CASE REPORT

Biomechanics Strategies for Space Closure in Deep Overbite

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ABSTRACT

Space closure is an interesting aspect of orthodontic treatment related to principles of biomechanics. It should be tailored individually based on patient's diagnosis and treatment plan. Understanding the space closure biomechanics basis leads to achieve the desired treatment objective. Overbite deepening and losing posterior anchorage are the two most common unwanted side effects in space closure. Conventionally, correction of overbite must be done before space closure resulted in longer treatment. Application of proper space closure biomechanics strategies is necessary to achieve the desired treatment outcome. This cases report aimed to show the space closure biomechanics strategies that effectively control the overbite as well as posterior anchorage in deep overbite patients without increasing treatment time. Two patients who presented with class II division 1 malocclusion were treated with fixed orthodontic appliance. The primary strategies included extraction space closure on segmented arch that employed two-step space closure, namely single canine retraction simultaneously with incisors intrusion followed by en-masse retraction of four incisors by using differential moment concept. These strategies successfully closed the space, corrected deep overbite and controlled posterior anchorage simultaneously so that the treatment time was shortened. Biomechanics strategies that utilized were effective to achieve the desired treatment outcome

ABSTRAK

Strategi biomekanika penutupan ruang pada tumpang gigit dalam. Penutupan ruang dalam perawatan ortodonti merupakan aspek yang menarik berkenaan dengan prinsip-prinsip biomekanika. Dibatasi khusus secara individu berdasarkan diagnosis dan rencana perawatan. Pemahaman dasar-dasar biomekanika penutupan ruang akan meningkatkan kemampuan operator untuk mencapai tujuan perawatan yang diinginkan. Efek samping yang paling sering terjadi dalam penutupan ruang adalah bertambah dalamnya tumpang gigit dan hilangnya penjangkaran posterior. Umumnya tumpang gigit dikoreksi sebelum penutupan ruang, sehingga waktu perawatan menjadi lebih lama. Untuk mengatasi masalah-masalah tersebut, diperlukan penerapan strategi biomekanika penutupan ruang yang tepat untuk memperoleh hasil perawatan yang sesuai harapan. Tujuan laporan kasus-kasus ini adalah untuk menunjukkan penerapan strategi biomekanika yang efektif untuk mengontrol tumpang gigit dan penjangkaran posterior pada pasien dengan tumpang gigit dalam, tanpa memperpanjang waktu perawatan. Dilaporkan dua kasus maloklusi kelas II divisi 1 yang dilakukan perawatan alat ortodonti cekat. Strategi utama meliputi penutupan ruang pencabutan di lengkung segmental dalam dua tahapan yaitu retraksi kaninus secara individu dengan intrusi insisivus secara simultan, diikuti dengan retraksi empat insisivus dengan menggunakan konsep momen diferensial. Dengan strategi ini, dapat dilakukan penutupan ruang, perbaikan tumpang gigit dalam, dan pengendalian penjangkaran posterior dalam waktu bersamaan, sehingga diperlukan waktu perawatan yang lebih singkat. Strategi biomekanika yang digunakan pada kasus-kasus ini efektif mencapai hasil perawatan yang diharapkan.

Keywords: anchorage, biomechanics, deep overbite, differential moment, intrusion, space closure

INTRODUCTION

During orthodontic treatment, closure of extraction space in deep overbite patients is biomechanically a difficult task. In many extraction cases, space

closure have a tendency to generate detrimental effect particularly deepening the overbite and losing the posterior anchorage. Deep overbite correction is necessary to properly reduce overjet, especially in class II division 1 extraction case. If the correction

of deep overbite is not considered during retraction period, the palatal aspects of the maxilla incisors could interfere with the mandibular incisor, causing lingual tipping, loss of anchorage, and temporomandibular joint dysfunction. In growing individuals, it is imperative to correct deep overbite to allow the mandible to grow and develop normally.¹ In most orthodontic treatment for deep overbite extraction case, correction of overbite must be done before space closure and therefore, treatment time will be longer.²

To control the deep overbite and posterior anchorage, various methods have been proposed. Those methods are ranged from traditional headgear to contemporary TADs (Temporary Anchorage Devices) with their shortcomings such as patient compliance; invasive procedures; and additional treatment cost.¹ The biomechanics strategies that are presented in this cases report will be used to overcome those problems. The purpose of this cases report was to show the space closure biomechanics strategies that effectively control the deep overbite as well as posterior anchorage in deep overbite extraction cases.

