.70	2.00	-7.16	1.30	-4.86	2.83	-3.15	1.00
FH-NP (°)	85.40	3.70	92.51	84.51	90.39	86.52	87.59	86.38
NA/PA (°)	6.00	4.40	-17.03	-2.31	-11.47	1.03	-7.62	-2.01
U1-NA (mm)	3.50	6.50	9.42	5.47	9.11	4.80	2.99	5.58
U1-NA (°)	22.80	5.70	36.82	25.26	42.84	23.85	23.39	28.08
L1-NB (mm)	6.70	2.10	1.95	4.56	3.50	4.80	2.27	5.65
L1-NB (°)	30.50	5.80	18.61	28.62	19.67	24.75	13.53	24.92
U1/L1 (°)	124.20	8.20	131.73	124.81	122.36	128.57	146.23	126.00
U1/SN (°)	105.70	6.30	115.33	105.20	126.07	110.61	100.66	107.20
MP/SN (°)	32.50	5.20	36.92	39.62	27.08	26.40	44.17	41.73
MP/FH (°)	31.10	5.60	31.24	36.09	25.48	26.18	37.26	35.38
L1/MP (°)	93.90	6.20	76.02	90.38	84.48	94.42	68.94	85.06

Table II. Time frames of three Class III orthognathic surgical cases.

Time frames (months)	Cases			
	1	2	3	Mean $\pm$ SD
Closing upper extraction space <sup>1</sup>	4.0	5.6	6.5	$5.4 \pm 1.3$
Pre-surgical orthodontics <sup>2</sup>	11.7	11.3	12.9	$12.0 \pm 0.9$
Post-surgical orthodontics <sup>3</sup>	4.1	4.2	5.9	$4.7 \pm 1.0$
Total treatment time <sup>4</sup>	19.4	18.6	23.2	$20.4 \pm 2.4$

<sup>1</sup> The period from when the upper teeth were aligned and leveled to when the maxillary dentition spaces were closed.

<sup>2</sup> The period from when the brackets and bands were placed on the maxillary dentition to the last orthodontic adjustment prior to the orthognathic surgery.

<sup>3</sup> The period from the first orthodontic adjustment after the orthognathic surgery to the debonding date.

<sup>4</sup> The period from when the brackets and bands were placed on the maxillary dentition to the debonding date.

pre- and post-treatment tracings (Figures 1D, 2D, 3D) and cephalometric analysis (Table I) revealed improved skeletal and dental relationships. Periodontal probing examinations showed unchanged pocket depths of 1 to 3 mm in the maxillary anterior area after therapy.

## Discussion

Wilcko recommended Accelerated Osteogenic Orthodontics in 2001 to enhance orthodontic tooth movement and reduce treatment time.<sup>4</sup> The surgical intervention to accelerate tooth movement has been described by various procedures since the 1800s,<sup>7,8</sup> but Köle's publication in 1959 was the first to illustrate contemporary corticotomy-facilitated orthodontics.<sup>20</sup> The term 'bony block' was coined to describe the suspected mode of tooth movement after corticotomy surgery, which was essentially a combination of a corticotomy and osteotomy procedure. Wilcko et al.<sup>4</sup> proposed the hypothesis that a corticotomy induced the acceleration of a physiologic demineralisation and remineralisation process (reversible osteopenia) and the increase in turnover of alveolar spongiosa, rather than 'bony block movement'. Sebaoun et al.<sup>9</sup> and Baloul et al.<sup>12</sup> supported this hypothesis and suggested that a kinetic balance between osteoblasts and osteoclasts can be achieved after the mechanical injury.

Luther et al. reported that the median duration of pre-surgical orthodontic treatment for Class III patients was 18 months (range 7–34 months).<sup>2</sup> Many factors may influence the preoperative orthodontic preparation and include the extraction protocols, the malocclusion type, the severity of the dental malocclusion or skeletal discrepancy, the clinician's experience, gender and age, amongst others. Dowling et al. found that the median time of preoperative orthodontics was 15.4 months (range 3–92).<sup>21</sup> An additional factor that significantly increased treatment time was the need for extractions and whether the patients were treated in a university clinic. Extraction cases were found to require five additional months in preoperative preparation compared with non-extraction cases ( $p < 0.001$ ).<sup>21</sup>

In the present preliminary report, the three patients presented with similar Class III, crowded malocclusions requiring extraction (upper two bicuspids extraction for each) and were treated using the same orthognathic surgery procedures by the same

surgeon. The mean preoperative treatment duration was reduced to 12 months, which was approximately half a year shorter than Luther's presented data.<sup>2</sup>

