Assessment of skeletal stability of intraoral vertical ramus osteotomy with one-day maxillary–mandibular fixation followed by early jaw exercise

Seigo Ohba [a,c,*,1], Haruna Tasaki [b,1], Takayoshi Tobita [a], Tokutarou Minamizato [a], Takako Kawasaki [a], Naomi Motooka [a], Etsuko Watanabe [a], Noriaki Yoshida [b], Izumi Asahina [a]

[a] Department of Regenerative Oral Surgery, Nagasaki University, Graduate School of Biomedical Sciences, 1-7-1 Sakamoto, Nagasaki 852-8588, Japan
[b] Department of Orthodontics and Dentofacial Orthopedics, Nagasaki University, Graduate School of Biomedical Sciences, 1-7-1 Sakamoto, Nagasaki 852-8588, Japan
[c] Division of Dental and Oral Surgery, Faculty of Medical Science, University of Fukui, 23-3 Shimoaizuki, Matsuoka, Eiheiji-cho, Yoshida-gun, Fukui 910-1193, Japan

ARTICLE INFO

ABSTRACT

Purpose: Intraoral vertical ramus osteotomy (IVRO) is an effective surgical technique for cases of mandibular setback, is simpler and has a lower incidence of mental paraesthesia when compared to sagittal split ramus osteotomy (SSRO). However, IVRO has a disadvantage in the prolonged duration of postoperative maxillary–mandibular fixation (MMF) required due to the absence of rigid bone fixation. To avoid an extended MMF period, we developed a postoperative management protocol for our IVRO patients, using jaw exercises with elastic bands starting on the second day after surgery.
Methods: We evaluated the cephalometric skeletal and dental stabilities of 16 IVRO patients as they followed our protocol.
Results: The stabilities were confirmed and were similar to those of previous reports.
Conclusion: One-day MMF and early initiation of jaw exercise after IVRO did not affect the jaw position stability. Moreover, our findings suggest that starting jaw exercise earlier after IVRO surgery is beneficial, as it allows patients to avoid a long period of rigid MMF so that they can resume their normal daily activities sooner.

1. Introduction

Sagittal split ramus osteotomy (SSRO) and intraoral vertical osteotomy (IVRO) are common strategies for the treatment of mandibular prognathism (Chang et al., 2000; de Lir et al., 2013; Paeng et al., 2012). Both surgical techniques are well established, and each has risks and benefits. IVRO has the advantage of a lower incidence of damage to the inferior alveolar neurovascular bundle (Gbali and Sikes, 2000), with a frequency of less than 1% (Bell and Yamaguchi, 1991). In contrast, SSRO reportedly has a strong association with inferior alveolar nerve injury, with an incidence of

more than 85%. Moreover, 2–3.5% of cases with transected nerves never completely recover (Turvey, 1985; van Merkesteyn et al., 1987; Nishioka et al., 1987; Westemark et al., 1998) and, therefore, it is important to confirm the anatomical position of the inferior alveolar nerve by CT imaging preoperatively (Yoshioka et al., 2012). In addition to the lower incidence of nerve injury, IVRO offers other advantages over SSRO, including reduced operating time and less bleeding (Bell and Yamaguchi, 1991; Westemark et al., 1998). Furthermore, IVRO is a more favourable osteotomy procedure for asymmetry cases, because bony interference is reduced compared to that associated with SSRO (Ueki et al., 2006).

Some disadvantages of IVRO relative to SSRO have been reported. Only cases of mandibular prognathism are suitable for IVRO (Ayoub et al., 2000) as the proximal and distal segments of the mandible after IVRO cannot contact each other after mandibular advancement to correct mandibular retrognathism. Some authors have reported the use of internal rigid fixation (IRF) with plates and/or screws after osteotomy with IVRO (Troulis and Koban, 2004;

* Corresponding author. Present address: Division of Dental and Oral Surgery, Faculty of Medical Science, University of Fukui, 23-3 Shimoaizuki, Matsuoka, Eiheiji-cho, Yoshida-gun, Fukui 910-1193, Japan. Tel.: +81 776 61 8410; fax: +81 776 61 8128.
E-mail addresses: seigoohba@gmail.com, sohba@u-fukui.ac.jp (S. Ohba).
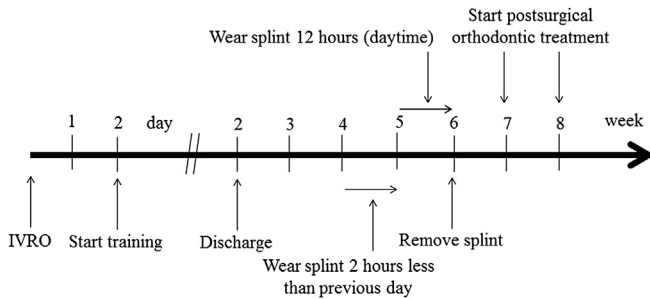[1] These authors contributed equally to this study.

