

## Effect of lateral pterygoid myotomy on the structures of the temporomandibular joint: a histological study

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*Twenty rhesus monkeys (Macaca mulatta) were used in a study of the lateral pterygoid myotomy, which was performed in five animals; 15 were controls. In some instances, a Silastic sheet was placed in an attempt to prevent reattachment of muscles. The animals were killed eight weeks postoperatively. The regions of the temporomandibular joint were removed and prepared for histological analysis. Hematoxylin- and eosin-stained sections of the temporomandibular joint regions of these animals confirmed muscle reattachment, even when inert barriers were used in an attempt to prevent reattachment. Additionally, articular remodeling changes and irregularities of the condylar articular surface and fibrosis of the joint were observed. Results of the study indicate that the success of the lateral pterygoid myotomy may be due to postsurgical scarring, with subsequent limitation of motion, rather than through the detachment and ultimate loss of function of the lateral pterygoid muscle. The use of inert barriers to prevent muscle reattachment may not serve its purpose because the lateral pterygoid muscle may effectively return to its preoperative orientation by reattaching to a pseudocapsule formed around the inert barrier.*

Mandibular dislocation refers to displacement of the mandibular condyle anterior to the articular eminence.<sup>1</sup> Although the condyle moves to this position during maximum opening in many normal individuals, dislocation is uncommon.<sup>2,3</sup> Uncoordinated neuromuscular activity with spasm of the lateral pterygoid muscle may dislocate the mandible, holding it on the anterior slope of the articular eminence.<sup>4,5</sup> Dislocation may also result from external trauma, sudden or prolonged wide opening, and laxity of the temporomandibular joint capsule.<sup>5-10</sup> With each dislocation, there is further rupture and stretching of the capsular ligament, aggravating the condition and leading to further recurrence.<sup>11-13</sup> Spontaneous dislo-

cation may also occur as a complication of drug therapy.<sup>13-15</sup>

Many methods of treatment have been advocated. Among the surgical treatments recommended are articular disk extirpation with partial lateral pterygoid muscle detachment<sup>2,11,16-19</sup> and lateral pterygoid myotomy without disk extirpation.<sup>20</sup> After disk extirpation and partial lateral pterygoid myotomy, Boman<sup>18</sup> reported no recurrences of mandibular dislocation in 21 patients during a follow-up period ranging from three to 12 years.

Laskin<sup>20</sup> has modified the lateral pterygoid myotomy by leaving the disk intact and inserting a sheet of Silastic over the condylar neck to prevent reattachment of the lateral pterygoid muscle. After use of a bilateral procedure, he reported no recurrences of mandibular luxation in ten patients during a follow-up period of up to four years.

It appears that the lateral pterygoid myotomy and its modifications have the highest reported success rate of the surgical treatments available for correction of chronic mandibular dislocation. However, little is known regarding the ultimate fate of the lateral pterygoid muscle and its associated structures. In an experimental study in the rhesus monkey, Burke and McNamara<sup>21</sup> reported that the lateral pterygoid myotomy has only a transient effect on the function of the lateral pterygoid and certain other masticatory muscles. In this electromyographic study, they found that activity in the region of the lateral pterygoid muscle returned within a few days after myotomy and that within eight weeks, patterns of normal electromyographic activity had returned in all muscles studied. This study indicated that myotomy did not have a long-term effect on the function of the lateral pterygoid muscle, at least as observed electromyo-

graphically, casting doubt on whether the myotomy procedures indeed inhibited lateral pterygoid function. Other mechanisms which limited the mobility of the temporomandibular joint seemed to account for the success of clinical treatment.

The purpose of this investigation was to evaluate the lateral pterygoid muscle after detachment to determine if reattachment occurs after myotomy and, if it does, to determine the nature of the reattachment; to find out if reattachment can be inhibited by the use of a tissue-tolerated intermediary agent; and to ascertain what structural adaptations, if any, occur in the temporomandibular joint after lateral pterygoid myotomy.

■ *Materials and Methods*

Twenty rhesus monkeys (*Macaca mulatta*) were studied, five as experimental animals and 15 as histological controls. The five experimental animals were those previously used in the electromyographic study by Burke and McNamara.<sup>21</sup> Based on scales of tooth eruption,<sup>22</sup> three of the experimental animals were 6 to 7 years of age, one experimental animal was 5 to 5½ years of age, and one experimental animal was approximately 2 years 8 months old. Fifteen animals were used as unoperated controls; in this group, there were ten females, four males, and one animal of unknown sex. Thirteen of the animals were adults. One additional female was approximately 3 years old and another female was 5 to 5½ years of age.

