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Revision of Lingual Bracket Direct Bonding Clinical Procedures

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ABSTRACT

Rationale: Lingual brackets are typically bonded indirectly based on setup models with ideal tooth alignment to overcome the variability in lingual tooth anatomy and difficulties in measuring bracket position. However, direct bonding is the original philosophy of the inventor of lingual orthodontics and is still performed by a minority of lingual orthodontists. This article aims to revise the clinical procedures of direct bonding of lingual brackets and forming of lingual archwires and prove the effectiveness of the direct bonding philosophy through two case reports.

Patient concerns: The patient in Case 1 was a 29-year-old female who presented with moderate crowding and normal inclinations of the maxillary and mandibular incisors. The patient in Case 2 was a 25-year-old female patient who presented with severe crowding and proclined maxillary and mandibular incisors.

Diagnoses: The patient in Case 1 was diagnosed with a half-cusp Class II relationship on a Class I skeletal relationship. The patient in Case 2 was diagnosed with Class I dental and skeletal relationships. Both patients had a normodivergent facial pattern.

Interventions and outcomes: The treatment option in Case 1 was to extract all third molars combined with total distalization of both arches and interproximal stripping. The treatment option in Case 2 was to extract maxillary and mandibular first premolars to create spaces for relieving crowding. The post-treatment records in both cases showed improved smile aesthetics and occlusion.

Conclusions: Direct lingual bracket bonding offers some advantages and disadvantages compared to indirect one. Successful treatment results of two case reports demonstrate the accuracy and effectiveness of the direct lingual bracket bonding approach.

Keywords: Lingual Orthodontics, Mushroom Archwire, Direct Bonding, Lingual Brackets, Offset Bends.

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INTRODUCTION

In 1968, Fujita pioneered lingual orthodontics by bonding labial brackets to the lingual side of teeth, marking the beginning of the era of invisible orthodontics.[1,2] Until now, two lingual bracket bonding philosophies have been developed by him and his colleagues. The more popular approach is indirect bonding, where brackets are bonded to aligned copies of the patient's teeth, called setup models, outside of the mouth. This method overcomes the variability in lingual tooth anatomy and difficulties in measuring bracket position on the lingual side of teeth. [3-5] On the other hand, a minority of lingual orthodontists still bond lingual brackets directly following the original philosophy of Fujita.[1]

However, clinical procedures of direct bonding of lingual brackets are not yet thoroughly described in the literature. This article aims to revise the clinical procedures of direct bonding of lingual brackets and forming of lingual archwires and prove the effectiveness of the direct bonding philosophy through two case reports.

CLINICAL PROCEDURES

Bracket bonding

Lingual surfaces of incisors are usually concave, causing a change in the torque prescription of lingual bracket slots when moving brackets in the occluso-gingival direction (Figure 1a,b) [6]. As a result, a small error in the height of the lingual bracket from the incisal edge of the tooth would lead to a greater difference in the incisal edge position compared to the labial bracket, particularly in the upper arch, because of the torque alteration. This may explain why incisal edge leveling is generally less satisfactory with direct bonding of lingual brackets compared to labial brackets. Therefore, in the direct bonding technique, the palatal surfaces of upper incisors are flattened by applying orthodontic adhesives (Enlight, Ormco, US) to minimize this phenomenon. Additionally, lingual brackets with flat bases could be more stably positioned on these flattened resin bases (Figure 1c). On final appliance removal, the adhesive will be removed using a round carbide tungsten bur (C141, Diaswiss, Switzerland) mounted on a low-speed handpiece (20,000 rpm), ensuring precise removal while preserving enamel integrity.

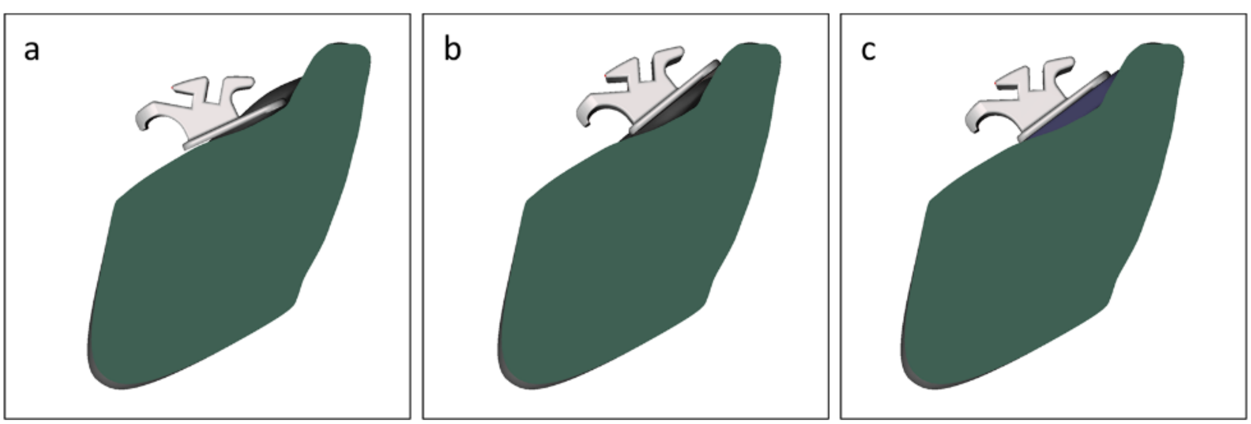

Figure 1 (a, b) Torque difference when moving lingual brackets vertically. (c) Flattening of palatal tooth surfaces with orthodontic adhesives.

There is great variability in lingual tooth anatomy in which prominent cingulum, marginal ridges, and Carabelli cusps may interfere with lingual bracket placement (Figure 2). For a more stable and correct bracket positioning, these abnormally prominent tooth anatomies should be reduced with burs. In most Asian patients, the mesial marginal edge and cingulum of upper canines are usually reduced as they are more prominent and may cause errors in rotation and torque. Additionally, reducing prominent lingual features in combination with the strategic addition of orthodontic adhesive to the palatal surfaces of lateral incisors helps balance tooth size discrepancies between lateral incisors and canines, eliminating the need for offset bends between these teeth. Both the procedures of composite addition and tooth grinding are carefully controlled to create even lingual tooth surfaces among the six anterior teeth. The lingual surfaces of molars are generally not modified, except for cases with prominent Carabelli cusps, which are selectively reduced to facilitate stable bracket placement.

