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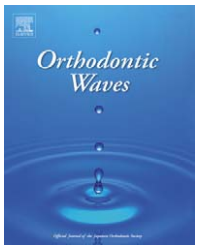

Research paper

Three cases of anterior retraction using a preadjusted edgewise appliance with interrupted orthodontic force generated by a screw device☆

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ABSTRACT

The objectives of the present study were to determine the usefulness of interrupted orthodontic force in anterior retraction and to identify its problems. Subjects were three patients (maxillary protraction, bimaxillary protrusion, and mandibular protrusion). As a multi-bracket appliance, the 0.022 preadjusted edgewise appliance was used. After attaching a 0.019 in. × 0.025 in. stainless steel wire, the screw device was placed. With regard to the screw adjustment, each patient was instructed to turn the screw clockwise 360° every three days. In all three patients, anterior retraction was completed in a period of only three months. Cephalograms showed that the tooth axis of the anterior teeth was tilted lingually. When superimposing curves expressed as quadratic polynomials at initial examination and during retention, marked constriction at the second premolar region, lateral expansion in the molar region were seen for both the maxilla and mandible. Panoramic radiography did not reveal root resorption. No radiographic abnormalities were seen in the periodontal membrane or dental root. Therefore, the screw device appeared to properly control physiological tooth movement and shorten the duration of orthodontic therapy.

1. Introduction

When performing anterior and canine retraction in orthodontic therapy using a preadjusted edgewise appliance, continuous orthodontic force is generated using devices such as NiTi closed-coil springs, power chains, or active tiebacks [1]. For anterior retraction, Dixon et al. [2] reported that NiTi closed-coil springs are most effective with an average duration of four months.

Due to the risk of root resorption, interrupted orthodontic force has been used for lateral expansion of the jaw and dental arch. In recent years, interrupted orthodontic force is being re-examined for its ability to securely control orthodontic force, and it has been used for canine retraction [3–5] and molar distalization [6,7]. According to Graber and Vanarsdall [8], Dwinelle was the first to use interrupted orthodontic force in labial movement of anterior teeth using original Jack screws.

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However, interrupted orthodontic force may induce root resorption, and thus it has not been used to move single teeth for long periods of time [9].

McLaughlin et al. [10] used a screw appliance for closing slight unilateral residual space in one adult patient at the final stage of orthodontic therapy, but to the best of our knowledge, no reports have described interrupted orthodontic force being used in maxillary anterior retraction. The objective of the present study was to clarify the usefulness of interrupted orthodontic force in anterior retraction in three patients and to identify its problems.

2. Appliance structure and adjustment

Interrupted orthodontic force was generated using the screw device (Hycon Device™, Adenta GmbH, Germany, Fig. 1A and B). The screw device was placed in the oral cavity by inserting a support wire into the auxiliary tube of the molar band to bend the appliance in the gingival direction (Fig. 1C and D). In order to transmit orthodontic force, a ligature wire was tied to connect the hook attached at the anterior region of the main wire and the ligature-tying ring of the screw region. Orthodontic force was generated by turning the screw using the attached flathead screwdriver. The amount of tooth movement achieved with a single adjustment is 0.35 mm.

3. Anterior retraction protocol

As a multi-bracket appliance, the 0.022 MBT set-up preadjusted edgewise appliance (MBT set-up) was used. Anterior retraction was carried out after attaching the main arch wire (0.019 in. × 0.025 in. stainless steel wire). After ligating the anchors (first and second molars) using a ligature wire, the screw device was placed. The patients were told to turn the screw clockwise 360° every three days. The patients were instructed to stop adjustment if they experienced pain.

4. Cases

4.1. *Case 1. Angle II case due to mandibular hypoplasia*

This female patient was 19 years and 8 months of age. From the frontal view, her face was symmetrical, and from the lateral view, her profile was of the convex type (Fig. 2). The overjet was +8.4 mm, the overbite was +5.6 mm, and the left and right molar occlusion was Angle Class II (Fig. 3). The arch length discrepancies for the maxilla and mandible were −8.9 and −10.6 mm, respectively. On lateral cephalograms, mandibular hypoplasia (SNA 82.4°, SNB 73.6°, and AMB 8.8°) and lingual tilting of the upper incisors (U1–FH 106.1° and U1–SN 94.8°) were confirmed (Table 1). Panoramic radiographs (Fig. 4) taken at the initial examination showed Grade I root resorption of the maxillary left central incisor, mandibular left canine, mandibular right central incisor, and mandibular right canine (Table 2).

4.1.1. *Treatment*

After maxillary canine retraction, the screw device was placed to initiate maxillary anterior retraction. To reinforce anchorage, a removable palatal arch was used, but the arch was removed one week after the start of anterior retraction because it caused marked discomfort. Maxillary anterior retraction was completed in three months, and retention began thereafter.