**EXPERIMENTAL GROUPS**—The experimental animals were allocated to three groups. In the first group (two animals), a bilateral lateral pterygoid myotomy was performed. In the second group (one animal), a bilateral lateral pterygoid myotomy was performed, after which a piece of 0.007-in reinforced Silastic sheet was inserted bilaterally along the anterior and medial surfaces of the mandibular neck to prevent reattachment. In the third group (two animals), a bilateral lateral pterygoid myotomy was performed with unilateral insertion of reinforced Silastic sheet.

**SURGICAL PROCEDURES**—The lateral pterygoid myotomy was performed using procedures described by Boman<sup>17,18</sup> and Laskin,<sup>20</sup> as modified for use in the rhesus monkey.<sup>21</sup> After the surgical field was prepared, an inverted, modified hockey stick incision was made immediately anterior to the auricle. Its oblique component extended anterosuperiorly approximately 1.5 cm while its vertical component extended in a curvilinear fashion from the superior attachment of the pinna of the ear to the inferior attachment of the lobule. After the skin flaps were

undermined, dissection was begun in contact with the cartilaginous portion of the external auditory meatus, using that cartilage as a guide. The parotidomasseterica fascia was incised horizontally along the zygomatic arch. Parotid glandular tissue was retracted anteriorly and inferiorly. Once the temporomandibular region had been exposed, and sigmoid fascia incised, the lateral pterygoid muscle was identified and stabilized with a tenotomy hook. Both heads were freed from their mandibular attachments using curved scissors directed superiorly inferior and medially along the anterior and medial aspects of the condylar neck (Fig 1). In those animals in which Silastic was used,<sup>21</sup> a hole was made through the condylar neck and an appropriately sized piece of 0.007-in Silastic sheet was wired to the anterior and medial aspects, using 28-gauge stainless steel wire (Fig 2). The wound was then closed in an appropriate fashion. The animals received necessary veterinary care and dietary supplements until they had fully recovered from the effects of these surgical procedures.

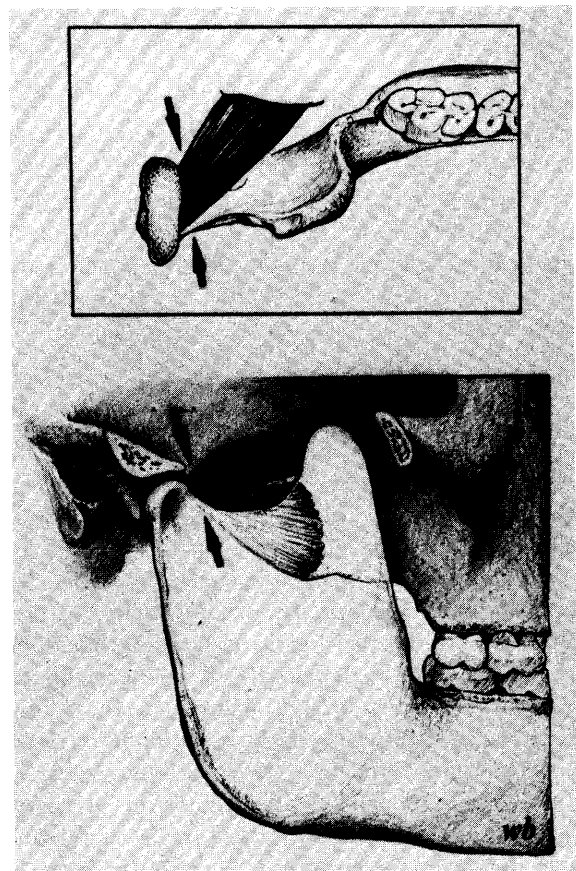


Fig 1—Representation of lateral pterygoid muscle in adult female rhesus monkey (arrows). During myotomy procedure, the two heads of the lateral pterygoid muscle were detached from their insertion on mandibular condyle.