A piezoelectric surgical device was used on each patient instead of a low-speed hand piece. In a previous study, the use of a low-speed drill produced signs of thermal damage and bone fragmentation, therefore piezosurgery was preferred to perform the osteotomies in thin and fragile bones.<sup>22</sup> The ultrasound appliance is precise, easily handled and the micro-vibrations allowed a selective cut of only mineralised structures. This ensured minimal damage to adjacent soft tissue. In addition, the corticotomy incisions were only performed on the buccal side of the cortical plate without additional subapical horizontal cuts (Figure 4). Sebaoun et al. reported that grooves only on the buccal side were adequate for inducing reversible osteopenia.<sup>9</sup>

Bony dehiscence and fenestration is a common finding in adult patients before, during and after orthodontic treatment when the teeth have been moved along the alveolar bone. Kim et al.<sup>23</sup> and Ahn et al.<sup>24</sup> reported the use of a corticotomy and bone augmentation on the mandibular anterior alveolus in Class III patients and found an increase in alveolar bone thickness at the level of the root apex after an AOO procedure. Case 1 of this report identified a pre-existing bony fenestration in the buccal cortex near the middle of the right lateral incisor root when a muco-periosteal flap was reflected during the corticotomy (Figure 5A, B). Bone graft material was used to cover the defect in the buccal cortical plate. After treatment, computerised tomographic scanning revealed the pre-existing bony fenestration was corrected (Figure 5C). At the time of corticotomy and at treatment completion, CBCT scans of Case 1 showed that the labial alveolar bone thickness at the root apex level of the right lateral incisor had increased from 2.2 mm to 3.1 mm (Figure 6).

The main advantage of AOO is a reduction in orthodontic treatment time. Wilcko et al.<sup>7</sup> emphasised that AOO could extend the range of orthodontic treatment capability and possibility. Wang et al.<sup>25</sup> reported that AOO facilitated mandibular incisor decompensation and maintained better periodontal health. In the present preliminary report, a multidisciplinary approach that included corticotomy, orthodontic mechanotherapy and orthognathic surgery was an efficient method; however, no solid conclusions may be drawn. The unanswered questions are whether