CASE OPERATION PROCEDURE 1

Diagnosis and etiology

Patient was an 11 years 3 months old girl with forward position of her front teeth and unable to close the lips when resting as her chief complaint. Past and present medical history was negligible. The conditions of dentition and other intra oral structure were partially erupted lower second molars; adequate periodontal health; amalgam filling on 16 and 26, and no other past dental history. Upon examination, temporomandibular joint revealed normal finding with a normal range of motion and no joint sounds. She had symmetrical mesofacial face and convex facial profile. When resting, incisors display was excessive and lips were strain upon closure. Facial and upper dental midlines were coincided. The patient was in early permanent dentition stage which molar along with canine relationships were 75% class II in both sides. Overjet was 8mm and deep overbite in such case, the incisal edges of lower incisors nearly impinge palatal mucosa. The lower dental midline was shifted 2mm to the right. Moderate crowding could be seen in the upper and lower arches (Figure 1). The pretreatment cephalometric analysis (Table 1) revealed that the patient had a mild class II skeletal pattern with slightly high mandible plane angle. Upper incisors were protruded and proclined. Interincisal and nasolabial angle were acute.

Figure 1. Pretreatment facial and intraoral photographs. Facial photographs showed the view at rest, smile, and lateral profile, respectively. Intraoral photographs showed the condition of occlusion, dentition and other intra oral structure

Table 1. Pretreatment cephalometric measurement

Parameters	Norm	-SD	+SD	Pre-treatment
SNA (degree)	84.6	82.6	86.6	76.0
SNB (degree)	81.0	79.0	83.0	72.0
Facial angle (degree)	86.1	83.4	88.8	81.0
Convexity (mm)	4.80	2.80	6.80	3.00
Mandible Plane (degree)	25.0	20.7	29.3	29.0
Lower Incisors - A Pog (mm)	4.10	2.40	5.80	4.50
Lower Incisors - A Pog (degree)	25.3	19.9	30.7	31.0
Upper Incisors - A Pog (mm)	6.40	4.90	7.90	14.0
Upper Incisors - A Pog (degree)	35.5	31.9	39.1	48.0
Interincisal (degree)	119.6	112.1	127.1	102.0
Nasolabial (degree)	98.5	85.2	111.8	93.0
Lower Lip - E Line (mm)	4.10	3.00	5.20	5.00
Upper Lip - E Line (mm)	3.20	1.60	4.80	4.00

Lower and upper lips were protruded relative to esthetic line. The patient had passed the peak of mandibular growth period. Panoramic radiograph confirmed that there was no pathology existed (Figure 2). This malocclusion was diagnosed as class II division 1. The suspected etiology was probably combination of genetic and environment factors.

Treatment Objective

The treatment objectives were established to relieve upper and lower arches crowding, relieve upper incisors protrusion proclination, achieve adequate overbite and overjet, maintain lower incisor inclination, achieve adequate intercusp relationship, and improve facial esthetic.

Treatment Plan

The treatment plans were determined as follows: (1) Removing upper first premolars; (2) Leveling and aligning upper and lower dental arches; (3) Intruding the upper incisors and simultaneously retracting the canines to class I relationship on three-piece segmented arch; (4) Retracting the previously intruded upper incisors in group A anchorage by using differential moment concept; (5) Coordinating upper and lower arches; (6) Retention to achieve stabilization of the treatment result. The 0.018 slot preadjusted appliance with Roth's prescription (Minisprint, Forestadent, Pforzheim, Germany) and molar bands with auxiliary tube were used.