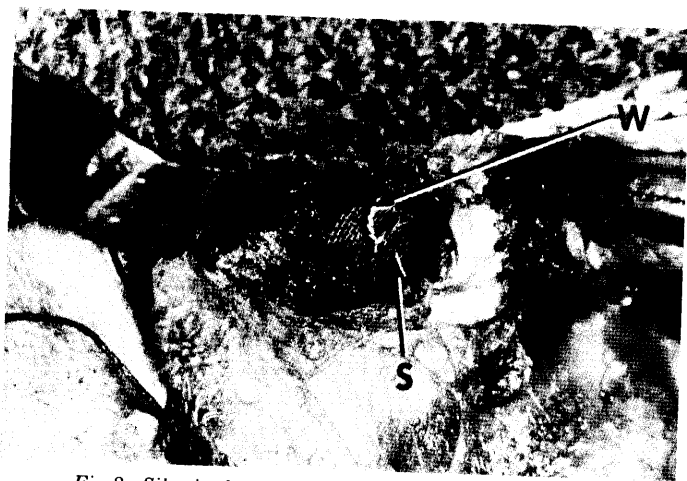


Fig 2—Silastic sheet (S) held in position in front of condyloid process with stainless steel wire (W).

**HISTOLOGICAL TECHNIQUES**—After an eight-week postsurgical period of electromyographic analysis,<sup>21</sup> the animals were killed by perfusing them with saline and phosphate-buffered Formalin solutions. The right and left temporomandibular joints and the surrounding tissues were removed en bloc and placed in Formalin solution. These tissue blocks were then decalcified in formic acid, embedded in celloidin, and serially sectioned parasagittally at 10 to 20  $\mu$ . One of every ten sections was stained with hematoxylin and eosin. The temporomandibular joints from the five experimental animals were compared with those from the 15 unoperated animals, which had been used in a previous study.<sup>23</sup>

#### ■ Results

**CONTROLS**—The histological findings in the control animals agree with those reported in the literature.<sup>23-26</sup> Relevant aspects of these observations follow and are shown in Figure 3.

Three layers of cartilage were observed on the condyle. The outer articular zone consisted of dense fibroelastic connective tissue, with collagenous fibers oriented parallel to the surface. The intermediate or proliferative zone contained densely packed spindle-shaped cartilage cells, with a basophilic ground substance. The inner zone contained maturing hypertrophic chondrocytes with a territorial matrix surrounding each cell. There was an inner region of endochondral bone formation beneath this zone. The relative thickness of the condylar cartilage was greatest in the younger animals. This cartilage was replaced by dense, fibrous connective tissue in older animals. In many adult animals, there was evidence of



Fig 3—Typical histological section of temporomandibular joint region from one of 15 control animals. Condyle (C), miniscus (M), articular eminence (AE), external auditory meatus (EAM), lateral pterygoid muscle (LP) (sagittal section; H&E, orig mag  $\times 6$ ).

the potential for continued condylar growth; however, in one very old animal, no condylar cartilage was observed. Periosteal resorption and endosteal deposition were seen at the site of the lateral pterygoid muscle attachment.

The articular surface of the temporal bone was covered by a dense fibroelastic connective tissue. Fibrocartilage and chondrocytes were commonly observed within the deeper layers. The glenoid fossa was flatter in older animals, apparently because of a higher rate of bone deposition at the surfaces of the fossa than along the articular eminence.

Various remodeling changes were observed in the region of the postglenoid spine; in some animals, these changes occurred along the major portion of the anterior border; in others, they occurred only at the tip.

The articular disk was continuous with the fibrous connective tissue of the condyle, medially and laterally. It blended with the retrodiscal pad posteriorly. Disk fibers attached to the joint capsule and perimysium of the muscle fibers of the lateral pterygoid muscle anteriorly. The epimysium of the lateral pterygoid muscle is attached to the ligament of the temporomandibular joint capsule and the condyle. Loose areolar connective tissue was seen anterior to the condyle.

**LATERAL PTERYGOID MYOTOMY**—Reattachment of the lateral pterygoid muscle occurred in all temporomandibular joint regions in which myotomy had been done. However, various adaptations occurred in



Fig 4—Temporomandibular joint after myotomy only. Lateral pterygoid muscle has reattached to condyle during 12-week postoperative period. Note increase in collagenous tissue in region of lateral pterygoid muscle reattachment (sagittal section; H&E; orig mag  $\times 8$ ).