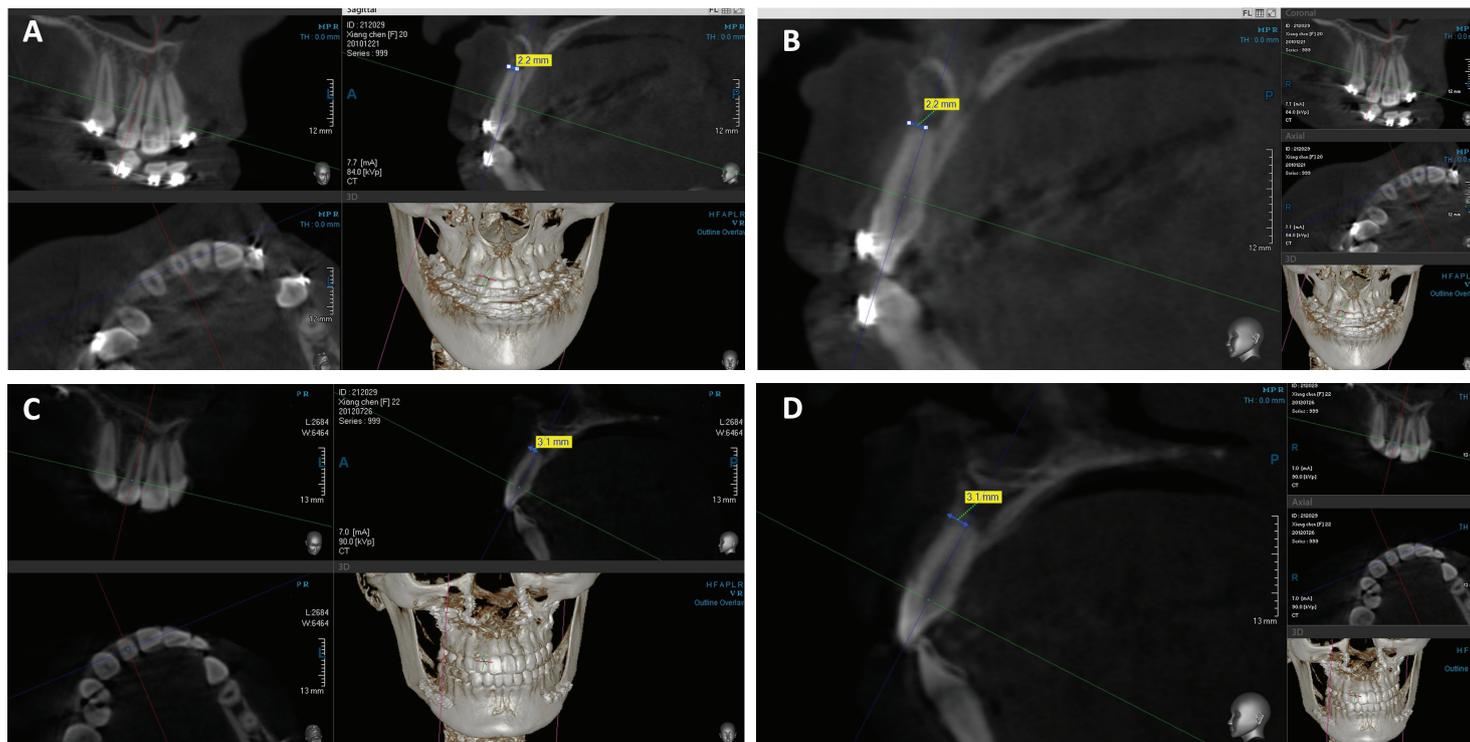


Figure 6. The CBCT of Case 1 showed the labial alveolar bone thickness at root apex levels of the right lateral incisor. (A, B) Pretreatment CBCT; (C, D) Post-treatment CBCT.

the AOO procedure is verifiably able to reduce the time of preoperative orthodontic treatment and whether AOO in the upper arch could facilitate better maxillary incisor decompensation and periodontal preservation. Further clinical research is required in this area, directed at an assessment of maxillary digital dental models and CBCT scans obtained before and after treatment, as outlined in Figure 7.

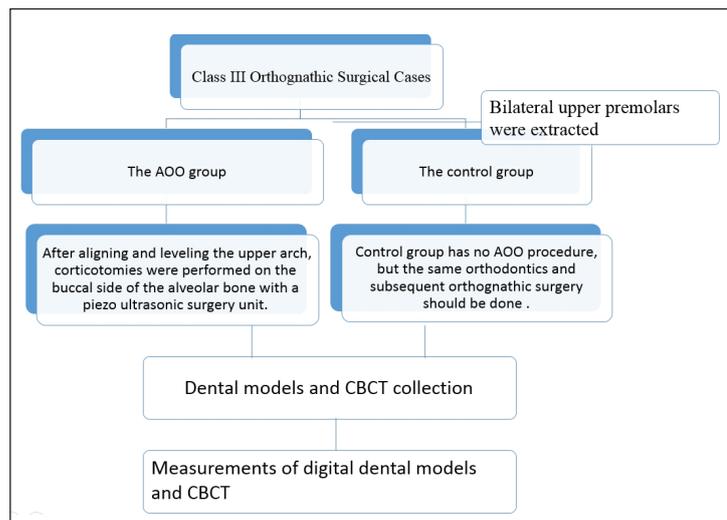


Figure 7. Outline of the future study.

Corticotomy is becoming a routine periodontal procedure, similar to periodontal osseous surgery. However, it is an invasive technique with moderate morbidity and also bears a financial burden. Nevertheless, the orthognathic surgical procedures would be more complicated and more costly compared with the periodontal AOO procedure in isolation. Furthermore, young adult patients are keen to finish treatment quickly and, as a result, AOO is likely to be more favourably accepted.