Fig. 1. The postoperative time schedule. The time the splint was worn was reduced by 2 h every day for a week at the beginning of the fourth week after surgery. All patients had resumed orthodontic treatment within eight weeks after surgery.

Proffit et al., 2008; Haerle et al., 2009). However, IRF with IVRO is not a standard procedure with MMF performed more often.

The MMF period after IVRO is longer than that after SSRO (Ueki et al., 2005; Chen et al., 2011). While postoperative MMF is generally required for a period of up to two weeks for SSRO (Yoshioka et al., 2008; Kitahara et al., 2009), IVRO may require two to six weeks (Ueki et al., 2005; Chen et al., 2011). There is no consensus thus far on what constitutes an adequate period of MMF after IVRO. SSRO was thought to be more beneficial to patients than IVRO because they could return to normal daily living sooner after surgery due to the shorter duration of MMF. As a result we developed a new postoperative management protocol for IVRO patients employing two days of MMF, followed by jaw exercise. We evaluated the postoperative skeletal and dental stabilities of patients who were treated using the new protocol.

2. Materials and methods

This study was approved by the human research ethics committee of Nagasaki University Hospital.

2.1. Patients

We included eight male and eight female patients with an average age of 24.75 years (range: 19—38 years) who were receiving orthodontic treatment and only IVRO surgery to correct skeletal mandibular prognathism at Nagasaki University Hospital. We followed the usual IVRO postoperative regimen (Fig. 1). Patients who did not agree to participate in this study or who were not followed up after surgery were excluded from the study. None of the patients had undergone previous orthognathic surgery. IVRO was performed according to the surgical technique described by Hall and McKenna (1987). Additional procedures, including genioplasty, were not combined with the procedure. Surgery was considered complete once the patient had wire MMF with a splint on the maxillary arch.

2.2. Postoperative management (Fig. 1)

The wire MMF was replaced with elastic bands on the second postoperative day. The patient then wore a splint and elastic bands for 24 h a day and commenced jaw exercises using them. The elastic bands were replaced every morning, and larger sizes were used as patients were able to open their mouths wider without symptoms. At the beginning of the fourth postoperative week, all patients reduced the amount of time they wore the splint by 2 h progressively each day. By the beginning of the fifth week, patients wore the splint for 12 h at night, removing it for 12 h during the day. During the fifth week, patients wore the elastic bands all the time except during meals and while brushing their teeth. At the beginning of the sixth postoperative week, the patient no longer wore the splint, but continued the jaw exercise with elastic bands for one week. If occlusion was established during the seventh week, postoperative orthodontic treatment commenced. If occlusion was not established by that time, the patient wore a splint for 12 h a day for four days, then not at all for the following three days. In all cases, postoperative orthodontic treatment began no later than the eighth week after surgery. It takes approximately six months to develop functional and skeletal stability (Ueki et al., 2008), and therefore, after postoperative orthodontic treatment was started, patients continued to wear the elastic bands for jaw exercise for approximately six months after surgery until the occlusion stabilized and the jaw opening and closing paths were steady.