Fig 6—Fusion of condylar head with articular eminence. In this animal, dense scar formation was sufficient to limit mobility of temporomandibular joint (sagittal section; H&E; orig mag  $\times 12$ ).



Fig 5—Condylar changes after myotomy only in left condyle of same animal as specimen in Figure 4. Note morphological changes in condylar region of this joint. Bone deposition has occurred along anterior border of the condyle region usually resorptive in control animals. Note dense scar formation and irregularities along superior and posterior head of condyle (sagittal section; H&E; orig mag  $\times 6$ ).



Fig 7—Fusion of condylar head with articular eminence. Increased morphological changes are observed in region of temporomandibular joint, including significant structural changes in condylar head. Note apparent fusion of condylar head with articular eminence. Fusion could lead to limitation of mobility on this side (sagittal section; H&E; orig mag  $\times 6$ ).

the morphology of these regions. For example, the articular surface of the condyle in the temporomandibular joint of one animal in which a lateral pterygoid myotomy had been performed was similar to that seen in unoperated controls (Fig 4). The opposite operated side demonstrated varying degrees of irregularity (Fig 5). The temporomandibular joints of two other animals showed fibrosis between the condyle, temporal surface of the joint, and the articular eminence (Fig 6, 7). Areas of active proliferation of

cartilage were observed on the posterior and superior articular surfaces of the condyle of one animal and on the superior articular surfaces of another animal. Variable remodeling of bone was seen anteriorly on the condyle at the site of the lateral pterygoid muscle attachment (Fig 5). Bone remodeling was also evident at the anterior and inferior aspect of the postglenoid spine and the temporal surface of the joint.

Except in one animal in which fibrosis had occurred, the articular disk was similar to controls in all cases.

**LATERAL PTERYGOID MYOTOMY WITH INSERTION OF SILASTIC SHEET**—Various changes were noted in those temporomandibular joints in the three monkeys in which myotomy and the placement of a Silastic barrier had been undertaken. One animal demonstrated fibrosis between the condyle, temporal surface of the joint, and the articular eminence. Active cartilage proliferation was observed on the posterior and superior articular surfaces of all condyles. In all cases, periosteal resorption and endosteal deposition were seen anteriorly on the condyle at the site of the lateral pterygoid muscle attachment. This had increased over control levels. Bone remodeling was observed at the anterior and inferior aspect of the postglenoid spine and at the temporal surface of the temporomandibular joint. The articular surface of the condyle was similar to that seen in unoperated control animals, bilaterally in one animal and unilaterally in the other animal. The articular disk was similar to controls in all cases except where fibrosis had occurred on the right side of one animal.

Dense, multidirectional connective tissue fibers were seen anterior to the condyloid process in the region of the sigmoid notch. These fibers appeared to encircle the Silastic sheet, forming a pseudocapsule and attaching to the temporomandibular joint capsule, meniscus, and sigmoid notch region (Fig 8). Fibers that appeared to originate from the lateral pterygoid muscle were interspersed with these fibers in an intimate relationship. Lateral pterygoid muscle fascicles appeared more prominent than in controls, with a greater thickness of connective tissue comprising the endomysium and perimysium. In several sections, cross striations were not as prominent as those observed in controls. Foreign body giant cells were not observed.

#### ■ Discussion

Results of the study indicate that the lateral pterygoid myotomy can cause profound structural changes within the temporomandibular joint. The clinical success of such procedures in preventing a recurrence of mandibular dislocation may be due to structural changes within the temporomandibular joint, rather than to detachment of the lateral pterygoid muscle. In a previous study using the same experimental animals,<sup>21</sup> the effect of the lateral pterygoid myotomy on the function of the lateral pterygoid muscle, as studied electromyographically, was transient. Although all electromyographic activity was usually eliminated in both the superior and inferior heads of the lateral pterygoid muscle, a gradual return of muscle function was observed in all cases. Electromyographic patterns of normal function could be

