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Efficacy of Mandibular Subluxation for Carotid Endarterectomy with Combined Fixation Using Interdental Wire and Putty

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Abstract

Bifurcation of the carotid artery at a cephalic location greatly increases the risk associated with carotid endarterectomy (CEA). Mandibular subluxation (MS) can improve access to the cephalic location; however, the benefits of MS remain unclear. The present study objectively assessed the efficacy of MS. MS was performed with only wire fixation of healthy teeth in four patients (Group A), with wire fixation reinforced by inserting Coltoflax® putty between healthy teeth in 17 patients (Group B), and with wiring between maxillary and mandibular screws reinforced by inserting Coltoflax® putty between the wires in five edentulous patients (Group C). Pre- and postoperative axial computed tomography angiography images at the level of the tip of the mastoid process were used to compare the following measurements: mastoid-mandible distance between the anterior margin of the mastoid process and posterior margin of the mandible; and mastoid-internal carotid artery-mandible (MIM) angle between the line connecting the anterior margin of the mastoid process and the center of the internal carotid artery, and the line connecting the posterior margin of the mandible and the center of the internal carotid artery. MS increased the overall mastoid–mandible distance by 5.7 ± 3.1 mm. The increase was significantly greater in Group B (6.7 ± 2.0 mm) than in Group A or C (4.0 ± 4.1 mm) (P=0.032). MS increased the overall MIM angle by 13.3 ± 7.9°. MS with the combination of wire with Coltoflax® putty offered the widest surgical corridor for CEA.

Keywords: Carotid endarterectomy; Carotid stenosis; Mandibular subluxation

Introduction

Carotid endarterectomy (CEA) requires adequate exposure of the cephalic location of the internal carotid artery (ICA) for removal of the distal end of the plaque. CEA becomes a high-risk procedure if the bifurcation of the carotid artery is located at a cephalic location [1]. In Japanese patients, the position of the carotid artery bifurcation is approximately one vertebral body higher than in patients in Western countries [2], so that adequate exposure of the ICA is more difficult to achieve. If a higher approach is taken (above the mastoid-mandibular line, which extends from the tip of the mastoid process to the angle of the mandible), an operative space cephalic to the mastoid-mandibular line is required [3]. Mandibular subluxation (MS) for CEA has been proposed to access such a cephalic location of the bifurcation [3-12]. However, only the subjective effects of MS have been reported, so the objective effects are still unclear. The present study used computed tomography (CT) angiography to objectively assess the efficacy of MS with three methods for CEA.

Methods

Thirty-four patients underwent CEA at Kitasato University Hospital between March 29, 2011 and August 21, 2014. Eight patients were excluded for the following reasons: nasotracheal intubation was impossible because of a nasal polyp in one patient; the oral surgeon's schedule for MS could not accommodate six patients; and CT angiography evaluation of one patient was impossible because of artifacts. Ultimately, this study included 26 patients who underwent CEA using MS (carotid stenosis was symptomatic in 12 and asymptomatic in 14 patients).

All CEA procedures were performed by the first author (KS). A skin incision was made along the anterior margin of the sternocleidomastoid and extended cranially, passing between the posterior margin of the mandible and the anterior margin of the mastoid process. An intraluminal shunt was used in all procedures. Perioperative antiplatelet therapy was continued without interruption. If there were no findings indicating hyperperfusion, anesthesia was terminated and the patient was extubated on the next or following days after surgery.

All MS procedures were performed by author YY, an oral surgeon. After nasotracheal intubation and induction of general anesthesia, MS was performed by grasping and manipulating the mandible gently using the fingers but firmly anteriorly, inferiorly, and then contralaterally approximately 10-15 mm. Ideally, the ipsilateral condyle should be displaced to, but not beyond, the articular eminence. Unilateral temporary MS was maintained with interdental monofilament stainless steel wiring (Surgical Steel; Ethicon, Inc., Somerville, NJ) between the ipsilateral mandibular bicuspids and the contralateral maxillary frontal teeth in patients with healthy teeth. At the beginning of this study, MS was maintained with only wiring (Group A) (Figure 1A), but this approach did not offer strong enough holding force to prevent the mandible from returning to the pre-subluxation position during surgery, so the wire fixation of healthy teeth was reinforced by inserting Coltoflax® putty (Coltene/Whaledent