4.1.2. *Outcomes*

When comparing lateral cephalograms taken before anterior retraction and during retention, the SNA decreased by 3.1° to

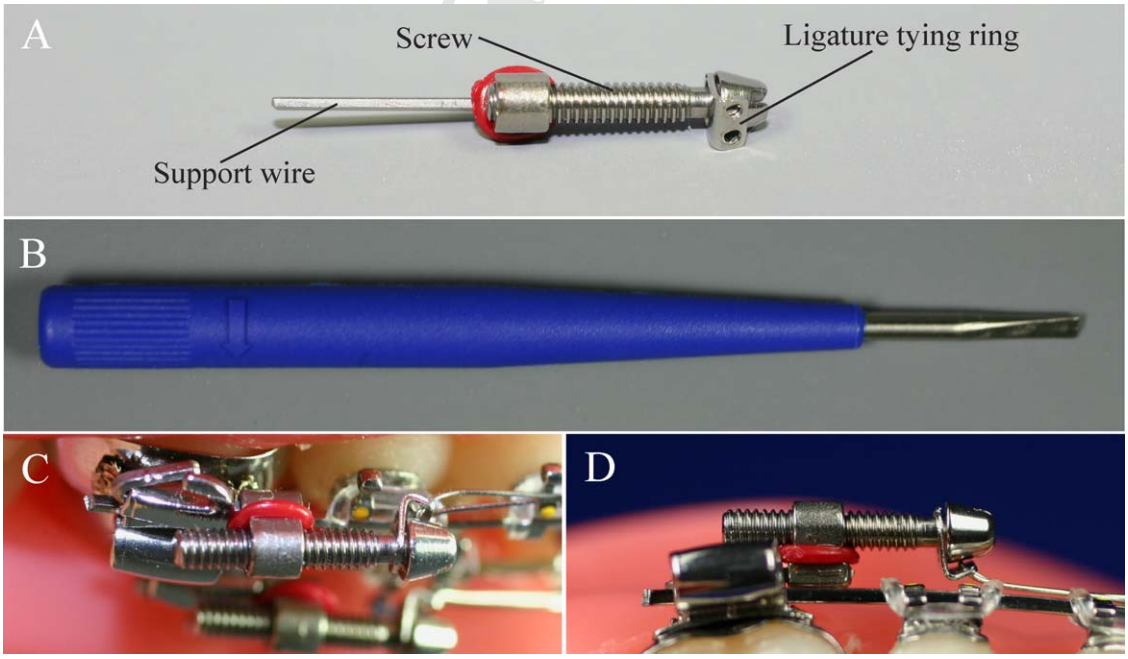

Fig. 1 – Screw device and other devices in oral cavity. (A) Screw device; (B) adjustment driver; (C) upper view; (D) occlusal surface.

Fig. 2 – Facial photographs (Case 1). T0: initial examination; T3: during retention.

79.0°. Although U1-to-FH before anterior retraction was 109.1°, this figure decreased during retraction by 9.7° to 99.4°, thus confirming lingual tilting (Fig. 5). With regard to the amount of tooth movement, U1y and U1x decreased by 2.0 and 3.0 mm, respectively, thus revealing that the maxillary anterior teeth retracted with depression. The degree of change in U6x (the maxillary first molar where the screw device was attached) was −0.5 mm, and thus there was very little anchorage loss.

With regard to changes in dental arch configuration, in the maxilla, the inter-canine width increased by 1.9 mm between initial examination and retention (Table 3). The inter-second premolar width markedly decreased by 1.6 mm, while the inter-second molar width increased by 2.4 mm. In the mandible, the inter-canine width markedly increased by 4.8 mm and the inter-second premolar width increased by 1.4 mm. Only the distance between the canine and anterior teeth for the maxilla increased, while other parameters decreased for both the maxilla and mandible. Between initial examination and during retention (Fig. 6), marked constriction was seen in the second premolar region in the maxillary dental arch. In addition, the dental arch expanded laterally in the molar region with the second premolar region acting as a fulcrum.

Table 1 – Assessment of cephalograms

Measurement	Mean		Case 1				Case 2				Case 3			
	Male	Female	T0	T1	T3	T3–T1	T0	T1	T3	T3–T1	T0	T1	T3	T3–T1
SNA (°)	83.4	83.2	82.4	82.1	79.0	−3.1	90.0	90.0	90.0	0.0	77.3	77.2	77.2	0.0
SNB (°)	80.0	80.4	73.6	73.2	72.1	−1.1	88.0	88.0	88.0	0.0	79.1	79.0	79.0	0.0
ANB (°)	3.4	2.8	8.8	8.9	6.9	−2.0	2.0	2.0	2.0	0.0	−1.8	−1.8	−1.8	0.0
Occl. P.A. (°)	8.4	8.6	13.5	14.2	18.4	4.2	6.3	6.3	6.2	−0.1	12.3	7.8	8.1	0.3
Mand. P.A. (°)	24.8	26.4	32.1	32.3	33.7	1.4	24.0	23.7	23.6	−0.1	27.6	27.9	26.4	−1.5
U1-to-FH (°)	110.8	115.2	106.1	109.1	99.4	−9.7	129.6	128.2	117.1	−11.1	105.4	128.0	117.2	−10.8
U1-to-SN (°)	103.7	103.4	94.8	97.6	88.0	−9.6	126.4	124.9	105.1	−19.8	101.5	118.1	107.6	−10.5
L1-to-mand. (°)	97.1	98.2	98.3	97.3	101.8	4.5	106.1	104.4	93.8	−10.6	86.3	89.2	80.2	−9.0
Overbite (mm)	3.2	3.5	5.6	4.2	2.2	−2.0	2.5	2.0	2.5	0.5	4.2	3.4	2.0	−1.4
Overjet (mm)	3.3	3.3	8.4	6.0	2.2	−3.8	3.3	3.0	3.3	0.3	−2.5	4.7	3.8	−0.9
U6y (mm)	–	–	44.0	45.8	44.0	−1.8	55.0	55.0	56.2	1.2	51.0	54.0	55.2	1.2
U1y (mm)	–	–	51.0	51.0	49.0	−2.0	52.0	52.0	53.5	1.5	52.5	54.2	52.2	−2.0
L6y (mm)	–	–	50.0	53.0	51.3	−1.7	62.0	62.0	63.8	1.8	59.0	62.0	63.1	1.1
L1y (mm)	–	–	61.5	62.0	62.8	0.8	69.0	70.9	70.0	−0.9	71.0	72.0	73.0	1.0
U6x (mm)	–	–	16.0	21.5	21.0	−0.5	39.0	39.0	40.2	1.2	16.0	15.5	23.0	7.5
U1x (mm)	–	–	51.0	49.0	46.0	−3.0	70.5	68.9	66.0	−2.9	45.0	50.0	48.0	−2.0
L6x (mm)	–	–	13.5	20.0	19.5	−0.5	41.0	40.5	41.0	0.5	17.5	17.0	23.8	6.8
L1x (mm)	–	–	40.2	41.9	38.4	−3.5	68.2	67.0	63.0	−4.0	47.5	48.0	47.0	−1.0