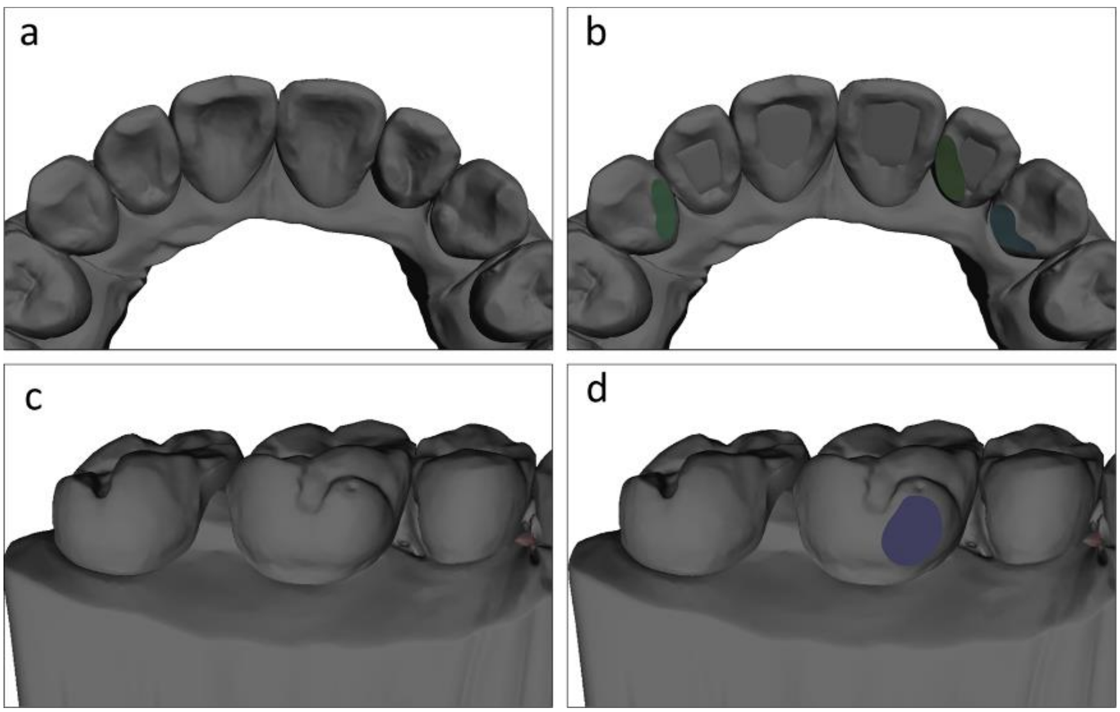

Figure 2 (a, b) Reduction of prominent cingula and marginal ridges and flattening of palatal concaving with adhesives. (c, d) Reduction of prominent Carabelli cusp.

After modifying lingual tooth surfaces, they are prepared with phosphoric acid 37% followed by the application of an orthodontic primer (Ortho Solo, Ormco, US). Intraoral sandblasting is not performed to avoid patient discomfort and unnecessary additional procedural steps. A regular bracket holder is used, with the bracket base positioned parallel to the holder handle and the occlusal wing oriented toward the operator's hand. Orthodontic adhesives are then applied to bracket bases and brackets are directly placed closely adapted to the modified lingual tooth surfaces. An intraoral mirror and a dental explorer are used to refine bracket positioning, ensuring proper height and angulation for optimal alignment. Operators have to keep in mind that lingual brackets usually do not have pre-adjusted tip values. Therefore, brackets need to be tipped distally to create angulations with tooth axes (Figure 3). Operators' experience is very important as there is no gauge to measure the bracket heights and angulations. The authors' recommended bracket angulations and heights are shown in Table 1, which are based on seven years of clinical experience with direct bonding of lingual brackets. The height value may be slightly reduced in cases of incisal or cusp wear to accommodate anatomical variations. Tip and torque values are universal irrespective of pretreatment state, similar to stock labial brackets. Individual torque adjustments can be made later by incorporating bends in the archwire as needed. In cases of severe crowding where lingual brackets cannot be initially bonded in the correct positions, brackets may be temporarily placed on marginal ridges for the initial alignment. They can be rebonded in the correct positions later when there is adequate space available (Figure 3). The bracket positions have to be re-evaluated with intraoral photographs and panoramic radiographs after the leveling and alignment stage, and incorrectly placed brackets can be identified and repositioned.

Table 1. Recommended lingual bracket torque, tip, and height for direct bonding.

Upper	Central	Lateral	Canine	1st premolar	2nd premolar	1st molar	2nd molar
Torque	55 °	55 °	55 °	5 °	5 °	10 °	5 °
Tip	5 °	7 °	10 °	0 °	0 °	0 °	0 °
Height	7.5 mm	7 mm	8 mm	4.5 mm	4 mm	4 mm	3.5 mm
Lower	Central	Lateral	Canine	1st premolar	2nd premolar	1st molar	2nd molar
Torque	45 °	45 °	45 °	5 °	0 °	-10 °	-10 °
Tip	3 °	5 °	7 °	0 °	0 °	0 °	0 °
Height	6 mm	6 mm	7 mm	4.5 mm	4 mm	4 mm	3.5 mm

Note: Torque values are already built into the bracket prescription. Bracket height is measured from the incisal edge for incisors and the cusp tip for canines, premolars, and molars to the center of the main slot.