2.3. Jaw exercise

Each patient followed an oral surgeon's instructions for practicing the jaw exercise while looking in a mirror. Patients opened their mouths in the phonetic sign of "a" and closed their mouths in the phonetic sign of "i", and held their breath after each jaw movement. The jaw was led by the patients' own hands placed on the mental region in order to ensure that it moved symmetrically
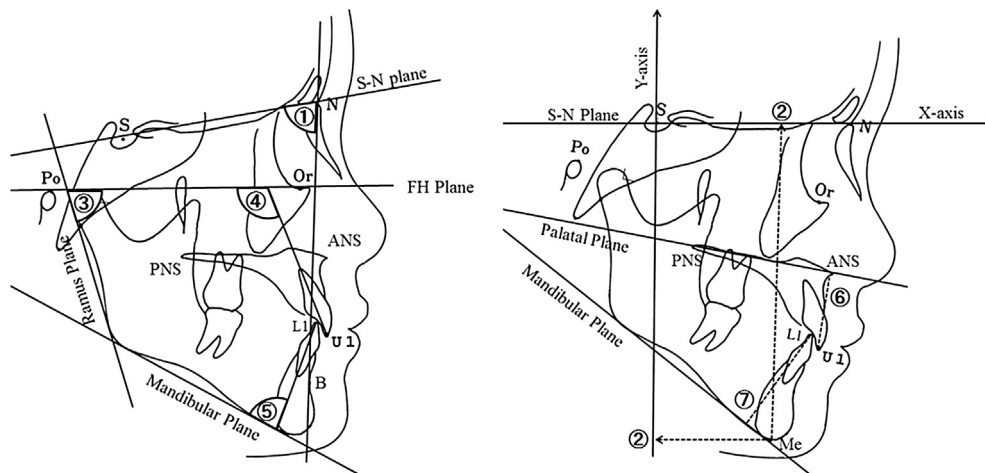

Fig. 2. Cephalometric measurements: ① SNB angle: the angle between the SN line and NB line. ② Me(x, y): the perpendicular length from the menton to the x- or y-axis. ③ Ramus: the angle between the posterior border of the mandible and the Frankfort horizontal (FH) plane. ④ U1-FH: the angle between the long axis of the upper central incisor and the FH plane. ⑤ L1-MP: the angle between the long axis of the lower central incisor and the mandibular plane (MP). ⑥ U1⊥PP: the perpendicular length from the edge of the upper central incisor to the palatal plane. ⑦ L1⊥MP: the perpendicular length from the edge of the lower central incisor to the mandibular plane.

on a vertical movement path. During this exercise, special attention was paid to prevent the patient from using their hands to assist in jaw opening and closing. If any patient could not bite on the splint firmly or the fitting was unsecured, the mandible was guided by the patient's hands to fit the dentition into the splint completely. Each exercise was performed for approximately 15 min, four times a day.

2.4. Cephalometric measurement (Fig. 2)

Cephalometric radiographs were taken preoperatively (pre), immediately postoperatively (post), one month after surgery (1M), six months after surgery (6M), and 12 months after surgery (12M) for all patients. To evaluate the horizontal and vertical changes in the mandible, serial digital X-ray images were captured, landmarks identified, and the images digitized by using a cephalometric analysis software program (Winceph, version 9, Rise, Sendai, Japan). To evaluate the dental changes, the following were measured: U1-FH, the angle between the Frankfort horizontal (FH) plane and the long axis of the upper central incisor (U1); L1-MP, the angle between the mandibular plane (MP) and the long axis of the lower central incisor (L1); U1⊥PP, the perpendicular length from the maxillary incisor edge to the palatal plane (PP); and L1⊥MP, the perpendicular length from the mandibular incisor edge to the mandibular plane (MP). To evaluate the skeletal changes, the SNB angle was measured, as were the anterior–posterior and superior–inferior

positions of the menton (Me). To determine the two-dimensional position of Me, an x–y coordinate system was defined such that the SN line was used as the x-axis, and a perpendicular line to the SN from the sella turcica (S) was used as the y-axis. The ramus, the angle between the posterior border of the mandibular ramus (ramus plane) and the FH plane, was measured to evaluate the anterior–posterior movement of the proximal segment after surgery.

2.5. Electromyograms of masticatory muscles

Electromyograms of the masticatory muscles, specifically the temporalis, masseter, and digastric muscles, were examined using a Neurotop device (Nihon Kohden, Tokyo, Japan) during jaw opening and closing motions. The route along the edge of the lower incisor during jaw opening and closing motions, as well as during the chewing motion, were assessed by a jaw movement indicator, the MM-J2 (Shofu, Kyoto, Japan) at two time points: before surgery and after the positioners were set. The jaw opening width was measured at various intervals.

