Mouth Opening Retaining Appliance after Coronoidotomy for the Treatment of Trismus: Effects on Pain during Postoperative Training and Maximal Extent of Mouth Opening

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Abstract

Background: Coronoidotomy, the surgical resection of the coronoid process, is often successfully performed in patients with severely limited mouth opening related to coronoid process hyperplasia, temporomandibular joint ankylosis, oromandibular dystonia, and masticatory muscle tendon-aponeurosis hyperplasia. Although postoperative mouth opening training is important, it is significantly painful and considered a patients' burden.

Methods: To reduce severe pain related to the mouth opening exercise and produce better outcomes, silicone-made mouth opening retaining appliances were directly fabricated in the patients’ mouth. Thirty-four patients with limited mouth opening were recruited in this study. The patients were randomly assigned into two groups, with and without the appliance. All patients underwent bilateral coronoidotomy and masseter muscle stripping. The patients’ pain scores were compared statistically during the mouth opening training, and postoperative maximal interincisal mouth opening was measured at the first, third, seventh, and tenth days of the training between the groups.

Results: After the surgical procedures, the mean maximal distance of mouth opening significantly increased from 14.8 mm to 45.0 mm at discharge. The maximal interincisal distance was significantly larger at the first and third days of the mouth opening training in the group with the appliance than in the group without the appliance. Pain during the mouth opening training was significantly higher at the first, third, and seventh days in the group without the appliance than in the group with the appliance.

Conclusion: The oral appliance can reduce postoperative pain related to mouth opening training and produce better outcomes in patients undergoing coronoidotomy for trismus.

Keywords: Oral appliance; Coronoidotomy; Limited mouth opening; Mouth opening training; Masseter muscle

Introduction

Severely limited mouth opening has several causes including coronoid process hyperplasia [1-3], jaw closing dystonia [4,5], secondary jaw closing dystonia after a cerebrovascular disorder or cerebral palsy [5], masticatory muscle tendon-aponeurosis hyperplasia [6-9], temporomandibular ankylosis, inflammation, trauma, and tumors.

In coronoid process hyperplasia, the mandibular coronoid process is abnormally elongated, and the elongated section consists of histologically normal bone [3,10]. This leads to the impingement of the coronoid process on the body or arch of the zygomatic bone during mouth opening. Masticatory muscle tendon-aponeurosis hyperplasia is manifested by severely limited mouth opening due to the contracture of the jaw elevator muscles, which is caused by the overgrowth of the tendons and aponeuroses [6-9]. Dystonia is a movement disorder that is characterized by sustained or intermittent muscle contractions, which cause abnormal, repetitive movements and/or postures [11]. Oromandibular dystonia is a focal form of dystonia involving the masticatory and/or lingual muscles. Oromandibular dystonia includes jaw closing dystonia, jaw opening dystonia, lingual dystonia, jaw deviation dystonia, jaw protrusion dystonia, and lip dystonia [12-15]. Eighteen patients with severe trismus related to this disease, in whom treatment with botulinum toxin...
injections [14,16] or muscle afferent block therapy [12,17] had been ineffective, successfully underwent coronoidotomy [5].

Coronoidotomy or coronoidectomy, defined as the surgical resection of the coronoid process, is often performed as a surgical treatment for coronoid process hyperplasia [1-3]. According to oral surgeons, coronoidotomy is a simple and easy surgical procedure that only requires a short time. Postoperative intensive mouth opening training is important to produce better clinical outcomes. Nevertheless, the intensive exercise is accompanied with severe pain. Hence, it is crucial to reduce the pain and produce positive clinical outcomes. This study aimed to report a mouth opening retaining appliance after coronoidotomy in the treatment of severe limited mouth opening and to examine the effects of the appliance on pain during the training and maximal extent of mouth opening.