AG, Altstätten, Switzerland) between the teeth (Group B) (Figure 1B). Temporary MS was maintained with wiring between maxillary and mandibular screws inserted into the gingiva (Dual-Top Anchor System; Jeil Medical Corp., Seoul, Korea) in patients without teeth or with chronic periodontal disease, reinforced by inserting Coltoflax® putty between the wires (Group C) (Figure 1C). After postoperative CT angiography, the patient was moved into the intensive care unit, where the MS wiring was removed by an oral surgeon. Examples of methods of mandibular subluxation are shown in Figures 1A-1C.

Figure 1A: Subluxation to the right with only wiring (Group A).

Figure 1B: Subluxation to the left with wires and Coltoflax® (Group B) in patient with healthy teeth.

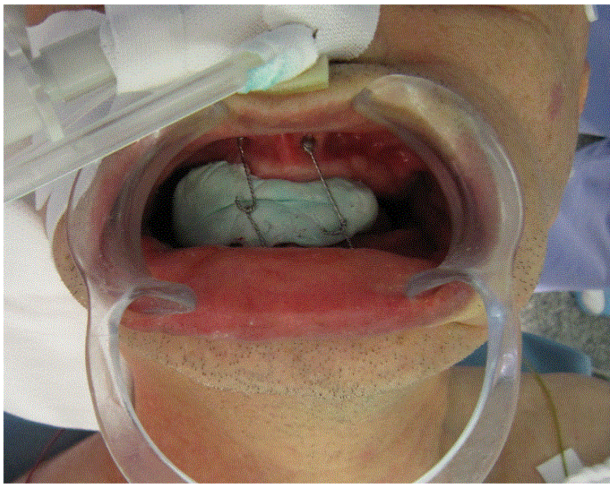

Figure 1C: Subluxation to the right with screws inserted into the gingiva and wires (Group C) in an edentulous patient.

CT angiography was performed before CEA and just after CEA while maintaining MS, and the images were retrospectively evaluated. Conventional CT was performed instead of CT angiography in the six patients with renal dysfunction. The following characteristics on the pre- and postoperative axial CT angiography images at the level of the tip of the mastoid process were compared on the affected side: mastoid-mandible distance between the anterior margin of the mastoid process and posterior margin of the mandible (Figure 2A); and mastoid-ICA-mandible (MIM) angle created by the line connecting the anterior margin of the mastoid process and the center of the ICA, and the line connecting the posterior margin of the mandible and the center of the ICA (Figure 2B).

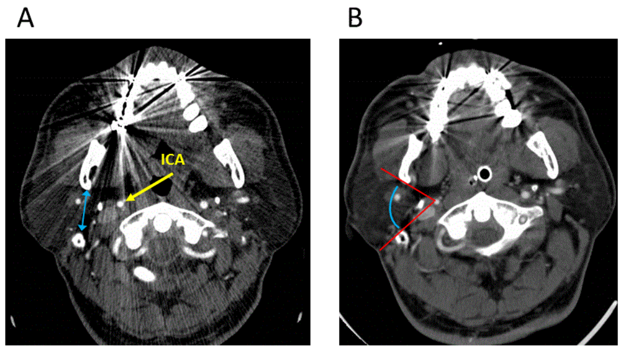

Figure 2: Measurements on axial computed tomography angiography images at the level of the tip of the mastoid process. **(A)** Mastoid-mandible distance between the anterior margin of the mastoid process and posterior margin of the mandible. ICA, internal carotid artery. **(B)** Mastoid-ICA-mandible (MIM) angle between the line connecting the anterior margin of the mastoid process and the center of the ICA, and the line connecting the posterior margin of the mandible and the center of the ICA.

The ethics committee of our hospital approved this study, and the requirement for informed consent was waived (B15-22).

Statistical analysis

Mastoid-mandible distances and MIM angles are presented as mean ± standard deviation. Student's *t*-test was used to compare the groups. Differences with a P value of <0.05 were considered statistically significant. All statistical analyses were performed using JMP® Version 10 (SAS Institute Inc., Cary, NC).