Standard: Iizuka, T0: initial examination, T1: before anterior retraction, T3: during retention. The vertical and horizontal tooth movements were assessed by methods of Byloff and Darendeliler [11].

Fig. 3 – Intraoral photographs (Case 1). T0: initial examination; T1: before maxillary anterior retraction; T2: after maxillary anterior retraction; T3: during retention.

No changes were seen in any dental roots when comparing before anterior retraction and retention.

4.2. *Case 2. Bimaxillary protrusion due to labial tilting of the maxillary and mandibular anterior teeth*

This male patient was 24 years of age. From the frontal view, his face was symmetrical, and from the lateral view, his profile was of the convex type (Fig. 7).

The overjet was +3.3 mm, the overbite was +2.5 mm, and the left and right molar occlusion was Angle Class I (Fig. 8). The arch length discrepancies for the maxilla and mandible were −7.5 and −7.2 mm, respectively. Lateral cephalograms showed: no abnormality in the positional relationship between the maxilla and mandible (SNA 90.0°, SNB 88.0°, and ANB 2.0°); labial tilting of the maxillary anterior teeth (U1–FH 129.6° and U1–SN 126.4°); and labial tilting of the mandibular anterior teeth (L1-to-Mand. 106.1°). Panoramic radiographs showed Grade 0 root resorption for the anterior teeth and canine at initial examination (Fig. 9).

4.2.1. *Treatment*

Using the screw device, maxillary and mandibular anterior retraction and canine retraction were performed. The maxillary anterior retraction took three months.

4.2.2. *Outcomes*

When comparing lateral cephalograms taken before anterior retraction and during retention, there were no marked changes in the skeletal system. Before anterior retraction, U1–FH was 128.2° and L1-to-Mand. was 104.4°, but during retention, U1–FH decreased by 11.1° to 117.1° and L1-to-Mand. decreased by 10.6° to 93.8°, thus confirming lingual tilting (Fig. 10). In terms of tooth movement, in the maxilla, U1y increased by 1.5 mm, while U1x decreased by 2.9 mm. In the mandible, L1y decreased by 0.9 mm and L1x decreased by 4.0 mm. These findings suggest that

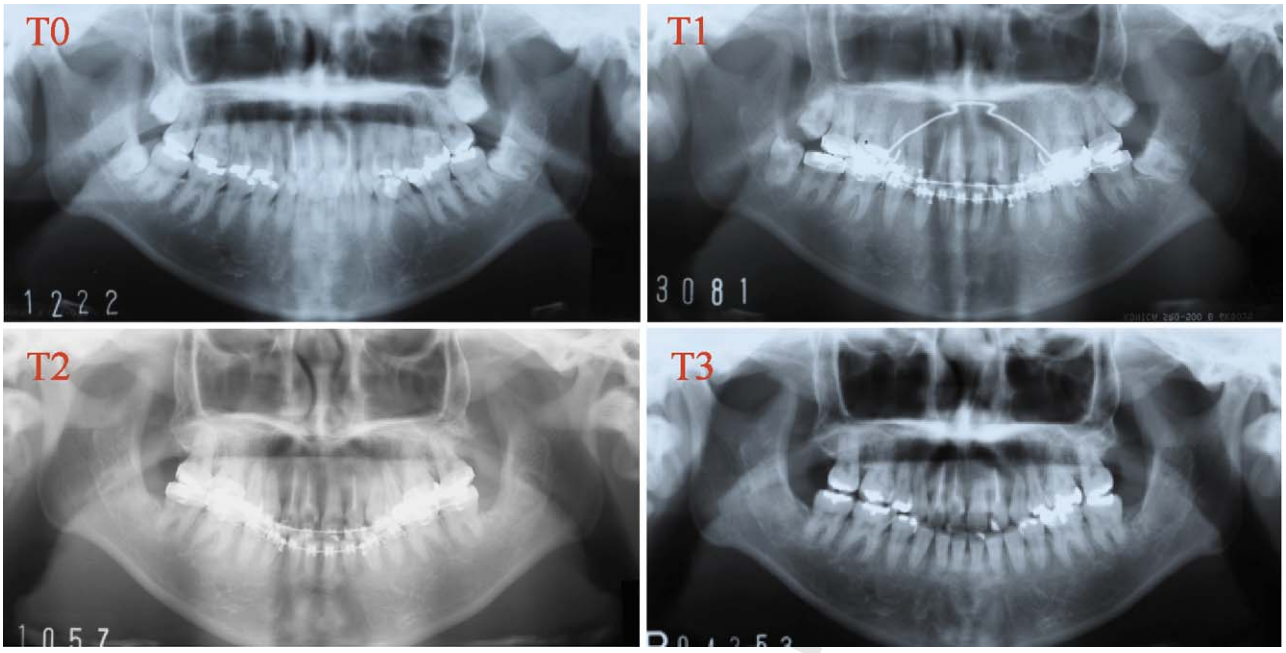

Fig. 4 – Panoramic radiographs (Case 1). T0: initial examination; T1: before maxillary anterior retraction; T2: after maxillary anterior retraction; T3: during retention.

anterior retraction was achieved in both the maxilla and the mandible. With the maxillary first molar, U6y increased by 1.2 mm and U6x increased by 1.2 mm. With the mandibular first molar, L6y increased by 1.8 mm and L6x increased by 0.5 mm. For both the maxilla and the mandible, there was very little anchorage loss.