**Materials and Methods**

**Patients**

The demographic characteristics of the 34 patients (26 women and 8 men; mean age, 48.5 ± 15.9 [standard deviation] years; age range, 25 to 84 years) with limited mouth opening examined in this study are summarized in Table1. Twenty-six patients had oromandibular dystonia, seven had masticatory muscle tendon-aponeurosis hyperplasia, and one had coronoid process hyperplasia. Their mean maximal distance of interincisal mouth opening was 14.8 ± 9.6 mm (range, 0 mm to 30 mm). Six patients could not open their mouths at all. The patients’ chief complaints were dysarthria, masticatory disturbance, and muscle pain due to prolonged restricted mouth opening. The patients’ symptoms were resistant to other therapies including pharmacotherapy, mouth opening training, dental treatment, splint therapy [18], muscle afferent block therapy [12-17], and botulinum toxin therapy [14,16]. The mean duration of the patients’ conditions was 47.4 ± 56.9 months.

Based on the clinical and diagnostic findings obtained from X-rays, computed tomography scans, and magnetic resonance imaging scans, we excluded patients with temporomandibular joint ankylosis or tumors of the coronoid process, such as osteochondroma. Oromandibular dystonia was diagnosed based on the characteristic clinical features of focal dystonia and the patients’ electromyographic findings [12-15]. The patients’ clinical features included stereotypy, task specificity, co-contraction, and morning benefit. Masticatory muscle tendon-aponeurosis hyperplasia was diagnosed using the following criteria:

1. Slowly progressing limited mouth opening without limitation of lateral and anterior jaw movement,
2. A hard cord-like structure at the anterior border of the masseter muscle during maximal extent of mouth opening, and
3. A square mandible [6-9].

The 34 patients were randomly classified into two groups, with and without mouth opening retaining appliance (Table1). Simple randomization was achieved through the use of random number tables. The group with the appliance included 16 patients (oromandibular dystonia, 13 patients; masticatory muscle tendon-aponeurosis hyperplasia, 3 patients). The group without the appliance included 18 patients (oromandibular dystonia, 13 patients, masticatory muscle tendon-aponeurosis hyperplasia, 4 patients; coronoid process hyperplasia, 1 patient).

All of the patients provided written informed consent after receiving a full explanation about the planned treatment.

**Coronoidotomy**

Under general anesthesia, the anterior aspect of the ascending ramus of the mandible was exposed using a standard sagittal split osteotomy approach after creating a mucosal incision along the external oblique line (Figure 1A). We then carefully and completely stripped the masseter muscle from the surface of the mandibular angle. Subsequently, the temporalis tendon attached to the coronoid process was carefully exposed. After stripping the temporalis attachment off the coronoid process, the coronoid process was cut from the anterior aspect of the ramus to the sigmoid notch using a fissure bur or an electrosonic surgical instrument (Figure 1B, 1C). Sharp edges were smoothed. In cases with masticatory muscle tendon-aponeurosis hyperplasia, dense and inelastic tendons were present in the anterior part of the masseter muscle. These tendons were cut using an electrosurgical knife. As the patients did not exhibit a significant overgrowth of the mandibular angle, anglectomy was not performed. Continuous intraoral drainage or drainage using the Penrose drain is effective for reducing postoperative swelling. Intraoperatively, we measured the maximal interincisal distance and complete muscle relaxation under general anesthesia. After the operation, the maximal extent of mouth opening was re-measured.

**Fabrication of oral appliance**

The oral appliance was made of a silicon material for dental impression (Lab Silicone, Shofu, Kyoto, Japan). The silicon was mixed with the accelerator and inserted directly in the patients’ mouth at the incisal area. The patient was asked to close his/her mouth to 20 mm between the upper and lower incisors. The silicone was formed its shape and pressed to the labial side of the incisors in an approximately

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**Figure 1:** The coronoid process was cut from the anterior aspect of the ramus to the sigmoid notch (A). After resecting the bilateral coronoid processes, the tips of the coronoid process were elevated due to the involuntary contraction of the temporal muscle (B, C).