Results

Fixation was performed with only wiring (Group A) in four patients, and with wiring plus Coltoflax® putty (Group B) between healthy teeth in 17 patients. Screw fixation plus putty (Group C) was used in five edentulous patients. Mastoid-mandible distance increased by 5.7 ± 3.1 mm with MS. The increase was significantly greater in Group B (6.7 ± 2.0 mm) than in Group A or C (4.0 ± 4.1 mm, P=0.032) (Figure 3A). MIM angle increased by 13.3 ± 7.9º with MS, but no significant difference was observed between Group B (13.9 ± 6.5º) and Group A or C (12.2 ± 10.5º, P = 0.60) (Figure 3B). Measurements of mandibular subluxation are shown in the Figures 3A and 3B.

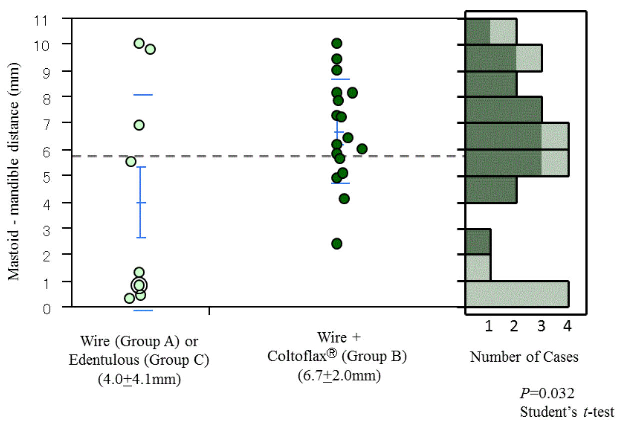

Figure 3A: Dashed straight line denotes increased mastoid-mandible distance (5.7 ± 3.1 mm) with mandibular subluxation. The increase was significantly greater in the 17 patients with healthy teeth who underwent wiring plus Coltoflax® (Group B) (6.7 ± 2.0 mm) than in the four patients who received only wiring (Group A) or the five edentulous patients with screw fixation (Group C) (4.0 ± 4.1 mm) (P = 0.032). In the bar graphs on the right, gray represents the number of cases in group B, and light gray represents the number of cases in group A or C.

No compression of the contralateral carotid artery caused by MS was observed. All patients underwent successful carotid revascularization, without evidence of cranial nerve dysfunction or postoperative cerebral neurological complications. The MS procedure was completed within 10 minutes for all patients and did not further extend total operative duration. No apparent postoperative signs, symptoms, or complaints were related to MS; in particular, no mandibular dislocation, temporomandibular joint pain, facial or jaw pain, tooth damage, impairment of mastication, bleeding, infection, or dental injury occurred, except for tongue ulcer in one patient.

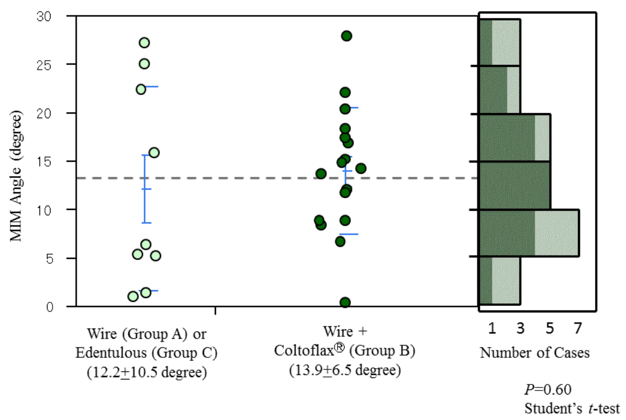

Figure 3B: Dashed straight line denotes increased mastoid-ICA-mandible (MIM) angle (13.3 ± 7.9º) with mandibular subluxation. No significant difference was observed between the 17 patients in Group B (13.9 ± 6.5º) and the four patients in Group A or five edentulous patients in Group C (12.2 ± 10.5º) (P = 0.60). In the bar graphs on the right, gray represents the number of cases in group B, and light gray represents the number of cases in group A or C.