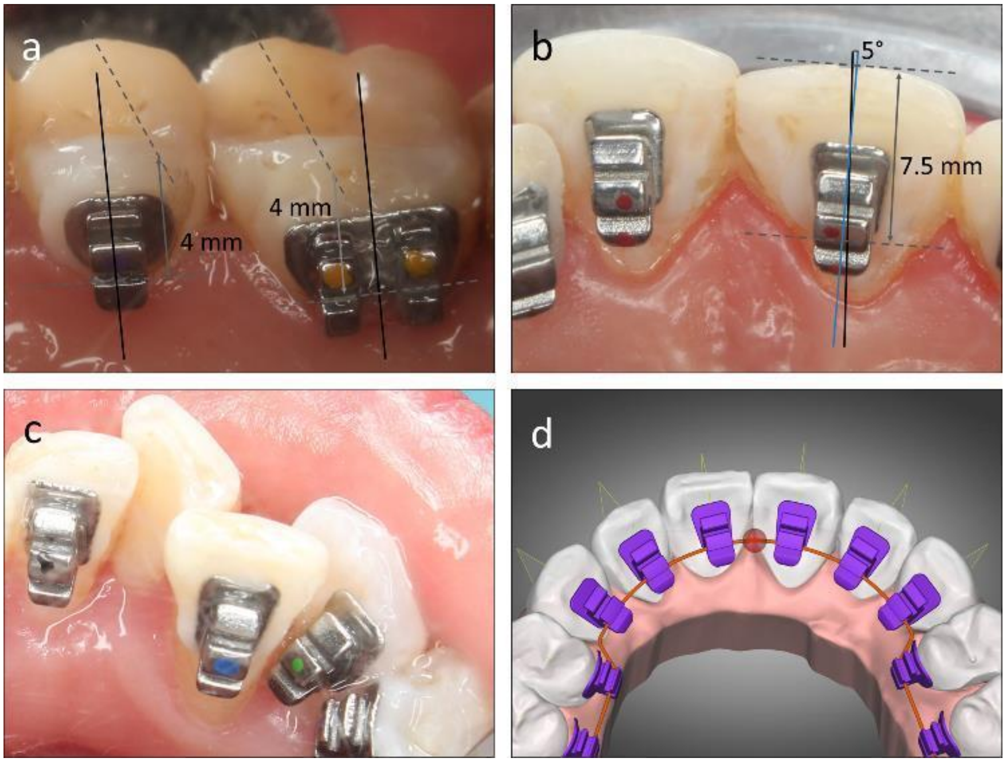

Figure 3: Direct bonding of lingual brackets. (a) Premolar and molar brackets are bonded parallel to tooth axes. (b) Incisor brackets are tipped distally to create angulations. (c) The mandibular right canine bracket was bonded on the distal marginal ridge for initial alignment. (d) Virtual bracket positions on the aligned teeth illustrate why anterior brackets are tipped distally.

Mushroom archwire forming

Lingual archwires usually have a mushroom shape because of the differences in buccolingual widths between canines and premolars and between premolars and molars unless these differences are compensated by adhesives in the indirect bonding technique. First, operators have to precisely mark the positions of the in-out compensation bends by inserting performed archwires into patients' dental arches. In crowding cases, some ligations may be required to allow precision marks distally to canines and second premolars. Next, the archwires are removed and the offset bends can be made with bayonet pliers of 1 mm, 1.5 mm, or 2 mm according to tooth size differences followed by flattening the bends with a Tweed arch-forming plier (Figure 4).

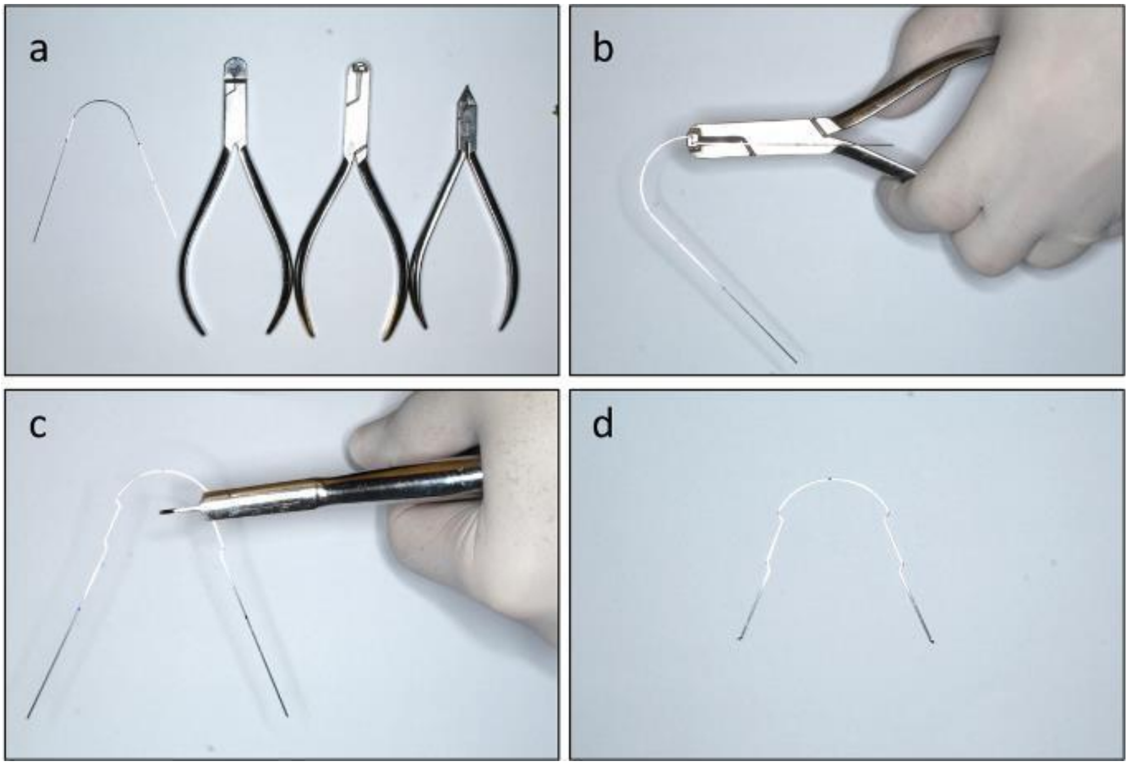

Figure 4: (a) Armamentarium for chairside mushroom archwire forming. (b) Create offset bends with bayonet plier. (c) Flatten offset bends with Tweed arch-forming plier. (d) Completed mushroom archwire.

Larger in-out compensation bends may be needed in case of an incisor or canine agenesis and in that situation, a three-prong plier is used to make the bends. Both nickel-titanium and stainless steel archwires can be formed with these pliers. Table 2 shows the authors' recommended widths of the offset bends in many clinical situations, but operators have to take tooth size discrepancies into consideration when performing the bends. Preformed mushroom lingual archwires are also available on the market, however, they have less versatility because of the variation in arch forms and mesiodistal tooth widths.

Table 2. Recommended Width of Offset Bends in Various Clinical Situations.

Position	Upper mesial	Upper distal	Lower mesial	Lower distal
Non-extraction	2 mm	1.5 mm	1.5 mm	1.5 mm
Premolar extraction	2 mm	1.5 mm	2 mm	1.5 mm
Canine agenesis	3 mm	1.5 mm	2.5 mm	1.5 mm

Note: mesial bends are located after canines or lateral incisors in cases of missing canines, and distal bends are located after second premolars.

The treatment sequence of the direct bonding technique is nearly identical to the indirect bonding technique. The initial leveling and alignment stage is usually done with flexible nickel-titanium archwires, followed by the space closure stage performed on stiff stainless steel archwires and the final detailing stage using beta titanium archwires. During space closure, main archwires may require replacement when the offset bends contact first molar brackets, therefore these bends should be positioned right after canine and premolar brackets to prevent them from interfering with space closure.