Figure 2. Pretreatment panoramic radiograph. No pathology condition was found

Figure 3. Canine retraction stage. Upper arch: Three-piece segmented and intrusion arch were used to simultaneously intrude incisors and enhance posterior anchorage during canine retraction. The intrusion arch was tied at the distal wing of the lateral incisor bracket to allow the line of force passes through the incisors center of resistance. Lower arch: Continued leveling and aligning with full sized archwire

Figure 4. Four incisors retraction stage. T- loop was used to retract four incisors on upper arch. The loops which directly engaged to the molar auxiliary tube bypassing the second premolars were preactivated, off-centered and *gable* bent on distal of T- loop to create differential moments effect. In the lower arch full sized stainless steel archwire was used

Treatment Progress

After upper first premolars had been extracted, leveling and aligning were started by using 0.014" and 0.016" martensitic active nickel titanium archwire (Copper Ni-Ti, Ormco, Glendora, Calif) to relieve crowding. When alignment had been achieved in the upper arch, three-piece segmented arch (0.016" x 0.022" stainless steel; Stainless Steel, Ortho Organizer, Carlsbad, Calif) was put on posterior and anterior segment, and then the upper canines were retracted to class I position. Simultaneously, an intrusion arch (0.016" x 0.022" β titanium; CNA Beta III, Ortho Organizer, Carlsbad, Calif) was included to intrude the four incisors and control posterior anchorage by tipping molar distally (Figure 3).

In lower arch, leveling and aligning were continued until full sized (0.016" x 0.022" stainless steel) archwire could be inserted. Once the upper canines had been retracted completely, the anterior segment was retracted by applying differential moment concept. In this step, β titanium continuous archwire (0.016" x 0.022") with preactivated, off-centered position, and *gable* bent T-loop was utilized (Figure 4). When the space had already been closed, the finishing phase would be started. This phase of treatment involved use of coordinated 0.017" x 0.025" β titanium wire. Intermaxillary elastics were used for coinciding the midline and settling the occlusion. Minor bends were placed in these β titanium wires for finishing details. Retention consisted of an upper and lower circumferential retainer.

Treatment Result

Crowding in upper and lower dental arch were relieved. Upper incisors had normal inclination and position. Canine relationship was class I with 100% class II molar relationship on both sides. Intercuspal relationship was settled with adequate overjet and overbite. The upper and lower dental midlines were coincided with the facial midline. The upper and lower arch form were ovoid and symmetric. Facial profile was improved significantly. Lips strain and excessive incisal display were disappearing when resting (Figure 5). Posttreatment cephalometric measurement (Table 2) showed some positive changes when compare to pretreatment measurement. The superimposed cephalograph tracing illustrates the changes associated with treatment and growth (Figure 6).

Overall superimposition showed that there was forward and particularly downward growth for upper and lower jaws. Nose and chin soft tissue also showed growth vector in the same direction. Maxillary superimposition showed upper incisors were retracted in control tipping movement approximately 13 degrees. Maxillary first molars moved forward in translation manner and downward approximately 2 mm and 1.5 mm, respectively. Nose and chin soft tissue also showed growth vector in the same direction.

Figure 5. Posttreatment facial and intraoral photographs. After treatment facial and intraoral photographs showed significantly improvement changes

Figure 6. Overall and regional superimposition. Superimposition of pretreatment (black solid line) and posttreatment (red dash line) cephalograph tracings illustrated the changes associated with treatment and growth

Table 2. Comparison of cephalometric measurement between pre and posttreatment

Parameters	Pre-treatment	Post-treatment
SNA (degree)	76.0	76.0
SNB (degree)	72.0	72.0
Facial angle (degree)	81.0	83.0
Convexity (mm)	3.0	3.0
Mandible Plane (degree)	29.0	32.0
Lower Incisors - A Pog (mm)	4.5	6.0
Lower Incisors - A Pog (degree)	31.0	34.0
Upper Incisors - A Pog (mm)	14.0	8.0
Upper Incisors - A Pog (degree)	48.0	35.0
Interincisal (degree)	102.0	112.0
Nasolabial (degree)	93.0	102.0
Lower Lip - E Line (mm)	5.0	2.0
Upper Lip - E Line (mm)	4.0	0.0

Mandibular molars and lower incisor were seen moved upward 2 mm and 3 mm in that order. Mandibular condyles were grown about 6 mm. Anterior rotation of maxillary and posterior rotation of mandibular were seen. At the end of treatment, panoramic radiograph showed adequate root parallelism and no sign of root resorption.