With regard to the changes in dental arch configuration, in the maxilla, the inter-canine width for the maxilla decreased

Table 2 – Assessment of root resorption

Measurement	Case 1			Case 2			Case 3		
	T0	T1	T3	T0	T1	T3	T0	T1	T3
11	0	0	0	0	–	0	0	0	0
12	0	0	0	0	–	0	0	0	0
13	0	0	0	0	–	1	0	0	0
15	0	0	0	0	–	0	0	0	0
16	0	0	0	0	–	0	0	0	0
17	0	0	0	0	–	0	–	0	0
21	1	2	2	0	–	0	0	0	0
22	0	1	1	0	–	0	0	0	0
23	0	0	0	0	–	0	0	0	0
25	0	0	0	0	–	0	0	0	0
26	0	0	0	0	–	0	0	0	0
27	0	0	0	0	–	0	–	0	0
31	0	1	1	0	–	0	0	0	0
32	0	1	1	0	–	0	0	0	0
33	1	2	2	0	–	1	0	0	0
35	0	0	0	0	–	0	0	0	0
36	0	0	0	0	–	0	0	0	0
37	0	0	0	0	–	0	–	0	0
41	1	2	2	0	–	0	0	0	0
42	0	1	1	0	–	0	0	0	0
43	1	2	2	0	–	1	0	1	1
45	0	0	0	0	–	0	0	0	0
46	0	0	0	0	–	0	0	0	0
47	0	0	0	0	–	0	–	0	0

T0: initial examination, T1: before anterior retraction, T3: during retention. Root resorption was assessed by examining panoramic radiographs according to the Malmgren system [12].

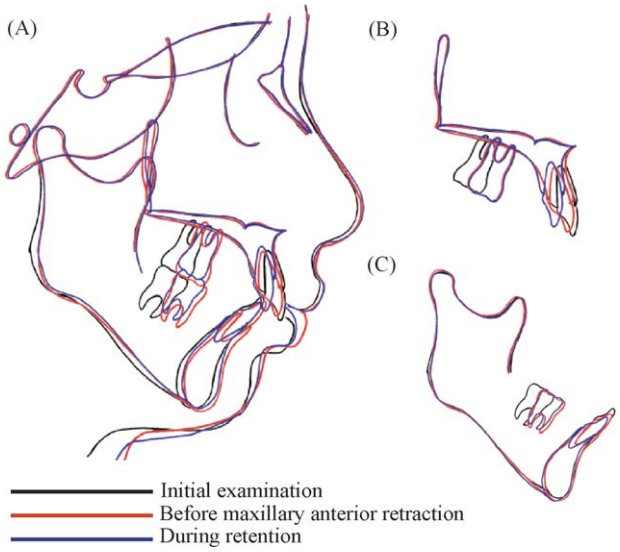

Fig. 5 – Cephalometric superimposition (Case 1). (A) S-N, S; (B) palatal plane, ANS; (C) mandibular plane, Me.

by 0.7 mm, while that for the mandible increased by 1.3 mm. The inter-second premolar width for the maxilla and mandible decreased markedly by 7.3 and 8.0 mm, respectively. The inter-first molar width for the maxilla and mandible decreased by 2.4 and 3.8 mm, respectively. In addition, the inter-second molar width for the maxilla and mandible decreased by 0.4 and 1.0 mm, respectively.

A panoramic radiograph was not taken before anterior retraction because the leveling period was short at four months. When comparing panoramic radiographs taken at the initial examination and during retention, the grade of root resorption changed from 0 to 1 for the mandibular left and right canines. Root resorption was not seen for the anchor teeth (molars).

4.3. *Case 3. Diagnosis: anterior overbite due to protrusive mandible*

This female patient was 11 years and 7 months of age. From the frontal view, her face was symmetrical, and from the lateral view, her profile was of the concave type (Fig. 11). The overjet was −2.5 mm, the overbite was +4.2 mm, and the left and right molar occlusion was Angle Class III (Fig. 12). Arch length discrepancy for the maxilla and mandible was −10.6 and −11.2 mm, respectively. Lateral cephalograms showed anterior protrusion of the mandible (SNA 77.3°, SNB 79.1°, and ANB −1.8°); labial tilting of the maxillary anterior teeth (U1–FH 105.4°, and U1–SN 101.5°); and lingual tilting of the mandibular anterior teeth (L1-to-Mand. 86.3°). Panoramic radiographs (Fig. 13) taken at initial examination showed Grade 0 root resorption for all anterior teeth and canines.

4.3.1. *Treatment*

After improving the anterior overbite, the maxillary and mandibular first premolars were extracted, and a 0.019 in. × 0.025 in. stainless steel wire was placed. After placing the screw device, maxillary and mandibular anterior retraction and canine retraction were initiated. Maxillary anterior retraction took three months to complete.