CASE 1

Diagnosis and etiology

A 26-year-old female patient presented to the orthodontic clinic with the request to correct her misaligned teeth. The patient's general health was good without systemic disorders. She had a traumatic dental injury to her maxillary right central incisor several years ago, but no symptom was reported.

The extraoral evaluation indicated a well-balanced facial harmony with a convex profile and left-sided chin deviation (Figure 5). The examination of the temporomandibular joint revealed no signs or symptoms.

Figure 5 Pretreatment facial and intraoral photographs of Case 1.

The intraoral evaluation indicated half-cusp Class II canine and molar relationships bilaterally. The maxillary right central incisor was discolored and did not respond to an electric pulp test. The midline of the maxillary arch deviated to the left while the midline of the mandibular arch deviated to the right concerning the facial midline.

The maxillary arch exhibited severe crowding with an arch length discrepancy of 10.5 mm while the mandibular arch showed moderate crowding with an arch length discrepancy of 5.2 mm. The maxillary left lateral incisor and right first molar were in crossbite.

The lateral cephalometric assessment indicated a Class I skeletal relationship and a mesofacial vertical pattern with a point A-nasion-point B (ANB) angle of 3.6° and Frankfort mandibular angle (FMA) of 28.5° (Table 3). The maxillary incisors had a normal inclination, and the mandibular incisors were slightly labially inclined with an upper incisor to sella-nasion (U1-SN) angle of 100.2° and lower incisor mandibular plane (L1-MP) angle of 33.5° (Figure 6). The panoramic radiograph indicated no tooth agenesis, including four third molars.

Table 3. Cephalometric measurements of Case 1.

	Pretreatment	Posttreatment
Skeletal		
SNA (°)	81.3	81.2
SNB (°)	77.7	77.6
ANB (°)	3.6	3.6
FMA (°)	28.5	27.8
Dental		
U1-SN (°)	100.2	97.4
U1-NA (°)	18.9	16.3
U1-NA (mm)	6.7	5.7
L1-MP (°)	95.6	95.4
L1-NB (°)	33.5	32.5
L1-NB (mm)	9.2	8.4
U1-L1 (°)	124.0	127.6
Soft tissue		
E-line/UL (mm)	0.0	-0.6
E-line/LL (mm)	2.0	1.4

ANB, A point, nasion, B point; FMA, Frankfort mandibular plane angle; L1, lower central incisor; LL, lower lip; MP, mandibular plane; NA, nasion point A; NB, nasion point B; SNA, Sella nasion point A; SNB, Sella nasion point B; U1, upper central incisor; UL, upper lip.

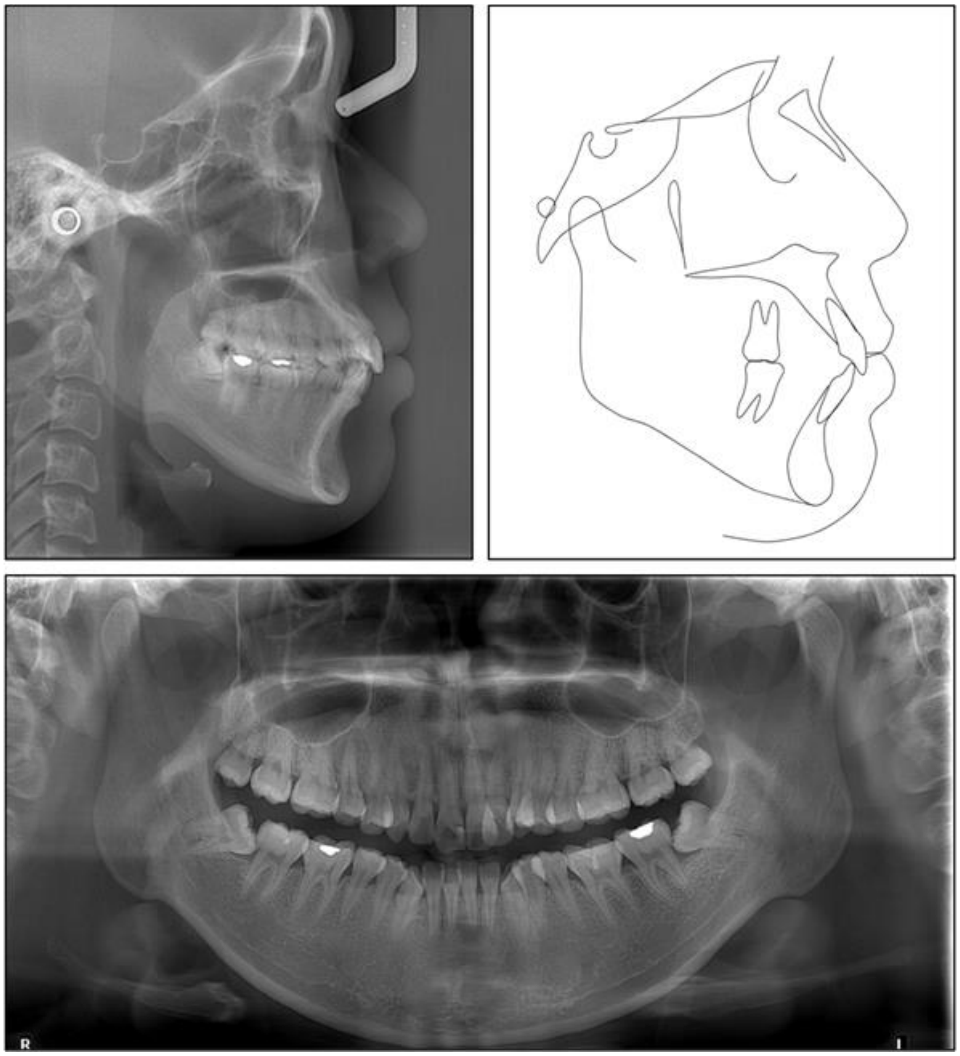

Figure 6 Pretreatment radiographs, and cephalometric tracing of Case 1.

Treatment Alternatives

The main treatment aims included aligning teeth in both arches without increasing labial inclinations of incisors, correcting Class II molar and canine relationships, and aligning dental midlines.

The first treatment option was to extract the maxillary first premolars and mandibular second premolars to create spaces for relieving crowding. The second alternative was extracting all third molars combined with total distalization of both arches and interproximal stripping. Because the mandibular third molars were mesially tipped, the patient chose the second option.