Discussion

Cephalic location of CEA and reported modifications

The distal cervical ICA can be defined as that portion of the artery cephalad to a line drawn between the tip of the mastoid and the angle of the mandible [5]. This line corresponds approximately to the upper border of the body of the second cervical vertebra. In general, lesions of the ICA below this level can be exposed using standard approaches, whereas ICA lesions cephalad to this level were considered surgically inaccessible [5,12]. Bifurcation of the carotid artery at the level of the second cervical vertebra is a risk factor for CEA [1]. Moreover, use of an intraluminal shunt requires more distal exposure of the ICA. Various techniques used for CEA in cases of cephalic location of the lesions have been reported, including the retrojugular approach [13], dissection and ligation of the adjacent structures (sternocleidomastoid artery, occipital artery and vein [14,15], ansa cervicalis [14], and posterior belly of the digastric muscle [14,16]), nasotracheal intubation [17], mandibular osteotomy [18,19], elevation of the hypoglossal nerve [1,15,16], and MS [3-11,20].

Definition of MS

To the best of our knowledge, MS was first described as the use of a maxillomandibular arch bar-wiring technique in the management of a traumatic case [21]. Subluxation is defined as a self-reducing partial dislocation of a joint. Subluxation is a normal physiologic function and is associated with normal mouth opening. Subluxation of the temporomandibular joint allows the condyle to move 2-3 mm anterior to the articular eminence during the opening movement. Tomographic analysis of the range of mandibular motion has shown that, in many individuals, the condyle may move physiologically as much as 5 mm anterior to the articular eminence when the mouth is completely open.

In contrast, dislocation is defined as a non-self-reducing pathologic derangement between the articulating components of a joint.

Quantitative findings and rationale for MS

The present study objectively demonstrated the efficacy of MS, which was previously only subjectively reported to increase ICA exposure by 5.5–20 mm to the cranial side [3-5,7-11]. We found that MS increased mastoid-mandible distance by 5.7 ± 3.1 mm and MIM angle by 13.3 ± 7.9º, and that wire fixation with interdental insertion of Coltoflax® putty was the most effective technique. We believe that this is because Coltoflax® putty enters the gap between wire and teeth and reinforces the fixation of the subluxation position. We found that the mandible often returned to the pre-subluxation position with only wire fixation, as well as in edentulous patients with gingival-screw fixation with wiring and Coltoflax® reinforcement [9-11,20]. Such ineffective maintenance of MS in some cases may explain the absence of wider application.

Limitations of MS

Known complications of MS include transient discomfort of the temporomandibular joint [12], transient ipsilateral temporomandibular joint pain [7], and compression of contralateral carotid sheath structures. However, the present study observed none of these complications, and only one case of tongue ulcer, suggesting the safety of the MS procedure. Nasotracheal intubation is necessary in MS, introducing a risk of epistaxis. However, the present study found no problems associated with epistaxis, possibly because all patients were extubated one or more days after surgery, consequently hemostasis had already been achieved at the time of extubation, even if dual-antiplatelet therapy was being continued. The focal point of the present study was not to recommend this protocol, but to present useful information to the prospective reader who will perform MS during CEA.

Recently, there has been a concept considering high-risk carotid artery stenting (CAS) in addition to high-risk CEA [22]. In cases of high-risk CAS, there could also be cases of cephalic location, for which CEA should be reconsidered. In such cases, we believe that the prospective readers can refer to the results of the present study.

This MS technique requires a specific device and the cooperation of an oral surgeon. Approximately 10 minutes are required for fitting and removal of the device. Unfortunately, the oral surgeon's schedule could not accommodate six of our patients who underwent surgery without MS. MS stabilization was reportedly maintained with only a mouthpiece, but that study was subjective and did not offer any objective verification. Furthermore, the technique could not be used in edentulous patients, who accounted for 43% (12 of 28) of the patients [23]. In contrast, the present technique may be applied to MS for edentulous patients by increasing the number of screws and wires.

Conclusion

Quantitative analysis demonstrated that MS could widen the retromandibular space for CEA. Coltoflax® reinforcement of wiring was effective to maintain the subluxation, which facilitated a wider surgical corridor during CEA. Larger studies are needed to confirm the findings of our single-institution study with a small sample size.

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Disclosure

The authors have no personal financial or institutional interest in any of the drugs, materials, or devices described in this article.

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