2.6. Statistical analysis

Student's t-test was used to compare the average cephalometric measurements and to evaluate the treatment-related changes at
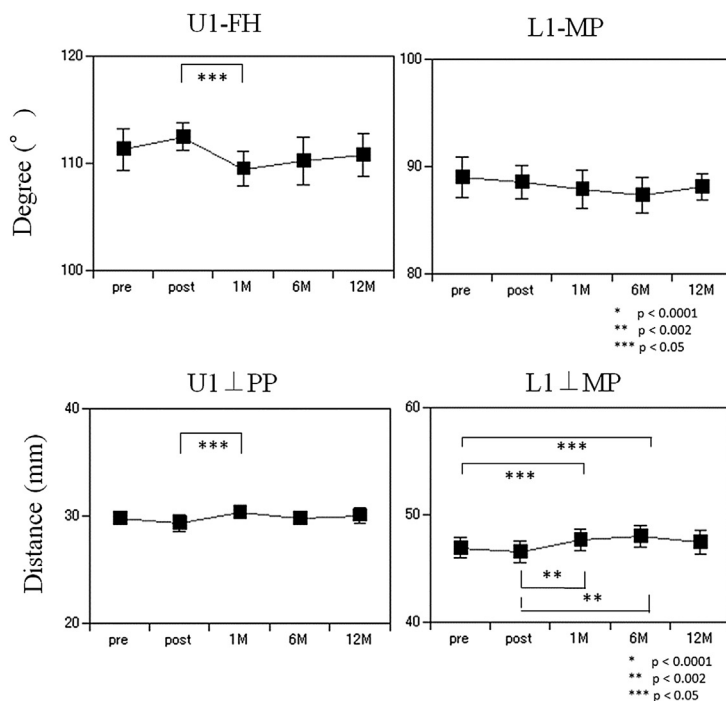
	pre	post	1M	6M	12M
U1-FH (°)	111.27	112.41	109.44	110.16	110.73
(S.E.)	(1.99)	(1.29)	(1.66)	(2.19)	(1.99)
L1-MP (°)	88.94	88.5	87.81	87.28	88.06
(S.E.)	(1.88)	(1.56)	(1.77)	(1.65)	(1.26)
U1⊥PP (mm)	29.69	29.28	30.25	29.76	30.00
(S.E.)	(0.57)	(0.74)	(0.56)	(0.54)	(0.69)
L1⊥MP (mm)	48.88	46.50	47.63	47.94	47.40
(S.E.)	(0.97)	(1.03)	(1.01)	(0.99)	(1.14)

Fig. 3. Dental changes after IVRO: U1-FH, L1-MP, U1⊥PP, L1⊥P.

different time points. A *p*-value ≤ 0.05 was considered to be significant.

3. Results

Among the 16 patients who underwent surgery, the mandible was moved posteriorly by an average of 6.43 mm (range: 0–11 mm) on the right and 7.00 mm (range: 3–11 mm) on the left. The difference between the movement on the right and left sides was 1.17 mm (range: 0–5 mm) on average.

3.1. Dental changes

3.1.1. The incisor angle (Fig. 3)
U1-FH was 112.41° post-surgery, and 109.44° at 1M, changing by an average of −2.97°, which was statistically significant. From 1M to 6M, it changed by 0.72°, and then by 0.57° from 6M to 12M, demonstrating a tendency for there to be a slight proclination after 1M. When compared with preoperative measurements, there were no significant differences at any of the time points. L1-MP was 88.5° post-surgery, and tended to move more lingually after 1M, 6M, and 12M. However, there were no significant differences at any of the time points.

3.1.2. Vertical linear distance (Fig. 3)
U1⊥PP changed by 0.97 mm between post-surgery and 1M, which showed significant U1 elongation; however, the amount of eruption was considered to be negligible. There were no significant differences between the preoperative value and that at any of the different time points after surgery. L1⊥MP moved by −1.25 mm from pre-surgery to 1M, by 1.13 mm from post-surgery to 1M, by 0.94 mm from pre-surgery to 6M, and by 1.44 mm from post-surgery to 6M. The mandibular incisor showed a tendency to erupt after surgery, with the position significantly different until six months after surgery. L1-MP changed vertically by 1.13 mm between post-surgery and 1M, and by 1.44 mm between post-surgery and 6M. There were significant differences between both periods. However, there was no statistically significant change in the lower incisor position (0.9 mm eruption) between post-surgery and 12M. In addition, L1-MP changed by −0.15 mm between the pre-surgery and 12M examinations, by 0.54 mm from 6M to 12M, and by 0.9 mm from post-surgery to 12M. None of these differences were significant.