Treatment Progress

First, the patient was referred to an endodontist for root canal treatment of the maxillary right central incisor and a maxillofacial surgeon for the removal of all third molars. The orthodontic treatment commenced with the placement of 0.018 x 0.025-inch pre-adjusted lingual brackets (ADB, Medico, Korea) on all teeth except the second molars and the maxillary left canine. Posterior bite ramps were placed on the palatal cusps of the maxillary first molars to prevent bracket interference and reduce the risk of bracket failure. This facilitated proper occlusal clearance during the initial stages of treatment. Two 1.6 mm diameter and 10 mm length mini-screws (Hifix, Medico, Korea) were inserted in the palatal alveolar bone between the maxillary first and second molars, and power chains (250 g force) were applied from the mini-screws to the maxillary first premolars. Open coil springs were also used to create space for the maxillary left canine. The archwire sequence was 0.012-inch, 0.016-inch, 0.016 × 0.022-inch, nickel-titanium and 0.016 × 0.022-inch stainless steel.

During treatment, some labial brackets were bonded to the second premolars and molars to improve the tooth alignment. After 14 months of treatment, interproximal stripping was carried out on all maxillary and mandibular premolars, canines, and incisors. Two 2.0 mm diameter and 12 mm length mini-screws (Hifix, Medico, Korea) were implanted in the mandibular buccal shelf. Distalizing forces of 250 g were applied with power chains from the mini-screws to distalize the entire lower arch together with the upper arch (Figure 7). The total treatment time was 21 months. A fixed retainer was placed in the lower arch, in combination with Essix retainers in both arches.

Figure 7 Total distalization of both arches with mini-screws.

Treatment results

The orthodontic treatment resulted in improved smile aesthetics and functional occlusion. The teeth were well-aligned with solid Class I canine and molar relationship bilaterally. The overjet and overbite were normalized with the midlines of both dental arches centered with the facial midline (Figure 8). The lateral cephalometric assessment indicated that the lower facial height and the labial inclination of the incisors in both arches were maintained with FMA of 27.8°, U1-SN of 97.4°°, and L1-MP of 95.4 (Figure 9). The panoramic radiograph showed acceptable root parallelism without root resorption. The cephalometric superimpositions confirmed significant amounts of molar distalization in both arches (Figure 10). The 16-month post-treatment records indicated a high stability of the achieved outcomes (Figure 11).

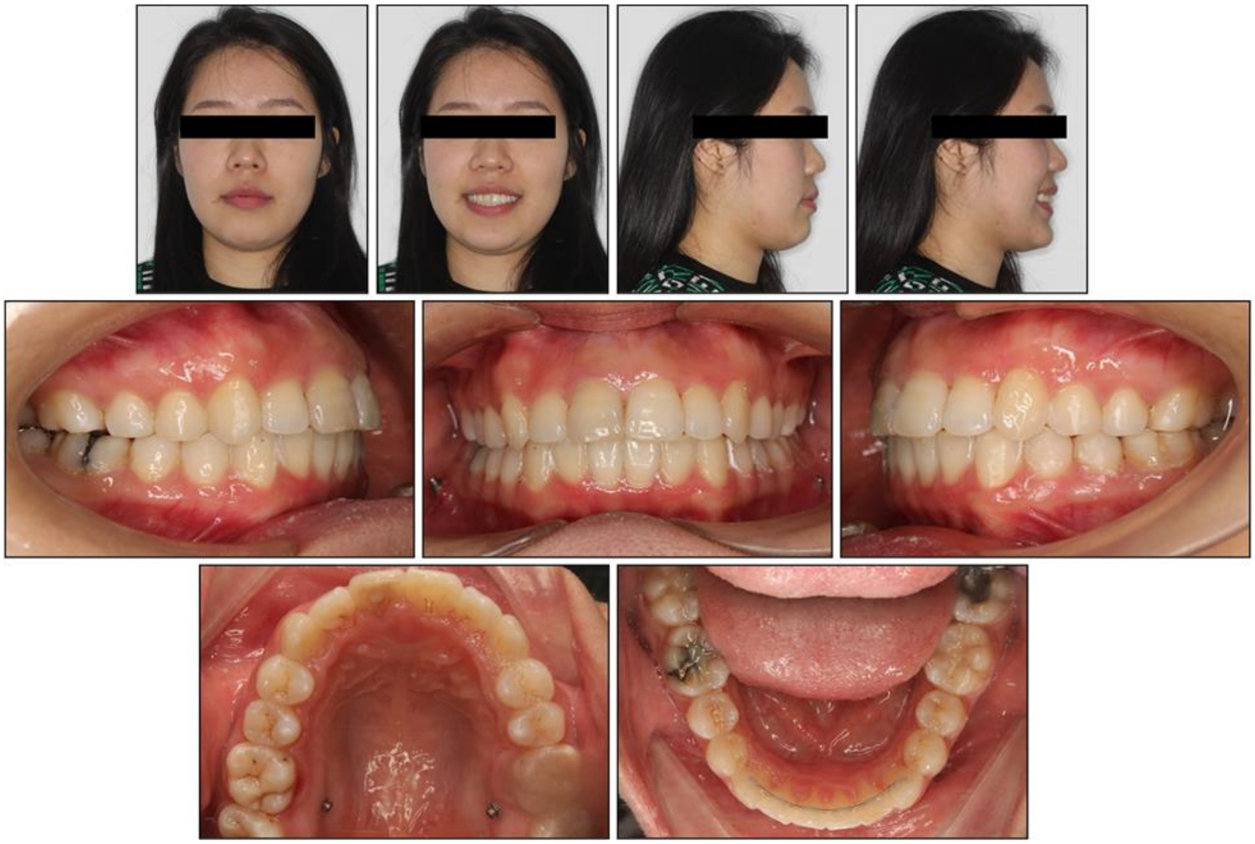

Figure 8: Post-treatment facial and intraoral photographs of Case 1.