**Figure 2:** The inner surface of the maxillary side of a mouth opening retaining appliance (A). The appliance in the mouth of a patient (B). The appliance was fabricated directly in the patient’s mouth just after the operation. It aimed to keep the mandible in an open position to alter the position at which the masseter muscle reattached to the mandible.
Table 1: Demographic characteristics of the patients.

| Groups          | N   | Age (y) mean (SD) | Sex       | Maximal mouth opening (mm) mean (SD) | Disease duration (mo) mean (SD) |
|-----------------|-----|-------------------|-----------|--------------------------------------|-------------------------------|
| With appliance  | 16  | 49.7 (12.1)       | 13 women 3 men | 16.1 (10.0)                          | 44.8 (47.8)                   |
| Without appliance | 18  | 47.4 (18.9)       | 13 women 5 men | 13.7 (9.4)                           | 49.6 (64.8)                   |
| Total           | 34  | 48.5 (15.9)       | 26 women 8 men | 14.8 (9.6)                           | 47.4 (56.9)                   |

SD: Standard Deviation

20 mm elevated jaw position. The appliance was completed with an acrylic bur and polished with silicone point (Figure 2A). In several patients who could not open their mouth at 20 mm, the device was fabricated immediately after the operation. During the first night after the operation, each patient was instructed to insert the oral appliance (Figure 2B). The appliance should be inserted for 2-3 days after the operation except during mealtimes.

Mouth opening training

The author started the mouth opening training at the third day after the surgical procedure. A jaw-opening device (Heister’s jaw opener) was applied to open the mouth passively three times a day. The Heister’s device was covered with a vinyl tube (diameter, 10 mm; thickness, 1 mm) to protect the teeth during the training (Figure 3). The blades of the device should rest on the occlusal surfaces of the molars. However, if molars are missing, the device can be applied on the canine region after the insertion of the upper and lower splints (Figure 3B), as previously described [18]. The mouth opening training consisted of three sessions: in the morning, afternoon, and evening. Each session included passive mouth opening using the Heister’s device. The mouth opening distance was gradually increased, taking several minutes with pause. The training was repeated three times during a session. The maximal interincisal opening extent was measured three times: Active mouth opening before training, passive opening with the device, and active mouth opening after the session. Pain during the training was assessed using a visual analog scale. The pain and active maximal opening extent were evaluated at the first, third, seventh, and tenth days of the training. The author conducted the training at least once a day. The patients were advised to take a tablet ofloxoprofen sodium hydrate (Loxonin, Daiichi Sankyo Company, Tokyo) 30 min before the training. They were instructed to perform the training by themselves at least twice a day. The training lasted 10-14 days during admission. The patients were requested to continue the training after discharge. Three months after surgery, the patients were instructed to keep the training once a day to maintain the maximal extent of mouth opening.

Analysis

Pain intensity during the mouth opening training was examined using a 100 mm visual analog scale at the first, third, seventh, and tenth days of the training. The endpoints of the visual analog scale represented “no pain” and “the worst conceivable pain,” respectively.

Differences in mean age, baseline mouth opening extent, and disease duration were compared using the unpaired t-test between the groups with and without the appliance. Gender distribution between groups was evaluated using the Fisher’s exact test. The mouth opening at baseline before and after the coronoidotomy at discharge were compared using the paired t-test in all subjects. The visual analog score during the mouth opening training and the maximal extent of mouth opening at baseline after the training at the first, third, seventh, and tenth days of the training were compared statistically using the unpaired t-test between the groups with and without the oral appliance. All analyses were performed using the statistical software package Statistical Package for the Social Sciences (SPSS) for Windows version 14.0 (SPSS Japan Inc., Tokyo, Japan). The null hypothesis was rejected at the 5% level (p<0.05).

This study was in accordance with the Declaration of Helsinki and was approved by the institutional review board and ethics committee of Kyoto Medical Center.

Results

The two groups with and without the appliance did not differ significantly in mean age, sex distribution, and maximal extent of mouth opening before treatment (Table 1). All the patients underwent bilateral coronoidotomy and masseter muscle stripping. They exhibited postoperative pain and swelling. However, no other significant complications were observed. Six patients required additional botulinum toxin injections into the masseter and/or medial pterygoid muscles after the operation [5]. None of patients required reoperations. The mean duration of follow-up period was 92.3 ± 42.5 months. Changes of visual analog scale scores and mouth opening measures are summarized in Table 2.