CASE OPERATION PROCEDURE 2

Diagnosis and Etiology

The patient was a boy, 14 years 6 months old at the time of consultation. His main complaint was forward position of her front teeth. He was in good health and no relevant medical history. The conditions of dentition and other intra oral structure were central upper diastema, healthy periodontal status with an adequate band of attached gingival, all permanent teeth were present except for third molars. He had experienced of upper right central incisor trauma that causing crown fracture. The temporomandibular joints were clinically normal.

The facial photographs showed a symmetrical dolichofacial face, convex facial profile with marked lip protrusion and an everted upper and lower lips. Facial and upper dental midlines were coincided. Molars and canines relationship were 50 % class II on both sides. Overjet was 12.5 mm with an impinging deep overbite. The lower dental midline was shifted to the left 2 mm. Moderate to severe crowding could be seen in lower arch (Figure 7). patient had a mild class II skeletal pattern with the Cephalometric analysis (Table 3) revealed that the slightly high mandible plane angle. Upper incisors were protruded and proclined. Nasolabial angle were acute. Lower and upper lips were protruded relative to E-line. The patient had passed the peak of growth period. Panoramic radiograph confirmed that there was no pathology existed (Figure 8). This patient can also be classified as class II division 1 malocclusion. Persistent sucking habit until the age of eight was suspected as the etiology of his malocclusion.

Treatment Objective

The treatment objectives were established to relieve upper incisors protrusion and proclination, achieve adequate overbite and overjet, relieve lower arch crowding, achieve adequate intercusp relationship, and improve facial esthetics.

Treatment Plan

The treatment were planned as follows: (1) Removing upper and lower first bicusps; (2) Leveling and aligning upper and lower dental arch; (3) Intruding the upper incisors and simultaneously retracting the canines to class I relationship on three-piece segmented arch; (4) Retracting the previously intruded upper incisors in group A anchorage by using differential moment concept; (5) Closing the extraction space on lower arch in group B anchorage; (6) Coordinating upper

Figure 7. Pretreatment facial and intraoral photographs. Photographs before treatment showed the severity of malocclusion with the impact on facial appearance

Figure 8. Pretreatment panoramic radiograph. This radiograph confirmed adequate condition of dentition and periodontal tissue for orthodontic treatment

Table 3. Pretreatment cephalometric measurement

Parameters	Norm	-SD	+SD	Pre-treatment
SNA (degree)	84.6	82.6	86.6	82.5
SNB (degree)	81.0	79.0	83.0	75.0
Facial angle (degree)	87.8	85.2	90.4	86.5
Convexity (mm)	3.8	0.9	6.7	8.5
Mandible Plane (degree)	25.0	20.6	29.4	31.0
Lower Incisors - A Pog (mm)	3.0	0.7	5.3	4.5
Lower Incisors - A Pog (degree)	23.2	19.1	27.3	25.0
Upper Incisors - A Pog (mm)	5.5	3.5	7.5	15.0
Upper Incisors - A Pog (degree)	34.9	30.5	39.3	49.0
Interincisal (degree)	121.9	114.5	129.3	106.5
Nasolabial (degree)	100.6	87.0	114.2	97.0
Lower Lip - E Line (mm)	1.6	-2.1	5.2	9.0
Upper Lip - E Line (mm)	3.0	1.4	4.6	8.0

and lower arches; (7) Retention to achieve stabilization of the treatment result. The Roth's prescription 0.018 slot preadjusted appliance (Minisprint, Forestadent, Pforzheim, Germany) and molar bands with auxiliary tube were used.