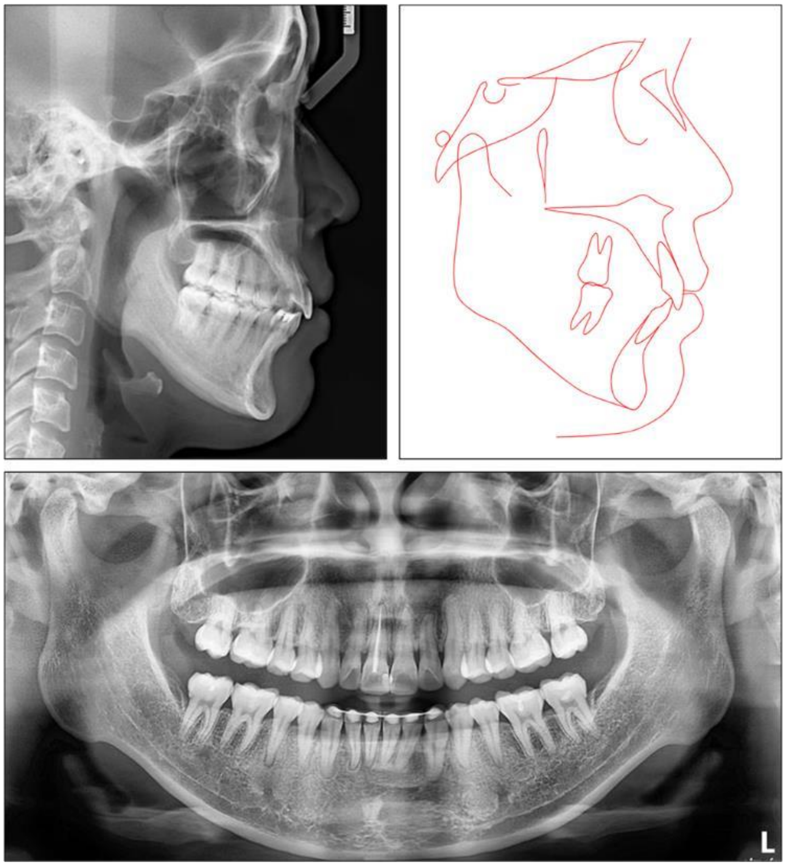

Figure 9 Post-treatment radiographs and cephalometric tracing of Case 1.

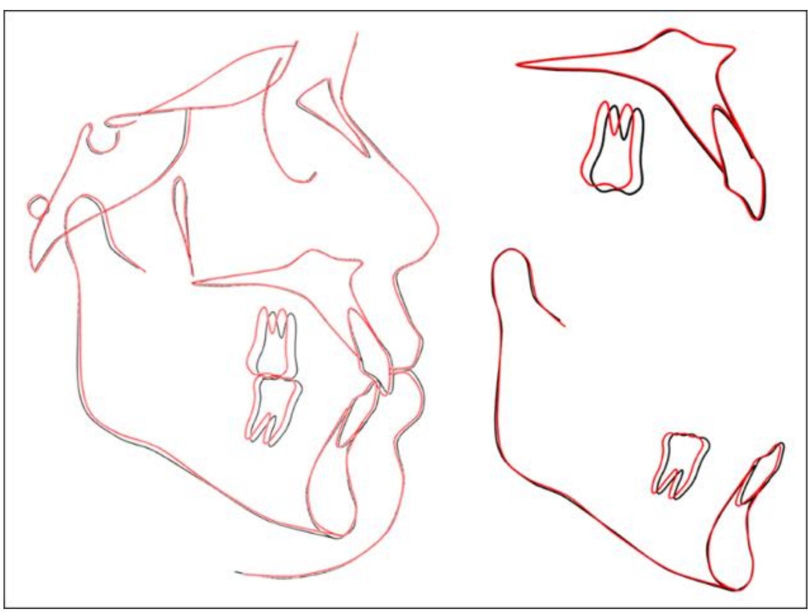

Figure 10 Overall and regional cephalometric superimpositions of Case 1, before (black) and after treatment (red).

Figure 11 Post-retention facial and intraoral photographs of Case 1.

CASE 2

Diagnosis and etiology

A 25-year-old female patient presented to the orthodontic clinic with the request to align her crooked teeth. The patient’s medical and dental history showed nothing that would affect her current situation.

The extraoral assessment indicated a convex profile, mild lip protrusion with acute nasolabial angle, and chin deviation to the right (Figure 12). The examination of the temporomandibular joint revealed no signs or symptoms.

The intraoral assessment revealed Class I canine and molar relationships on both sides. The midline of the mandibular dental arch deviated to the right concerning the facial midline. There was severe crowding in both arches with arch length discrepancies of 10.8 mm and 10.4 mm in the upper and lower arch, respectively. Both maxillary lateral incisors were in crossbite.

Figure 12 Pretreatment facial and intraoral photographs of Case 2.

The lateral cephalometric assessment indicated a Class I relationship of the skeletal base and a mesofacial vertical pattern with ANB of 1.2° and FMA of 23.6° (Table 4). The maxillary and mandibular incisors exhibited labial tipping with U1-NA of 29.5° and L1-NB of 32.5° (Figure 13). The panoramic radiograph showed the presence of all third molars.

Table 4. Cephalometric measurements of Case 2.

	Pretreatment	Posttreatment
Skeletal		
SNA (°)	75.7	75.6
SNB (°)	74.5	74.5
ANB (°)	1.2	1.1
FMA (°)	23.6	23.0
Dental		
U1-SN (°)	105.3	104.4
U1-NA (°)	29.5	28.8
U1-NA (mm)	8.7	4.9
L1-MP (°)	104.1	90.8
L1-NB (°)	32.5	19.0
L1-NB (mm)	7.7	3.5
U1-L1 (°)	116.8	131.1
Soft tissue		
E-line/UL (mm)	-1.7	-3.6
E-line/LL (mm)	-0.4	-3.5

ANB, A point, nasion, B point; FMA, Frankfort mandibular plane angle; L1, lower central incisor; LL, lower lip; MP, mandibular plane; NA, nasion point A; NB, nasion point B; SNA, sella nasion point A; SNB, sella nasion point B; U1, upper central incisor; UL, upper lip.