Maximal extent of mouth opening

The mean maximal distance of interincisal mouth opening increased significantly (p<0.001) from the baseline (14.8 mm ± 9.6 mm) to 45.0 mm ± 6.1 mm at discharge after the operation (Table 2). During the mouth opening training, the maximal extent of mouth opening was larger in the group with the appliance than in group without the appliance. At the first and third days of the training, the maximal extent of mouth opening was significantly (p<0.01) higher in the group with the appliance than that in the group without the appliance (Figure 4).

Visual analog scale score

Pain scores evaluated using the visual analog scale during the
mouth opening training were generally higher in the group without the appliance than in the group with the appliance (Table 2). Significantly higher differences were observed at the first and third days (p<0.01) and the seventh day (p<0.05) (Figure 5).

Discussion

This study is the first to examine the effect of a mouth opening retaining appliance, which was inserted immediately after coronoidotomy for patients with severe trismus. The simple appliance described here can significantly reduce pain during the mouth opening training and can produce better clinical outcomes particularly at early phase of the training.

Coronoidotomy and coronoidectomy are two typical surgical interventions for treating trismus. During coronoidectomy, the temporal muscle is stripped from the coronoid process, which is then completely resected. The release of the temporal muscle insertion is a traumatic procedure. On the contrary, during coronoidotomy, the coronoid process is sectioned at its base and left in place (Figure 1B, 1C). This method is less traumatic and can lead to less severe postoperative morbidities and better clinical outcomes [3,17]. In patients with coronoid process hypertrophy, limited mouth opening is principally caused by mechanical obstruction between the coronoid process and the zygomatic bone, which can be solved by surgically resecting the hypertrophic process. A meta-analysis of 61 cases of coronoid process hypertrophy revealed that coronoidotomy produced slightly better postoperative results, although 84% of the patients underwent coronoidectomy [3]. Nevertheless, a recent study reported that 92% of patients showed complete or partial osseous union to the mandibular ramus 1 year after coronoidotomy [19]. Some patients with coronoid process hypertrophy may require coronoidectomy to completely eliminate the mechanical cause of impingement.

After resecting the coronoid process, the tip of the coronoid process was elevated due to the involuntary contraction of the temporal muscle (Figure 1B, 1C). This method is less traumatic and can lead to less severe postoperative morbidities and better clinical outcomes [3,17]. However, the stripped muscles would have, without delay, reattached to the mandible. It must be necessary to prevent the masseter muscle from regaining its occlusal force. The appliance can keep the mandible in approximately 20 mm elevated position (Figure 2A, 2B). This device aimed to slightly alter the position at which the masseter muscle reattached to the mandible to reduce the effects of its involuntary contracture, namely, the stripped masseter muscle may slide approximately 10 mm superiorly and reattach (Figure 6A, 6B). The maximal muscle power can be executed at the optimal muscle length, and muscle tension can be decreased, shortening the muscle length. This length-tension relation has been explained on the sliding filament theory [20]. An approximately 10 mm shortened masseter muscle after reattachment (Figure 6B) would reduce the involuntary excessive bite force. Further studies are required to

Figure 3: A jaw-opening device (Heister’s type) covered with a vinyl tube to protect the teeth (A). The mouth opening training using the Heister’s device (B). This patient had several missing molars. Therefore, the upper and lower splints were inserted to protect the incisors (B).

Figure 4: Changes in the maximal extent of mouth opening with and without the appliance. The maximal interincisal distance was significantly (p<0.01) larger at the first and third days of the mouth opening training in the group with the appliance than in the group without the appliance. Data are presented as the mean ± standard deviation. *p<0.01

Figure 5: Changes in the visual analog scale scores with and without the appliance. Pain evaluated using the visual analog scale during the mouth opening training was significantly higher at the first and third days (p<0.01) and the seventh day (p<0.05) in the group without the appliance than in the group with the appliance. Data are presented as the mean ± standard deviation. *p<0.05; **p<0.01

Figure 6: Before operation (A). After coronoidotomy and masseter muscle stripping, the appliance retained the mandible at approximately 20 mm elevated position (B). The stripped masseter muscle might reattach to the superiorly slid site (B), reducing the involuntary excessive occlusal force. A part of the original masseteric tuberosity is shown in red dots (B).
confirm this hypothesis.