4.3.2. *Outcomes*

When comparing lateral cephalograms taken before anterior retraction and during retention, there were no horizontal

Table 3 – Assessment of dental arch configuration

Measurement (mm)	Case 1			Case 2			Case 3		
	T0	T3	T3–T0	T0	T3	T3–T0	T0	T3	T3–T0
Maxillary width									
3–3	38.0	39.9	1.9	44.2	43.5	−0.7	44.9	41.6	−3.3
5–5	50.0	48.4	−1.6	60.3	52.9	−7.3	55.5	51.2	−4.2
6–6	57.7	57.0	−0.7	64.9	62.5	−2.4	62.9	60.4	−2.6
7–7	62.2	64.6	2.4	72.2	71.8	−0.4	–	69.4	–
Maxillary length									
3–3	6.2	7.8	1.6	7.2	8.4	1.2	3.2	8.7	5.5
5–5	21.7	14.5	−7.2	24.1	16.6	−7.4	18.8	17.4	−1.4
6–6	29.8	23.6	−6.2	33.5	26.2	−7.3	27.7	26.5	−1.2
7–7	40.8	33.5	−7.3	43.5	36.3	−7.3	–	36.2	–
Mandibular width									
3–3	27.4	32.3	4.8	33.8	35.1	1.3	34.4	34.3	−0.1
5–5	40.3	41.6	1.4	53.3	45.2	−8.0	48.9	43.6	−5.3
6–6	51.2	50.2	−1.1	59.6	55.8	−3.8	55.6	52.2	−3.3
7–7	59.2	59.6	0.4	67.1	66.2	−1.0	–	62.6	–
Mandibular length									
3–3	4.5	4.0	−0.5	3.1	4.2	1.1	5.2	3.5	−1.7
5–5	18.3	10.8	−7.5	18.7	11.4	−7.3	19.1	11.3	−7.8
6–6	23.6	18.4	−5.2	27.0	20.2	−6.8	28.1	19.2	−8.9
7–7	35.2	30.4	−4.8	37.8	31.2	−6.7	–	30.9	–

T0: initial examination; T3: during retention. The width and length of the dental arch from initial examination to retention were assessed by analyzing the FA points of paralleling models using a three-dimensional coordinate measuring system [13,14].

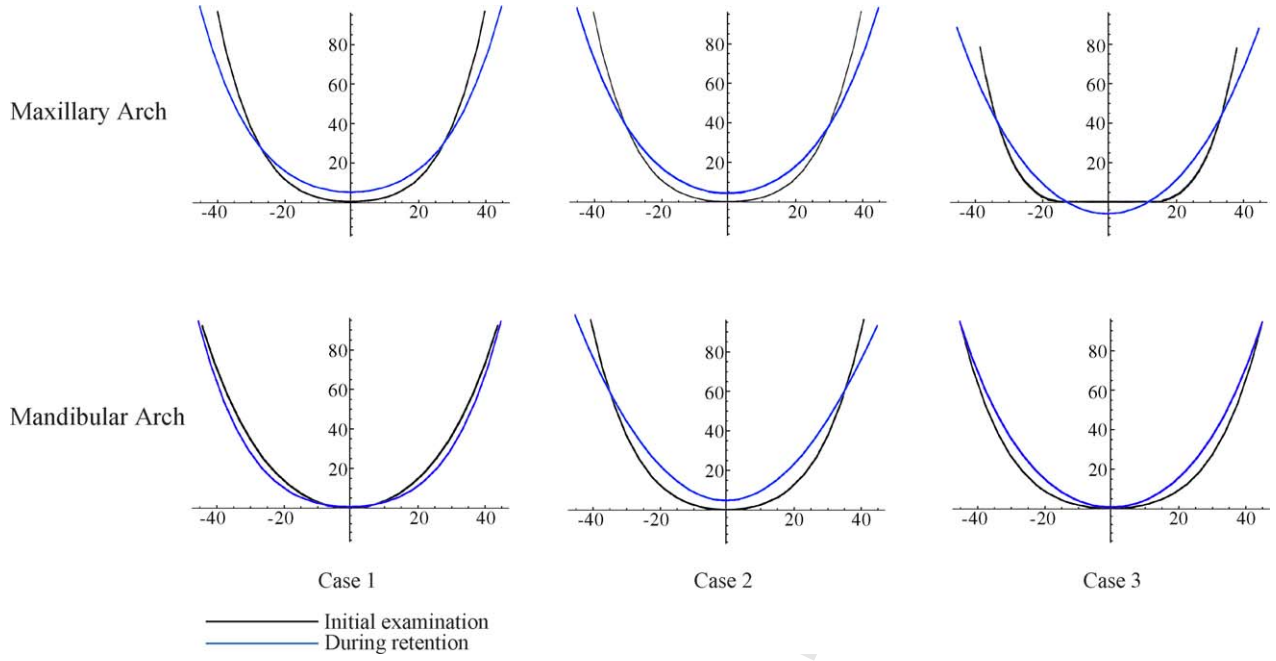

Fig. 6 – Dental arch configuration superimposition. According to Otani's methods [13], the quadratic polynomial expression of the maxilla and mandible was determined at initial examination and during retention. The coordinates were transformed such that the origin of quadratic polynomial expressions was at the midpoint of the line segment connecting the midpoint of the incisal edge of the left and right central incisors.
Quadratic polynomial expressions were superimposed as follows: Based on the amount of anterior retraction between initial examination and during retention as calculated from cephalograms, the origin of the quadratic polynomial expression at the initial examination was moved along the Y-axis in order to set the quadratic polynomial expression during retention.

changes in the maxilla and mandible. Before anterior retraction, U1–FH and L1-to-Mand. were 128.0° and 89.2°, respectively. During retention, U1–FH decreased by 10.8° to 117.2° and L1-to-Mand. decreased by 9.0° to 80.2° (Fig. 14). With regard to the degree of tooth movement, in the maxilla, U1y and U1x decreased by 0.2 and 2.0 mm, respectively, and in the mandible, L1y increased by 1.0 mm and L1x decreased by 1.0 mm. The degree of anterior retraction was minimal for both the maxilla and mandible. In the maxillary first molar, U6y and U6x increased by 1.2 and 7.5 mm, respectively. In the

Fig. 7 – Facial photographs (Case 2). T0: initial examination; T3: during retention.