3.2. Skeletal changes

3.2.1. SNB (Fig. 4)
All cases had skeletal mandibular prognathism and underwent a setback operation. Therefore, surgery significantly decreased the SNB (by −3.5° from pre- to post-surgery). The SNB was also significantly decreased between pre-surgery and 12M. While the SNB changed by −0.93° between post-surgery and 1M, which was a significant decrease, there were no significant differences at either 6M or 12M compared to immediately post-surgery. However, between 1M and 12M, the SNB changed by 0.73°, demonstrating a significant increase. This means that point B had moved posteriorly immediately after surgery, but tended to move anteriorly later, although the amount of change was very small.
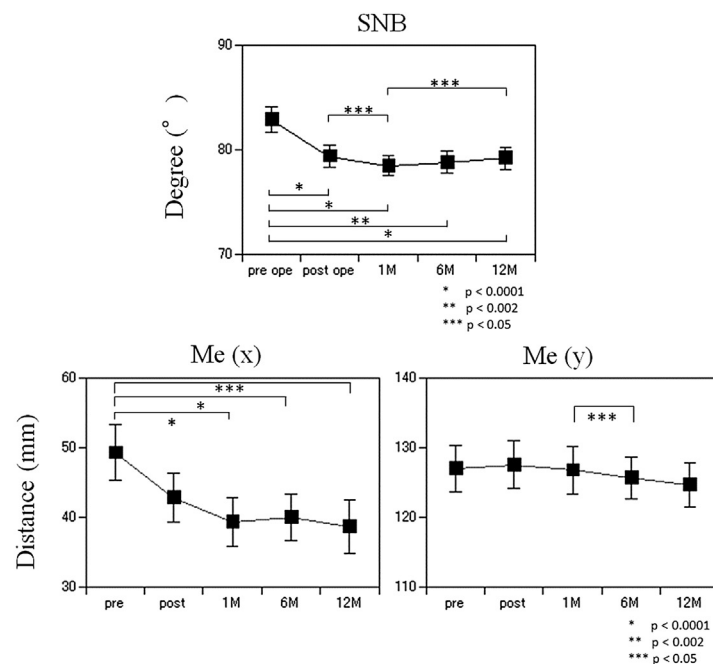
	pre	post	1M	6M	12M
SNB (°)	82.83	79.33	78.40	78.77	79.13
(S.E.)	(1.25)	(1.00)	(0.96)	(1.03)	(1.05)
Me (x) (mm)	49.17	42.77	39.21	39.92	38.59
(S.E.)	(4.00)	(3.46)	(3.47)	(3.31)	(3.81)
Me (y) (mm)	126.88	127.46	126.67	125.58	124.55
(S.E.)	(3.30)	(3.39)	(3.37)	(3.07)	(3.14)

Fig. 4. Skeletal changes after IVRO: SNB and Me(*x*, *y*).

3.2.2. Me (Fig. 4)

The antero-posterior movement of Me (Me(x)) decreased greatly, by −6.40 mm, as a result of surgery, but the difference was not significant, probably due to accidental error. However, the Me(x) was decreased significantly at 1M, 6M, and 12M compared to that measured pre-surgery (−9.96, −9.25 and −10.58 mm, respectively). There were no significant differences between the pre-surgery value and any of the time points after surgery. Therefore, the Me(x) moved slightly posteriorly in the first month after surgery and was stable thereafter. The vertical movement of Me (Me(y)) from 1M to 6M was −1.09 mm, showing a significant decrease, but this decrease is considered to be negligible because it does not impact on patient outcome.

3.2.3. Ramus (Fig. 5)

The measurement of the ramus was 89.20° immediately post-surgery, 85.34° at 1M, 84.56° at 6M, and 84.00° at 12M, showing significant increases during the periods from pre- to post-surgery, pre-surgery to 1M, and pre-surgery to 6M. However, there was no significant difference between pre-surgery and 12M. The ramus was significantly decreased after surgery at 1M (−3.86°), 6M (−4.6°), and 12M (−5.2°) compared to that at post-surgery. No other time points showed significant changes. In the ramus measurements, the proximal segment showed clockwise rotation after surgery and seemed to return to its original position.