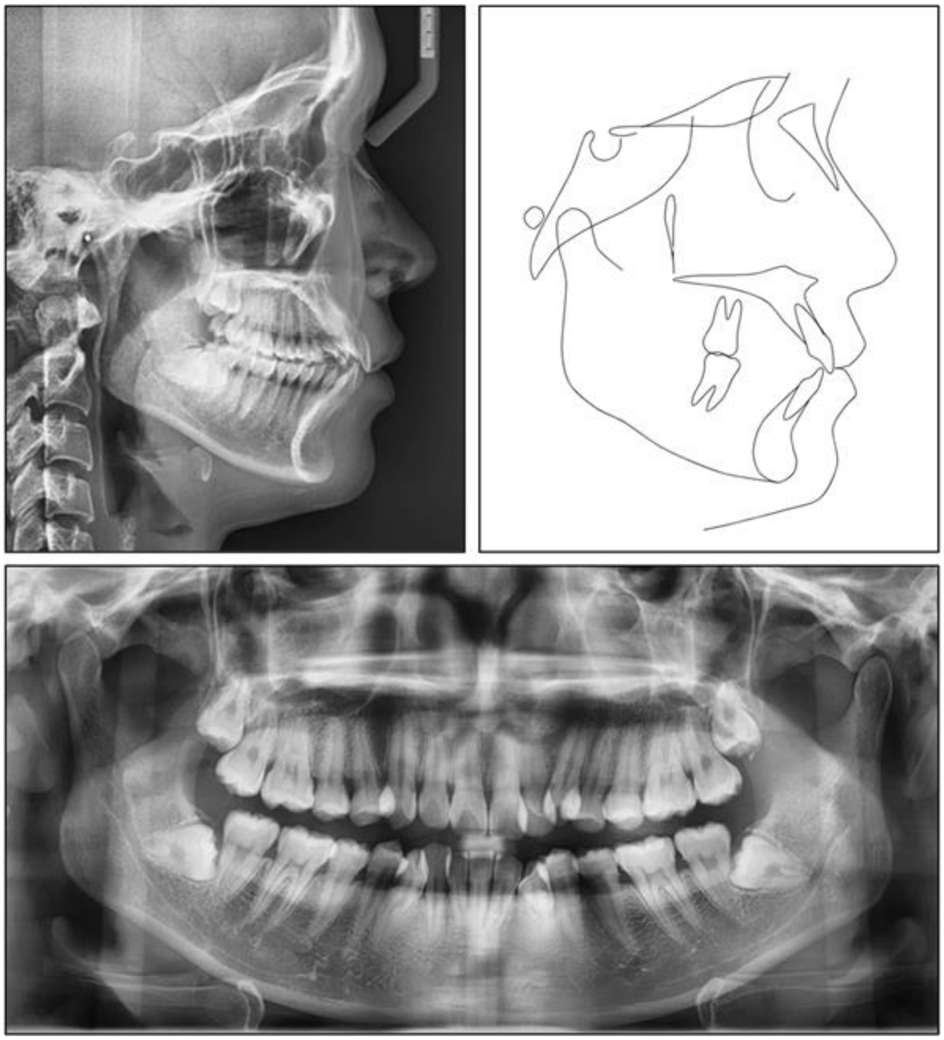

Figure 13 Pretreatment radiographs, and cephalometric tracing of Case 2.

Treatment alternatives

The treatment objectives were to relieve crowding in both arches, maintain Class I dental relationship, and align dental midlines.

The first treatment alternative was to extract maxillary and mandibular first premolars to create spaces for relieving crowding. The second space-creating alternative was a combination of interproximal stripping, molar distalization, and incisor proclination. Because the patient refused tooth reduction and mini-screw insertion, the first treatment alternative was selected.

Treatment progress

The treatment commenced by extracting all first premolars and placing 0.018 x 0.025-inch pre-adjusted lingual brackets on all teeth. With the crowded maxillary left and mandibular canines, brackets were bonded on the distal marginal edges for initial alignment and would be rebonded later. Light power chains (50 g force) were applied from the first molar brackets to the canine brackets for canine distalization. Due to the patient's severe crowding, Class I dental relationship, and well-balanced profile, moderate anchorage was utilized. The teeth were aligned using a series of nickel-titanium arch-wires, including 0.012-inch, 0.016-inch, and 0.016 x 0.022-inch wire. After engaging 0.016 × 0.022-inch stainless steel archwires, the space closure stage was initiated (Figure 14). During the finishing stage, Class II elastics (3/16-inch, 3.5 Oz) were applied on the right to correct the Class II relationship combined with cross elastics to correct the lower dental midline shift. The total active treatment time was 18 months. Fixed retainers were placed in both arches along with removable Essix retainers for nighttime wear.

Figure 14 Space closure with sliding mechanics.

Treatment results

Class I canine and molar relationships were maintained with normal overjet and overbite. The dental crowding and individual crossbite were eliminated. There was a significant improvement in the right-deviated midline of the mandibular dental arch (Figure 15). The panoramic radiographs revealed acceptable root parallelism without root resorption (Figure 16). The cephalometric superimpositions showed that space closure was done with moderate anchorage and good torque control (Figure 17). The one-year post-retention photographs showed the stability of the treatment results (Figure 18).

Figure 15 Post-treatment facial and intraoral photographs of Case 2.

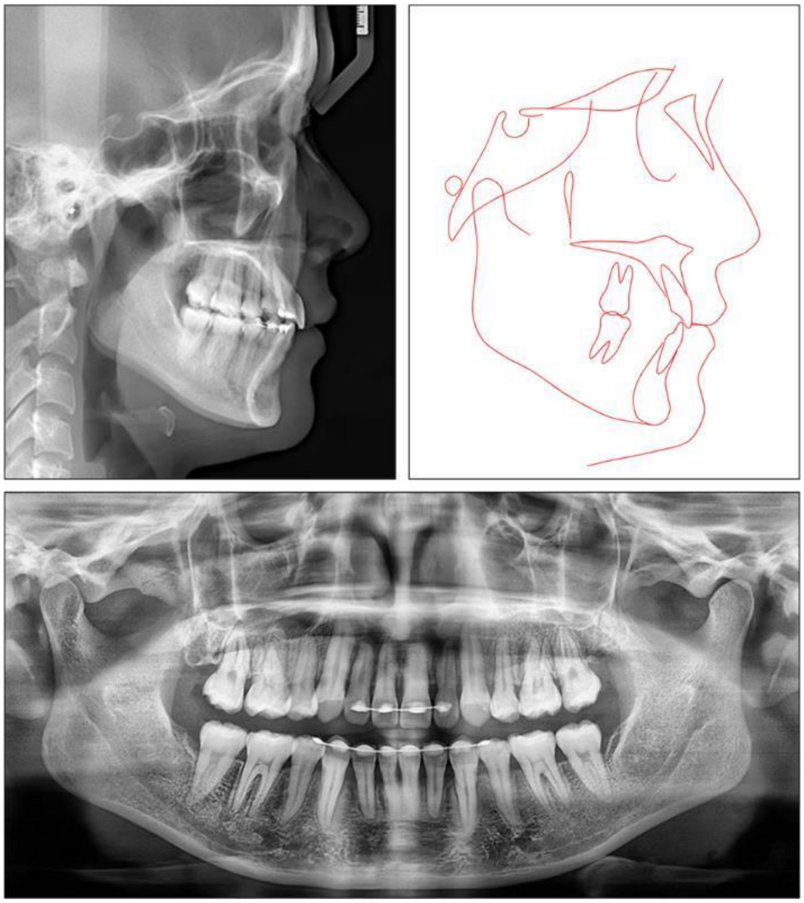

Figure 16 Post-treatment radiographs and cephalometric tracing of Case 2.