Fig. 8 – Intraoral photographs (Case 2). T0: initial examination; T1: before maxillary and mandibular anterior retraction including canine retraction; T2: after maxillary and mandibular anterior retraction including canine retraction; T3: during retention.

mandibular first molar, L6y and L6x increased by 1.1 and 6.8 mm, respectively. The degree of mesial movement for the molars was substantial for both the maxilla and mandible.

With regard to changes in dental arch configuration during retention, the inter-canine width for the maxilla and mandible decreased by 3.3 and 0.1 mm, respectively. The inter-second premolar width for the maxilla and mandible decreased markedly by 4.2 and 5.3 mm, respectively. The inter-first molar width for the maxilla and mandible decreased by 2.6 and 3.3 mm, respectively. With regard to the dental arch length, only the distance between the maxillary canine to anterior tooth increased, while the other parameters decreased. When compared with initial examination, there was marked constriction of the second premolar region during retention for both the maxilla and mandible. In addition, the dental arch expanded laterally in the molar region with the second premolar region acting as a fulcrum.

When comparing panoramic radiographs taken before anterior retraction and during retention, the grade of root resorption changed from 0 to 1 for the mandibular right canine. Root resorption was not seen in the anchor teeth (molars).

5. Discussion

5.1. *Interrupted orthodontic force*

With regard to canine retraction, Lee et al. [4] compared the rate of tooth movement between 10 patients with continuous orthodontic force using the NiTi extension coil spring and 10 patients with interrupted orthodontic force using a screw appliance. They reported that the rate of tooth movement was faster with interrupted orthodontic force. In the present study,

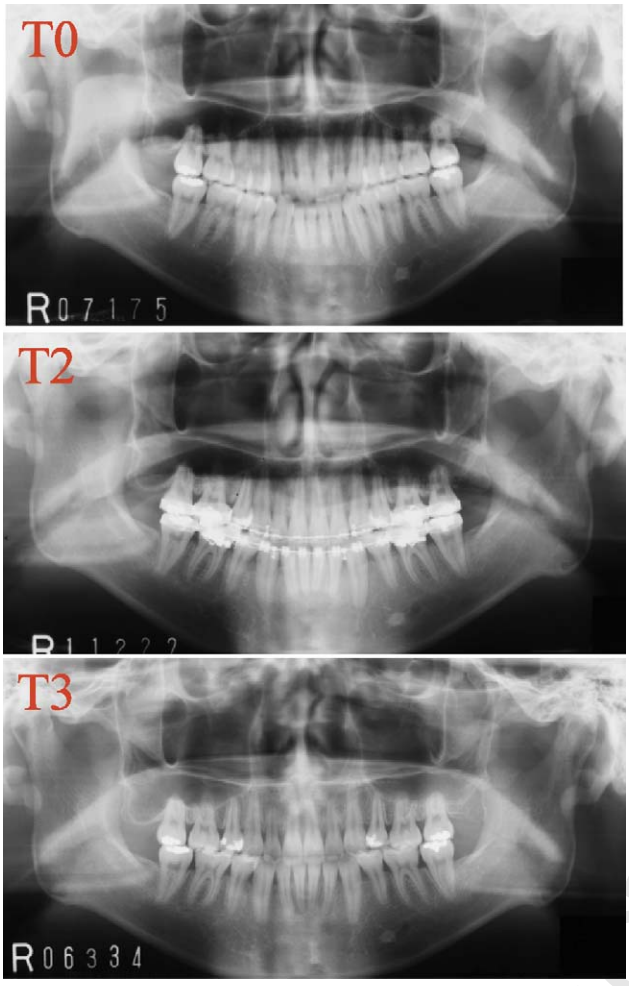

Fig. 9 – Panoramic radiographs (Case 2). T0: initial examination; T2: after maxillary and mandibular anterior retraction including canine retraction; T3: during retention.

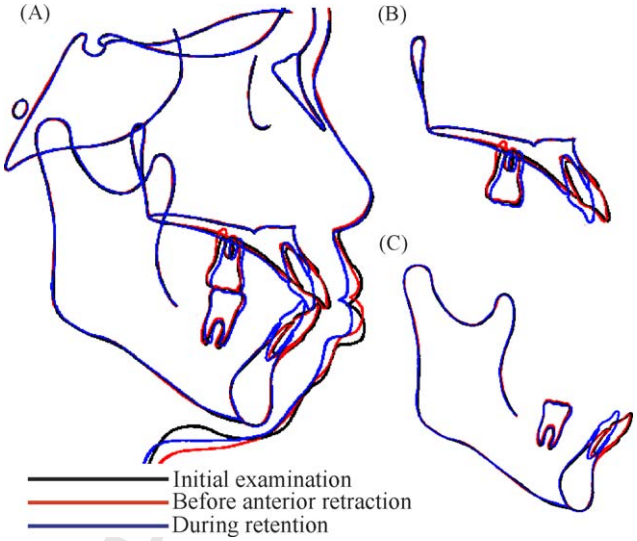

Fig. 10 – Cephalometric superimposition (Case 2). (A) S-N, S; (B) palatal plane, ANS; (C) mandibular plane, Me.

when interrupted orthodontic force was used for anterior retraction, the therapy was completed in only three months in all three patients.