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## References

- Phillips C, Proffit WR. Psychosocial aspects of dentofacial deformity and its treatment. In: Proffit WR, White RP, Sarver DM, eds. *Contemporary treatment of dentofacial deformity*. St Louis: Mosby, 2003;69-89.
- Luther F, Morris DO, Hart C. Orthodontic preparation for orthognathic surgery: how long does it take and why? A retrospective study. *Br J Oral Maxillofac Surg* 2003;41:401-6.
- Luther F, Morris DO, Karnezi K. Orthodontic treatment following orthognathic surgery: how long does it take and why? A retrospective study. *J Oral Maxillofac Surg* 2007;65:1969-76.
- Wilcko MW, Wilcko T, Bouquot JE, Ferguson DJ. Rapid orthodontics with alveolar reshaping: two case reports of de-crowding. *Int J Periodontics Restorative Dent* 2001;21:9-19.
- Murphy KG, Wilcko MT, Wilcko WM, Ferguson DJ. Periodontal accelerated osteogenic orthodontics: a description of the surgical technique. *J Oral Maxillofac Surg* 2009;67:2160-6.
- Dibart S, Sebaoun JD, Surmenian J. Piezocision: a minimally invasive, periodontally accelerated orthodontic tooth movement procedure. *Compend Contin Educ Dent* 2009;30:342-4, 346, 348-50.
- Wilcko MT, William MW, Bissada NF. An evidence-based analysis of periodontally accelerated orthodontic and osteogenic techniques: a synthesis of scientific perspectives. *Semin Orthod* 2008;14:305-16.
- Hassan AH, Al-Fraidi AA, Al-Saeed SH. Corticotomy-assisted orthodontic treatment: review. *Open Dent J* 2010;4:159-64.
- Sebaoun JD, Kantarci A, Turner JW, Carvalho RS, Van Dyke TE, Ferguson DJ. Modeling of trabecular bone and lamina dura following selective alveolar decortication in rats. *J Periodontol* 2008;79:1679-88.
- Lee W, Karapetyan G, Moats R, Yamashita DD, Moon HB, Ferguson DJ et al. Corticotomy-/osteotomy-assisted tooth movement microCTs differ. *J Dent Res* 2008;87:861-7.
- Wang L, Lee W, Lei DL, Liu YP, Yamashita DD, Yen SL. Tissue responses in corticotomy- and osteotomy-assisted tooth movements in rats: histology and immunostaining. *Am J Orthod Dentofacial Orthop* 2009;136:770-1.
- Baloul SS, Gerstenfeld LC, Morgan EF, Carvalho RS, Van Dyke TE, Kantarci A. Mechanism of action and morphologic changes in the alveolar bone in response to selective alveolar decortication-facilitated tooth movement. *Am J Orthod Dentofacial Orthop* 2011;139:S83-101.
- Iino S, Sakoda S, Ito G, Nishimori T, Ikeda T, Miyawaki S. Acceleration of orthodontic tooth movement by alveolar corticotomy in the dog. *Am J Orthod Dentofacial Orthop* 2007;131:441-8.
- Mostafa YA, Mohamed SFM, Mehanni S, ElBokle NN, Heider AM. Comparison of corticotomy-facilitated vs standard tooth-movement techniques in dogs with miniscrews as anchor units. *Am J Orthod Dentofacial Orthop* 2009;136:570-7.
- Sanjideh PA, Rossouw PE, Campbell PM, Opperman LA, Buschang PH. Tooth movements in foxhounds after one or two alveolar corticotomies. *Eur J Orthod* 2010;32:106-13.
- Kim SJ, Park YG, Kang SG. Effects of Corticision on paradental remodeling in orthodontic tooth movement. *Angle Orthod* 2009;79:284-91.
- Wilcko MT, Wilcko WM, Pulver JJ, Bissada NF, Bouquot JE. Accelerated osteogenic orthodontics technique: a 1-stage surgically facilitated rapid orthodontic technique with alveolar augmentation. *J Oral Maxillofac Surg* 2009;67:2149-59.
- Aboul-Ela SM, El-Beialy AR, El-Sayed KM, Selim EM, El-Mangoury NH, Mostafa YA. Miniscrew implant-supported maxillary canine retraction with and without corticotomy-facilitated orthodontics. *Am J Orthod Dentofacial Orthop* 2011;139:252-9.
- Cassetta M, Di Carlo S, Giansanti M, Pompa V, Pompa G, Barbato E. The impact of osteotomy technique for corticotomy-assisted orthodontic treatment (CAOT) on oral health-related quality of life. *Eur Rev Med Pharmacol Sci* 2012;16:1735-40.
- Köle H. Surgical operations on the alveolar ridge to correct occlusal abnormalities. *Oral Surg Oral Med Oral Pathol* 1959;12:515-29.
- Dowling PA, Espeland L, Krogstad O, Stenvik A, Kelly A. Duration of orthodontic treatment involving orthognathic surgery. *Int J Adult Orthodon Orthognath Surg* 1999;14:146-52.
- Romeo U, Del Vecchio A, Palaia G, Tenore G, Visca P, Maggiore C. Bone damage induced by different cutting instruments--an in vitro study. *Braz Dent J* 2009;20:162-8.
- Kim SH, Kim I, Jeong DM, Chung KR, Zadeh H. Corticotomy-assisted decompensation for augmentation of the mandibular anterior ridge. *Am J Orthod Dentofacial Orthop* 2011;140:720-31.
- Ahn HW, Lee DY, Park YG, Kim SH, Chung KR, Nelson G. Accelerated decompensation of mandibular incisors in surgical skeletal Class III patients by using augmented corticotomy: a preliminary study. *Am J Orthod Dentofacial Orthop* 2012;142:199-206.
- Wang B, Shen G, Fang B, Yu H, Wu Y. Augmented corticotomy-assisted presurgical orthodontics of class III malocclusions: a cephalometric and cone-beam computed tomography study. *J Craniofac Surg* 2013;24:1886-90.