3.2.4. Masticatory function (Fig. 6)

Fig. 6 shows typical electromyograms of the masticatory muscles during the simple jaw opening and closing motion (A) and the routes along the edge of the lower incision during the single jaw opening and closing motion (B), as well as during the chewing motion (C) after the positioner was set. The electric potentials of the jaw-closing muscles, temporalis and masseter, were detected during jaw closing, and those of the digastric jaw-opening muscle were upregulated during the jaw-opening motion (A). The pathway was almost a single line during the simple jaw opening and closing motions (B). During the chewing motion, the routes were symmetrical in the axial and coronal views, and the sagittal view showed a sufficient chewing motion area (C). Few differences were observed between two time points, i.e., before the operation and after the positioner was set (data from before the operation is not shown). The width of the jaw opening after the setting of the positioner was almost the same as that before surgery (data not shown).
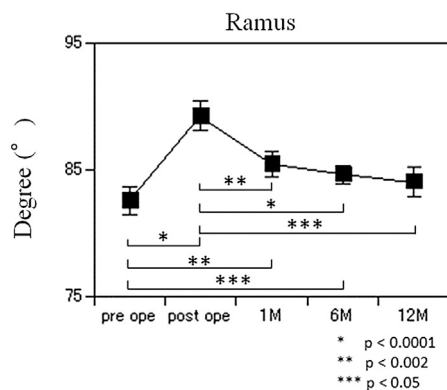

	pre	post	1M	6M	12M
Ramus (°)	82.50	89.20	85.34	84.56	84.00
(S.E.)	(1.09)	(1.14)	(1.01)	(0.74)	(1.14)

Fig. 5. Movement of the proximal segment.

4. Discussion

SSRO and IVRO are frequently used during the surgical treatment of mandibular prognathism. There is reportedly no difference between the IVRO and SSRO procedures in terms of postoperative long-term stability (Yoshioka et al., 2008). Due to the higher incidence of inferior alveolar nerve injury during SSRO compared to IVRO, IVRO is thought to be the preferable treatment for skeletal mandibular prognathism. However, due to the absence of bony fixation between the segments, the duration of MMF after IVRO is longer than that after SSRO (Ueki et al., 2005; Chen et al., 2011). Following the new regimen for IVRO, shown in Fig. 1, we release our patients from MMF on the second day after surgery and start jaw exercises using elastic bands and a splint.

Yoshioka et al. (2008) previously evaluated the horizontal and vertical positions of point B and pogonion on the x–y coordinates of individual tracings of the cephalograms. Point B moved 0.21 mm posteriorly and pogonion moved 0.23 mm posteriorly during the 12 months after IVRO, but the changes were very small. The stability of IVRO was shown to be the same as that of SSRO. Chen et al. (2011) evaluated the movement of Me by a method similar to ours using an x–y coordinate. In their study, Me relapsed by only 1.3 mm on the x-axis, and SNB relapsed by only 0.6°, thus demonstrating great skeletal stability after the IVRO procedure. However, those cases had MMF for 2–6 weeks. We think the mandible rotated clockwise slightly with the supporting point at Me, because the SNB tended to increase after surgery, whereas Me maintained its position. The change between 6 months and 12 months after surgery was not significant, and the range of the SNB difference between immediately after surgery and 12 months after surgery was 0.2°. These changes were similar to those reported in previous studies. Therefore, skeletal stability in the present study was confirmed.

In the evaluation of the movement of the proximal segment, this segment was noted initially to have shifted posteriorly, before returning to its original position after one year. During IVRO, the pterygomasseteric sling is detached, causing the proximal segment to be retracted anteriorly by the external pterygoid muscle and lateral ligament at the condylar process. The lower part of the mandibular ramus is moved posteriorly by the stylomandibular ligament, and since the condylar processes were within the temporomandibular fossa in all cases, this seemed to lead to posterior rotation of the proximal segment, with a supported point at the condylar process. Therefore, the proximal segment frequently showed a posterior position immediately after surgery. This jumping of the proximal segment is considered to recover its original position after masticatory balance is established by the jaw exercise. No patients complained of jaw movement impairment or temporomandibular joint disorders. Vigorous jaw exercise seemed to lead the proximal segment to an ideal site for the newly established jaw movement, and consequently, the condylar head was physiologically led into the fossa. There have been few reports on the change in the proximal segment after surgery (Ueki et al., 2009). Therefore, further research is needed.