As was the case with Liou and Huang [3], no periodontal membrane defects or dental pulp necrosis were observed. Lee et al. [4] monitored changes in the levels of PGE2, in gingival crevicular fluid for three weeks while applying either continuous or interrupted orthodontic force. When continuous orthodontic force was applied, PGE2 levels increased for up to 24 h and remained low for three weeks. But when interrupted orthodontic force was applied, PGE2 levels remained high for 24 h after adjustment, and similar changes continued periodically for three weeks. In terms of the

Fig. 11 – Facial photographs (Case 3). T0: initial examination; T3: during retention.

Fig. 12 – Intraoral photographs (Case 3). T0: initial examination; T1: before maxillary and mandibular anterior retraction including canine retraction; T2: after maxillary and mandibular anterior retraction including canine retraction; T3: during retention.

attenuation cycle, continuous orthodontic force continues to work until the next visit [15]. On the other hand, with interrupted orthodontic force, because adjustments are made at a specified interval, there are cyclic active and rest stages before the next visit. This periodicity of active and rest stages ensures that the remodeling process of periodontal support tissue is more physiological, thus facilitating tooth movement. Therefore, with interrupted orthodontic force, maxillary and mandibular anterior retraction can be performed efficiently, and the duration of total therapy can be reduced.

5.2. *Anterior tooth changes*

The degree of movement of anterior teeth was assessed based on changes in U1x on cephalograms. In Case 1, the degree of movement of the maxillary anterior teeth was −3.0 mm. In Case 2, the degree of movement of the maxillary and mandibular anterior teeth was −2.9 and −4.0 mm, respectively. In Case 3, the degree of movement of the maxillary and mandibular anterior teeth was −2.0 and −1.0 mm, respectively. Anterior retraction was achieved in a short period of time (three months) in these three patients.

Anterior retraction is the final stage of therapy, and during this stage, it is important to maintain the inclination of tooth axis. In the present patients, orthodontic therapy was performed with the 0.022 slot MBT brackets. With the MBT system, the amount of torque for the maxillary central and lateral incisors is set at +17° and +10°, respectively. In order to minimize the frictional resistance between the wire and bracket slot (which hinders sliding mechanics), a 0.019 in. × 0.025 in. stainless steel wire was used as a retraction wire to allow a 10° freedom between the wire and bracket slot. Therefore, in the present patients, labial crown torque was added to the main arch wire to suppress lingual tilting during anterior retraction. However, in terms of the degree of change in tooth axis for the anterior teeth during retention, U1–FH decreased by 9.7° in Case 1; U1–FH and L1-to-mand. decreased by 11.1° and 10.6°, respectively, in Case 2; and U1–FH