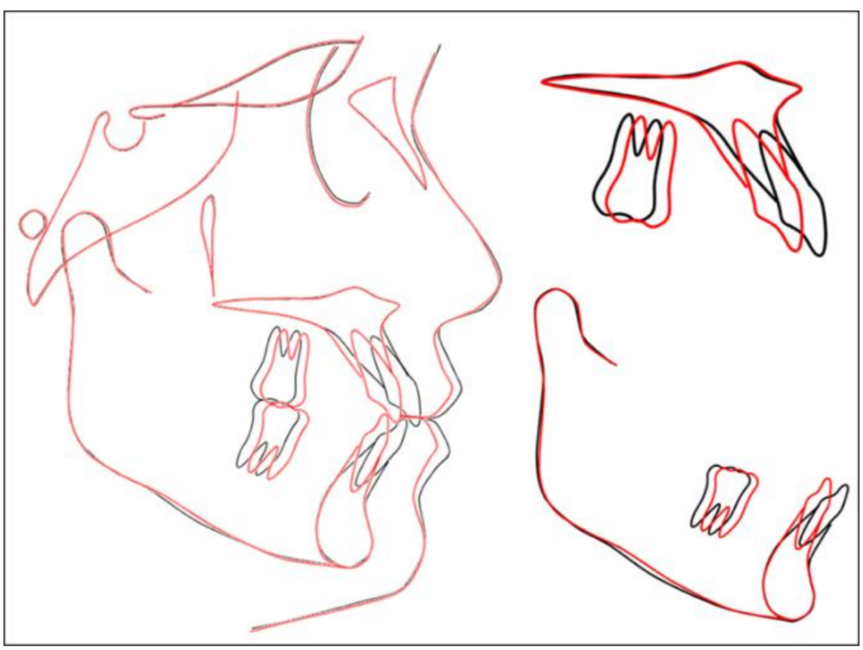

Figure 17 Overall and regional cephalometric superimpositions of Case 2, before (black) and after treatment (red).

Figure 18 Post-retention facial and intraoral photographs of Case 2.

DISCUSSION

One of the most significant obstacles that hinder orthodontists from performing lingual orthodontic treatment is the complexity of indirect bonding procedures. Unlike labial brackets, which are normally bonded directly to labial tooth surfaces, the procedures of lingual bracket indirect bonding consist of many steps in which an ideal orthodontic setup is made for bracket customization [7-9]. The indirect bonding procedures are usually time-consuming, high-costly, and dependent on the experience of orthodontic technicians. Furthermore, errors may occur during transferring brackets from the orthodontic setup to the patient's mouth, which may lead to less-than-ideal tooth alignment in the future [10]. Additionally, tooth overcorrection may be required in the orthodontic setup which is also technique-sensitive, particularly in extraction cases [11-13]. Nevertheless, well-performed indirect bonding procedures will make the treatment seamless and straightforward, as the brackets are positioned according to treatment results. Therefore, indirect bonding is more popular than direct bonding in lingual orthodontics.

However, in an era dominated by lingual bracket indirect bonding, a minority of lingual orthodontists continue to achieve success with the direct bonding technique. Lingual bracket direct bonding offers several advantages over indirect bonding, including cost-effectiveness, reduced laboratory time, easier rebonding of failed brackets, and faster replacement of broken archwires. A revision of the technique is necessary to comprehensively outline the procedures for creating flattened and uniform lingual tooth surfaces, along with the simplified formation of lingual mushroom archwires. Additionally, the lingual bracket prescriptions for direct bonding are provided as a reference for clinicians.

At present, direct bonding of lingual brackets is more well-recognized in cases of simple tooth movement with 2-dimensional brackets where strict torque control is not required [7]. However, the effectiveness of direct bonding has been proved by the inventor of lingual orthodontics and his colleagues, who treated all types of malocclusion including extraction and orthognathic surgery cases with direct bonding [12-14]. The authors have been performing lingual orthodontic treatment by both direct and indirect bonding for many years, and their experience shows that both techniques can provide good treatment results. [15] Additionally, it is more convenient to do direct bonding in severe crowding cases as the malpositioned teeth may impinge on the indirect bracket transfer jigs and the lingual tooth surface may not be adequately exposed for bracket base customization.

In the author' opinion, direct lingual bracket bonding requires more experience than indirect bonding because the bracket positions cannot be measured by a gauge like labial bracket bonding and the operator has to manually tip lingual brackets to create angulations. Before performing direct bonding on patients, orthodontic residents have to thoroughly practice lingual orthodontics on wax typodonts to gain experience in bracket positions and mushroom wire forming. Another disadvantage of direct bonding is the inability to use lingual straight archwires because the tooth size difference cannot be directly compensated in the patient's mouth. Multiple offset bends on mushroom archwires may affect their stiffness and result in inadequate control of tip and torque or the bowing effect [16].

Enamel reduction for bracket position is a potential disadvantage due to its irreversible nature, however, the reduction amount is minimal and carefully controlled and dentin exposure never occurs. In our experience, tooth sensitivity never occurs after flattening the lingual tooth surfaces for direct bonding of lingual brackets. Additionally, in the indirect bonding technique, the reduction of prominent anatomies in the lingual tooth surface is also recommended before taking impressions to reduce the adhesive thickness needed to compensate for the tooth size differences.[3] Furthermore, the prominent marginal edges may also be reduced in the finishing stage to eliminate premature contact even in orthodontic treatment with labial appliances. After bracket removal, the areas of enamel reduction have to be carefully polished and remineralized with topical fluoride.

During the finishing stage, some labial brackets may be bonded to premolars and molars to improve the alignment of labial cusps which is called the crossover technique [17]. Even with the indirect bonding technique and customized lingual appliances, labial brackets may also be needed on posterior teeth when the tooth alignment is not as ideal as the orthodontic setup, maybe because of bracket transfer errors or inadequate expression of bracket prescriptions due to archwire-slot plays [18]. Generally, patients are willing to accept the labial brackets because they were bonded only for a short period and located on posterior teeth that are not too visible. The aesthetic compromising of posterior labial brackets is equivalent to labial attachments in the clear aligner therapy.

CONCLUSION

Direct lingual bracket bonding offers some advantages and disadvantages compared to indirect one. Successful treatment results of two case reports demonstrate the accuracy and effectiveness of the direct lingual bracket bonding approach. Further research is needed to determine whether direct or indirect bonding of lingual brackets has higher effectiveness and efficiency.

CONFLICTING INTEREST STATEMENT

The authors declare no potential conflicts of interest concerning the research, authorship, or publication of this article.

ETHICS STATEMENT

Informed consent was obtained from the patient, and the patient consented to the publishing of all images and clinical data included in the manuscript.

DATA AVAILABILITY

All data generated or analyzed during this study are included in this manuscript.

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This research received no external funding.

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