There are some differences between the limited mouth opening caused by jaw-closing dystonia, masticatory muscle tendon-aponeurosis hyperplasia, and coronoid process hyperplasia [5]. Characteristic findings of masticatory muscle tendon-aponeurosis hyperplasia include severely limited mouth opening due to the contracture of the masticatory muscles, resulting from hyperplasia of the tendons and aponeuroses [6-9] and a square mandibular configuration associated with hyperplasia of the coronoid process and mandibular angle [7,18]. Different from coronoid process hyperplasia, interference is not observed between the coronoid process and zygomatic bone, even during the maximal extent of mouth opening. Although patients with jaw closing dystonia exhibited significant improvement in mouth opening under general anesthesia and complete muscular relaxation [5], muscular relaxation cannot improve mouth opening in masticatory muscle tendon-aponeurosis hyperplasia [9]. The patients in this study had more severely limited mouth opening (14.8 mm) than was observed in patients with coronoid process hypertrophy 16 mm and masticatory muscle tendon-aponeurosis hypertrophy 25.6 mm and 21.8 mm [3,9,17]. In a previous study, the patients with oromandibular dystonia (jaw closing dystonia) did not display any specific temporomandibular joint findings, impingement of the coronoid process, or limited movement caused by tendon or aponeurosis hyperplasia [5]. Thus, dystonic contracture was the sole cause of their limited mouth opening. Additionally, some of the patients were able to open their mouths with the help of sensory tricks by gently touching their mandibles or teeth with their fingers or hands [5]. The present study included patients with oromandibular dystonia (jaw closing dystonia), masticatory muscle tendon-aponeurosis hyperplasia, and coronoid process hyperplasia. However, jaw closing dystonia was prevalent. Unfortunately, the number of patients with masticatory muscle tendon-aponeurosis hyperplasia and coronoid process hyperplasia was insufficient to statistically analyze the differences in the response of coronoidotomy and the appliance. Further study with larger sample size is required to elucidate the differences.

Some patients with masticatory muscle tendon-aponeurosis hyperplasia might be predisposed to oromandibular dystonia [5]. Although patients with oromandibular dystonia exhibit the typical clinical features of focal dystonia and their contracture usually disappears during sleeping [12-15], some patients with oromandibular dystonia also demonstrate nocturnal bruxism. Initially, oromandibular dystonia patients exhibit task-specific dystonic contracture; however, subsequently, their symptoms may start to appear when performing other tasks and finally may even occur at rest. In such patients, hyperplasia of the tendons, aponeuroses, mandibular angle, and coronoid process could develop similar to patients with masticatory muscle tendon-aponeurosis hyperplasia. According to the current diagnostic criteria [6-9], such cases might be diagnosed with masticatory muscle tendon-aponeurosis hyperplasia. Certainly, five out of the 26 patients with oromandibular dystonia in the present study could be diagnosed with masticatory muscle tendon-aponeurosis hyperplasia. Patients with masticatory muscle tendon-aponeurosis hyperplasia took significantly longer to notice the limited mouth opening (97.3 and 140.4 months) than the patients in this study (47.4 months) [17,9]. The severe jaw hypomobility exhibited in this study might have initially been caused by jaw closing dystonic contracture and might have intensified in a secondary manner due to the presence of dense, inelastic tendons and a continuous contraction force at the affected muscles’ points of attachment. This would have resulted in tendon or aponeurosis hyperplasia. Further longitudinal studies with a significant number of patients with both entities are required to confirm the hypothesis.

**Conclusion**

The mouth opening retaining appliance can reduce postoperative pain related to the mouth opening training and produce better clinical outcomes for patients undergoing coronoidotomy for the treatment of trismus.

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