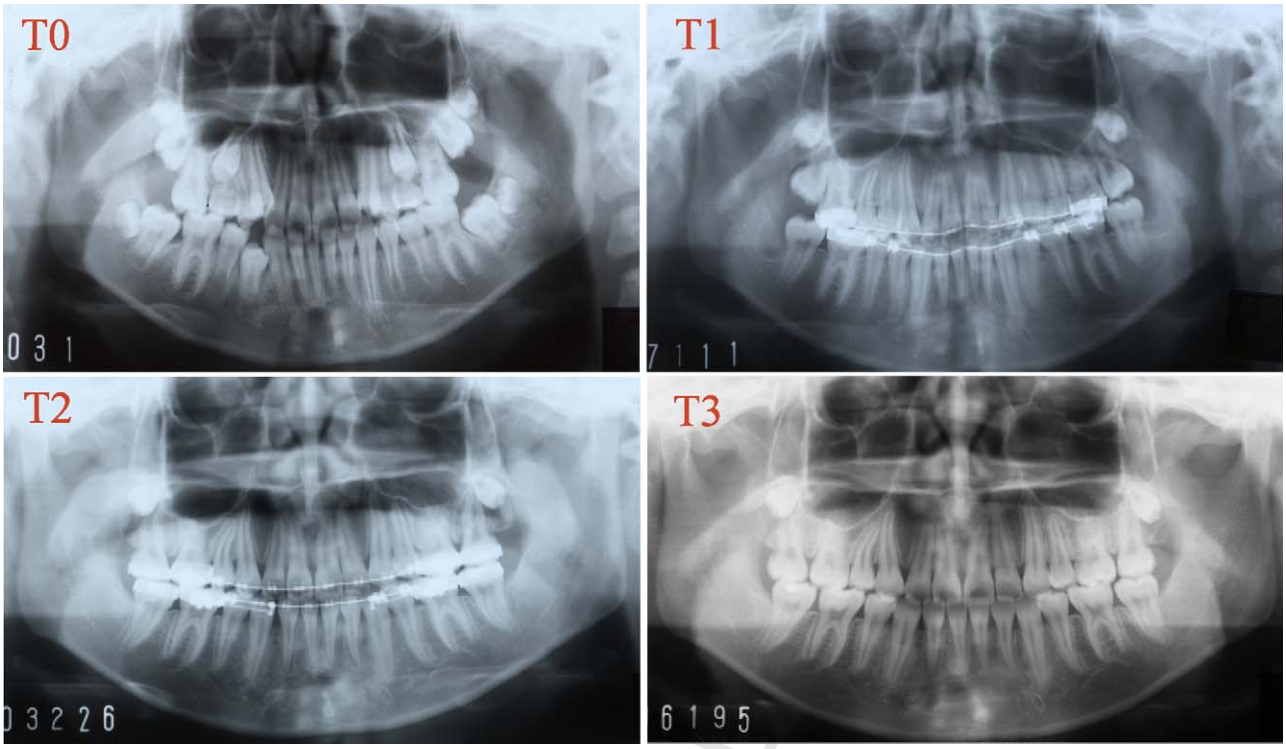

Fig. 13 – Panoramic radiographs (Case 3). T0: initial examination; T1: before maxillary and mandibular anterior retraction including canine retraction; T2: after maxillary and mandibular anterior retraction including canine retraction; T3: during retention.

and L1-to-mand. decreased by 10.8° and 9.0°, respectively, in Case 3. In all cases, lingual tilting was seen. There was no time for labial crown torque, which was added to the bracket and main arch wire, to work due to the high load. As a counter-measure for this problem, it may be possible to increase the amount of labial crown torque. Goldin [16] compared natural growth and labial root torque added to a multi-bracket appliance in 17 patients, and reported an annual root resorption of 12.7%. Because excessive labial crown torque may induce root resorption [17], it is necessary to consider reducing screw rotation using the screw device.

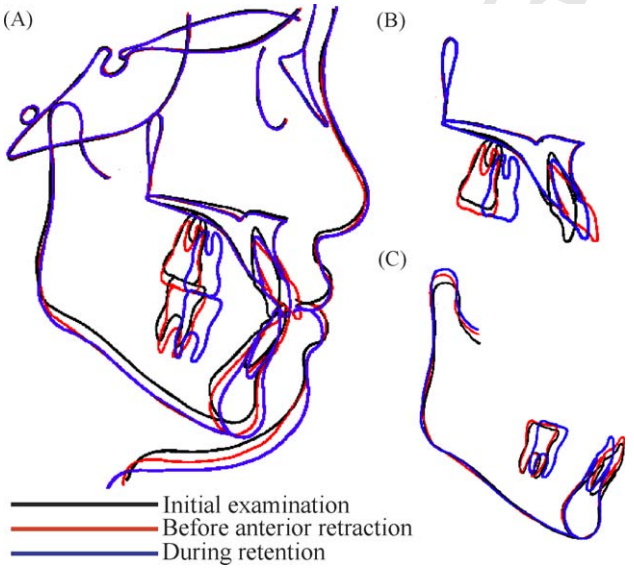

Fig. 14 – Cephalometric superimposition (Case 3). (A) S-N, S; (B) palatal plane, ANS; (C) mandibular plane, Me.

5.3. *Changes in dental arch configuration*

When comparing the dental arch at initial examination and during retention, in all three patients, the maxillary and mandibular dental arches with the screw device exhibited marked constriction in the second premolar region, and the arch expanded towards the posterior of the second premolar region. In addition, intraoral photographs taken before and after retraction in the three patients confirmed that the first molar, which served as an anchor, twisted mesially. McLaughlin et al. [10] studied the screw device and reported that although the duration of tooth movement was very short, because the orthodontic force generated was sufficiently strong to resolve the problem with frictional resistance, which hinders space closure, the configuration of a 0.019 in.× 0.025 in. stainless steel wire was also deformed. Sayin et al. [5] reported that when applying interrupted orthodontic force in canine retraction, reinforced anchorage is necessary to prevent anchorage loss. Therefore, when using the screw device, reinforced anchorage is necessary at the first molar to prevent deformation of the arch wire. The present study also showed that part of the screw device came in contact with the bracket on the second premolar. Therefore, it is important to improve the stiffness of the support wire for the screw device.

5.4. *Root resorption*

Several studies on continuous orthodontic force have reported that the incidence of root resorption was high for the maxillary anterior teeth [18–21]. Tagaya et al. [22] studied a total of 200 patients who underwent orthodontic therapy and reported the incidence of root resorption at 69%, and in particular, resorption in the maxillary anterior teeth was high, accounting for about 20%. The dental root apex for the maxillary anterior teeth in Japanese tends to be shorter when compared to Caucasians, and as a result, Japanese patients are more sensitive to orthodontic force. McLaughlin et al. reported that interrupted orthodontic force applied a relatively high orthodontic force. The risk factors for root resorption may thus include the strength and differences in orthodontic force [22].

In the present study, when interrupted orthodontic force was used for anterior retraction, root resorption of the anterior teeth was not seen in any of the three patients. With regard to canine retraction, Liou et al. reported that the incidence of dulling of the canine root apex was about 20%. Their appliance used a screw with which a single adjustment could yield 1.0 mm of retraction. Because the thickness of the periodontal membrane is (0.25 ± 50%) mm [23], this amount of retraction would have been too great. The screw device uses a screw with which a single adjustment can yield 0.35 mm of retraction. This equals the thickness of the periodontal membrane. Because interrupted orthodontic force is generated by turning a screw, it is possible to manage and control tooth movement by instructing patients in small adjustment frequency. Then, the screw device can apply physiological stimuli only to the periodontal membrane. In the present study, the patients were instructed to adjust the screw every three days. Because none of the patients complained of pain or discomfort after therapy, the screw pitch and adjustment interval for the screw device do not appear to negatively affect dental roots or periodontal tissue.

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