Treatment Progress

Extraction of four bicuspid had done before appliance were placed. An initial 0.016" martensitic active nickel titanium archwire (Copper Ni-Ti, Ormco, Glendora, Calif) was placed in the maxillary arch for leveling and

aligning. In the mandibular arch, 0.012" austenitic active nickel titanium archwire (BioStarter, Forestadent, Pforzheim, Germany) was employed to unravel. In the canine retraction stage, for upper arch, three-piece segmented arch (0.016" x .022" stainless steel; Stainless Steel, Ortho Organizer, Carlsbad, Calif) was put on buccal and anterior segment and an intrusion arch (0.016" x 0.022" β titanium; CNA Beta III, Ortho Organizer, Carlsbad, Calif) was included to intrude the four incisors as well as to enhance posterior anchorage (Figure 9). Canine retraction in lower arch was performed to relieve anterior crowding. Once the upper canines had been distalized completely and the class I relationship with lower canines had been achieved, the anterior retraction phase would be started. Differential moment concept was applied in the upper arch as part of space closure strategies to attain group A anchorage.

The remaining space in lower arch was closed by utilizing sliding mechanics on 0.016" x 0.022" stainless steel archwire (Figure 10). After retraction, the coordinated finishing archwires (0.017" x 0.025" β titanium) with detailing bending were used in upper and lower arch. Retention was provided by maxillary and mandibular circumferential retainer.

Treatment Result

Following treatment, the teeth were aligned. A class I molar and canine relationship with coincident midlines, proper interdigitation, adequate overjet and overbite were also obtained. The post-treatment facial photographs showed distinctly improvement of facial esthetics since significant dental protrusion was corrected (Figure 11).

The superimposed cephalometric tracing illustrates the changes achieved with treatment and growth process (Figure 12). Overall superimposition showed that there was slightly downward growth of upper jaw; significantly forward and downward growth of lower jaw. Nose and chin soft tissue also showed growth vector in forward and downward direction. Maxillary superimposition showed that upper and lower incisors were retracted in bodily movement approximately 7 mm and 2 mm, respectively. Maxillary incisors were also intruded about 2 mm.

Posttreatment cephalometric measurement (Table 4) confirmed the changes due to treatment effect as well as remaining growth when compare to pretreatment measurement. Maxillary first molars moved forward and downward approximately 1 mm and 1.5 mm, respectively. Mandibular first molars were seen moved forward and upward approximately 3 mm and 2 mm, respectively. Mandibular condyles were grown about 5 mm. Maxillary rotation were seen in anterior direction and no significantly posterior rotation of mandibular. Prior to debonding panoramic radiograph showed no sign of root resorption. However, minor adjustment of root position was needed.

Figure 9. Canine retraction stage. In upper arch, three-piece segmented arch in conjunction with intrusion arch was used in canine retraction stage. In lower arch, canines were distalized to alleviate anterior crowding

Figure 10. Differential moment concept in incisors retraction stage. This concept was applied in upper arch to retract four incisors for achieving group A anchorage. With this concept, the proper force system is created. Four incisors will be intruded and retracted appropriately. Molars will undergo tip back moment and extrusion force. As the space was closed, the deep overbite was corrected. The remaining space in lower arch was closed by utilizing sliding mechanics

Table 4. Comparison of cephalometric measurement between pre and posttreatment

Parameters	Pre-treatment	Post-treatment
SNA (degree)	82.5	81.0
SNB (degree)	75.0	75.0
Facial angle (degree)	86.5	84.5
Convexity (mm)	8.5	7.0
Mandible Plane (degree)	31.0	32.0
Lower Incisors - A Pog (mm)	4.5	3.5
Lower Incisors - A Pog (degree)	25.0	25.0
Upper Incisors - A Pog (mm)	15.0	8.0
Upper Incisors - A Pog (degree)	49.0	32.0
Interincisal (degree)	106.5	122.0
Nasolabial (degree)	97.0	95.0
Lower Lip - E Line (mm)	9.0	4.0
Upper Lip - E Line (mm)	8.0	4.5

Figure 11. Posttreatment facial and intraoral photographs. Improvement of facial appearance was obviously seen. Adequate occlusal relationship with proper overjet and overbite were evidenced

Figure 12. Overall and regional superimposition between pre-treatment (black solid line) and posttreatment (red dash line) illustrated the changes associated with treatment and growth