Evaluation of dental change was based on the inclinations and eruptions of the maxillary and mandibular incisors. The incisor inclinations of both the maxilla and mandible were stable. The mandibular incisor retroclined lingually, but this was not significant, and may have compensated for the slight forward rotation of the mandible. In addition, the mandibular incisors showed a tendency towards slight eruption. It is considered that the elastic bands used for the jaw exercise exerted a vertical eruption force on the incisors. The amount of tooth eruption was small, less than 1 mm; however, considering this reciprocal reaction, an anchor for the elastic force should be placed in the bone instead of on the teeth.
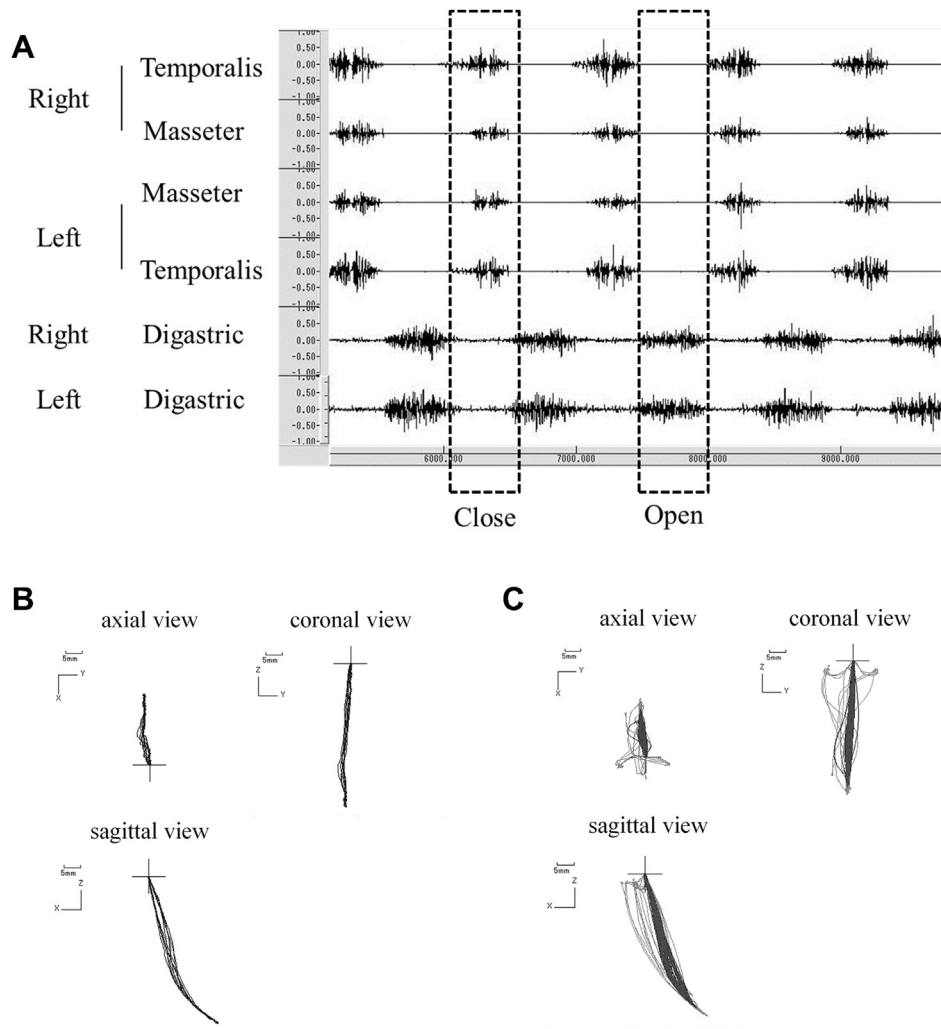
Fig. 6. Typical electromyograms of the masticatory muscles (temporalis, masseter, and digastric) during the simple jaw opening and closing motion (A). The routes along the edge of the lower incisor during the jaw opening and closing motion (B) and a chewing motion (C) after surgery were assayed. All patterns after the positioners were set were similar to those prior to the operation.

As shown in Fig. 6, the function of the mastication muscles was maintained, and jaw motion was stable after the positioner was set. We also calculated the jaw opening width, and the value after the positioner was set remained unchanged from the preoperative position (data not shown). These results suggest that early jaw exercise can restore the jaw function after IVRO surgery.

5. Conclusion

We developed a new regimen for the postoperative care after IVRO (Fig. 1), which initiates jaw exercise using elastic bands on the second postoperative day. In this regimen, favourable postoperative skeletal and dental stabilities were found, which were similar to previous studies. This suggests that early removal of MMF is possible, and patients can return to their daily routines sooner. We will continue to study how initial jaw exercise after IVRO surgery affects the masticatory system.

References

Ayoub AF, Millett DT, Hasan S: Evaluation of skeletal stability following surgical correction of mandibular prognathism. Br J Oral Maxillofac Surg 38: 305–311, 2000

Bell WH, Yamaguchi Y: Condyle position and mobility before and after intraoral vertical ramus osteotomies and neuromuscular rehabilitation. Int J Adult Orthodon Orthognath Surg 6: 97–104, 1991

Chang HP, Tseng YC, Chang HF: Treatment of mandibular prognathism. J Formos Med Assoc 105: 781–790, 2000

Chen CM, Lai SST, Wang CH, Wu JH, Lee KT, Lee HE: The stability of intraoral vertical ramus osteotomy and factors related to skeletal relapse. Aesthetic Plast Surg 25: 192–197, 2011

de Lir AL, de Moura WL, Ruellas ACO, Souza MMG, Nojima LI: Long-term skeletal and profile stability after surgical-orthodontic treatment of Class II and Class III malocclusion. J CranioMaxillofac Surg 41(4): 296–302, 2013

Gbali GE, Sikes JW: Intraoral vertical ramus osteotomy as the preferred treatment for mandibular prognathism. J Oral Maxillofac Surg 58: 313–315, 2000

Haerle FMD, Champy M, Terry BC: Atlas of craniomaxillofacial osteosynthesis, microplates, miniplates and screws, 2nd edn. New York: Thieme, 110–112, 2009

Hall HD, McKenna SJ: Future refinement and evaluation of intraoral vertical ramus osteotomy. J Oral Maxillofac Surg 45: 684–688, 1987

Kitahara T, Nakashima A, Kurahara S, Shiratsuchi Y: Hard and soft tissue stability of orthognathic surgery. Angle Orthod 79: 158–165, 2009

Nishioka GJ, Zysset MK, Van Sickles JE: Neurosensory disturbance with rigid fixation of the bilateral sagittal split osteotomy. J Oral Maxillofac Surg 45: 20–26, 1987

Paeng JY, Hong J, Kim CS, Kim MJ: Comparative study of skeletal stability between bicortical resorbable and titanium screw fixation after sagittal split ramus osteotomy for mandibular prognathism. J Craniomaxillofac Surg 40: 660–664, 2012

Proffit WR, White Jr PR, Sarver DM: Contemporary treatment of dentofacial deformity. Missouri: Mosby, 321–325, 2008

Troulis MJ, Koban LB: Endoscopic vertical ramus osteotomy: early clinical results. J Oral Maxillofac Surg 62: 824–828, 2004

Turvey T: Intraoperative complications of sagittal osteotomy of the mandibular ramus: incidence and management. J Oral Maxillofac Surg 43: 504–509, 1985

Ueki K, Marukawa K, Shimada M, Nakagawa K, Yamamoto E: Change in condylar long axis and skeletal stability following sagittal split ramus osteotomy and intraoral vertical ramus osteotomy for mandibular prognathia. J Oral Maxillofac Surg 63: 1494–1499, 2005

Ueki K, Marukawa K, Shimoda M, Nakagawa K, Alam S, Yamamoto E: Maxillary stability following Le Fort I osteotomy in combination with sagittal split ramus osteotomy and intraoral vertical ramus osteotomy: a comparative study between titanium miniplate and poly L-lactic acid plate. J Oral Maxillofac Surg 64: 74–80, 2006

Ueki K, Marukawa K, Hashiba Y, Nakamura K: Assessment of the relationship between the recovery of maximum mandibular opening and the maxillomandibular fixation period after orthognathic surgery. J Oral Maxillofac Surg 66: 486–491, 2008

Ueki K, Hashiba Y, Marukawa K, Nakagawa K, Alam S, Yamamoto E: The effects of changing position and angle of the proximal segment after intraoral vertical ramus osteotomy. Int J Oral Maxillofac Surg 38: 1041–1047, 2009

van Merkesteyn JPR, Groot RH, Van Leeuwaarden R: Intraoperative complications in sagittal and vertical ramus osteotomies. Int J Oral Maxillofac Surg 16: 665–670, 1987

Westemark A, Bystedt H, von Know L: Inferior alveolar nerve function after mandibular osteotomies. Br J Oral Maxillofac Surg 36: 425–428, 1998

Yoshioka I, Kbanal A, Tominaga K, Horie A, Furuta N, Fukuda J: Vertical ramus versus sagittal split osteotomies: comparison of stability after mandibular setback. J Oral Maxillofac Surg 66: 1138–1144, 2008

Yoshioka I, Tanaka T, Habu M, Oda M, Kodama M, Kito S, et al: Effect of bone quality and position of the inferior alveolar nerve canal in continuous, long-term, neurosensory disturbance after sagittal split ramus osteomy. J Craniomaxillofac Surg 40: e178–e183, 2012