DISCUSSION

Space closure is one of the most important steps in orthodontic extraction case. The strategy of space closure should be based on a careful diagnosis and treatment plan made according to the specific needs of the individual.¹ During space closure, controlling the overbite and posterior anchorage are a difficult biomechanical challenge. In extraction deep overbite cases, leveling and alignment of the anterior teeth do not correct the deep overbite, and therefore, it must be corrected to ensure that full space closure is possible.² The deep overbite can also be worsening due to iatrogenic factors during canines or incisors retraction. Canine retraction on light continuous wire will generate extrusive effect on incisors and deepening the bite due to wire deflection which creates by changing the canine inclination.³ Furthermore, during extensive retraction on incisors, aggravation of deep overbite is common because of uprighting of the proclined incisors.⁴ Excessive force overpowers the incisor torque control and deflects the archwire causing distal tipping and bite deepening which is also known as the “roller coaster” effect.⁵

The problem of anchorage control is rooted in Newton's third law of motion, for every action there is an equal and opposite reaction. Thus, the distal forces acting to retract anterior teeth must be opposed by equal forces acting on

the posterior anchorage units in the mesial direction.⁶ It is often desirable to maintain posterior units from any mesial movement, designated as group A anchorage which is at least 75 % of the extraction space needs to be closed by anterior teeth retraction.⁷

Headgear which is used to control anchorage and overbite is a device that has been used in orthodontic for at least a hundred years, unfortunately, the use of headgear depends on patient compliance for success. In recent years, with the introduction of temporary anchorage devices, a paradigm shift has occurred in the overall perspective toward patient compliance, preservation of anchorage and correct of deep overbite.

However, temporary anchorage devices are invasive as well as expensive appliances and have anatomy restriction in their application.^{1,8} One of the cardinal rules in orthodontics is to treat the overbite before the overjet, however, this approach will cause the longer treatment time.⁹ In the light of these problems, it is needed to use the extraordinary strategies in space closure that can correct deep overbite as well as preserve the posterior anchorage. To meet these goals, three-piece segmented arch in conjunction with intrusion arch was used to retract the canine and reduce deep overbite simultaneously so that while the canines were retracted, the deep overbite would be corrected.

The segmented arch diminish the possibility of overbite deepening that causing by canine retraction process. By breaking up the arches into various segments during treatment, we are able to evaluate the tooth movement in all three plane of space and apply proper force application, both in direction and amount.⁹ The intrusion arch not only creates vertical forces but also delivers distal tip back moments on the molars to effectively control the loss of anchorage that often associated with canine retraction. After canine retraction and deep overbite correction, the next stage is to retract four incisors. In this stage, a method that can retract and maintain the previously intruded incisors was required. Differential moment was the method of choice due to force systems that create not only intrusive force but also tip forward moment on four incisors during retraction movement. Tip forward moment (alpha moment) is important to produce control tipping or bodily movement of retracted incisors. In the posterior segment, differential moment concept will produce tip back moments (beta moment) to enhance posterior anchorage and extrusive force to reduce deep overbite.¹⁰

From these two cases treatment result, we can see that the treatment objective were accomplished. Although deep overbite was corrected mainly by extrusive of posterior teeth, fortunately, the remaining vertical growth of the ramus compensated for the extrusive of posterior teeth so that the mandibular did not significant rotate posteriorly.¹¹ Lips protrusion were improved significantly since the proclined upper incisors were retracted successfully with adequate type of movement. In the upper arches, seventy-five percent or more of the extraction space were effectively used for incisors retraction. Both cases do not show any extrusion

movement of retracted incisors. All of these outcomes were due to proper moment to force ratio that generate by applying differential moment concept during incisors retraction. Growing of the nose and soft tissue chin were also contributed for improving soft tissue profile. There were no significant maxillary growth in both patients, however, considerable mandibular growth that partly responsible for overjet and overbite reduction were evidence.

CONCLUSION

Biomechanics strategies that utilized in these cases report were effective to achieve the desired treatment outcome. It is recommended to provide more evidence in the efficacy of this treatment strategies via well controlled clinical studies.

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