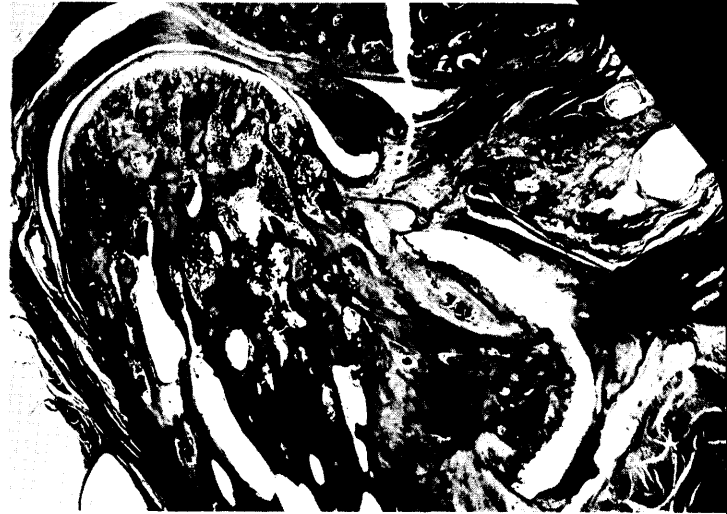


Fig 8—Temporomandibular joint after myotomy and insertion of Silastic sheet. Note formation of pseudocapsule around Silastic, which was removed before histological sectioning (sagittal section; H&E; orig mag  $\times 6$ ).

recorded from the lateral pterygoid muscle of all experimental animals eight weeks after surgery.

One of the mechanisms that has been hypothesized for the successful treatment of chronic dislocation by means of lateral pterygoid myotomy has been postoperative surgical scarring in the region of the temporomandibular joint. This hypothesis was tested in the current study. Microscopic analysis showed that the lateral pterygoid muscle reattaches, even where a tissue-tolerated agent (Silastic) is used in an attempt to prevent this reattachment. In these histological sections, it was obvious that a surgical procedure had been performed, as indicated by the presence of regenerating muscle fibers and by an increase in the connective tissue in the region. This increase in collagenous tissue occurred not only in the region of the temporomandibular joint, but was also evident in other areas. In some cases, fibrosis of the joint occurred. The amount of scarring evident was indicative of a reduction in the degree of movement possible in this articulation, supporting the hypothesis that postsurgical scarring may be an important factor in the clinical success of the lateral pterygoid myotomy.

To determine the completeness of lateral pterygoid muscle reattachment after myotomy, the region of the left temporomandibular joint of one animal was examined grossly by dissection after it was killed. A Silastic sheet had been inserted surgically along the mandibular attachment of the lateral pterygoid muscle on the opposite side only. The side examined grossly had fibrosis around the joint capsule. Although

there was dense scarring, the superior and inferior heads of the muscle remained distinct. Both heads appeared to have reattached in the regions of their preoperative insertions.

Another significant finding was evident in the histological sections. The majority of the postoperative temporomandibular joints had gross alterations in condylar surfaces in contrast to the mandibular condyles of the control animals. Several of the condyles of the experimental animals were characterized by surface irregularities and other alterations in morphology. Such changes in condylar morphology observed postoperatively may reflect the influence of altered lateral pterygoid function. This finding agrees with the research of Petrovic and associates,<sup>27</sup> who found that the lateral pterygoid muscle was the "final common link" in the various regulatory actions affecting the growth of the condylar cartilage. Altering the lateral pterygoid insertions may initiate remodeling events within the temporomandibular joint, particularly within the mandibular condyle. Mature animals that have relatively inactive compensatory mechanisms may not be able to fully adjust to these changes. Also, the lack of influence of the superior head of the lateral pterygoid muscle on the meniscus may initiate intracapsular changes through damage brought about by a lack of coordination between the meniscus and the condyle during joint excursions.

Another explanation for the observed condylar morphologic changes may be vascular disruption resulting from lateral pterygoid myotomy. Castelli and Huelke<sup>28</sup> have described the main vascular supply of the temporomandibular joint region. The main nutritional supply to the mandibular condyle arises from capsular arteries and arteries from the lateral pterygoid muscle, which penetrate cortical bone in the region of this muscle's insertion. The surgical procedure used in this study involves complete detachment of the lateral pterygoid muscle from its mandibular insertions, removing an important vascular source to the condyle. Depending on the potency and abundance of the capsular arteries, varying degrees of ischemia and localized nutritional deficiencies may occur, resulting in a spectrum of morphologic changes as observed in this study.

This study also investigated the use of a tissue-tolerated agent (Silastic) in preventing muscle reattachment. The finding of pseudoencapsulation of the Silastic sheet with muscle fibers reattaching around the capsule and to the surface of the condyle has important surgical implications. Even though muscle fibers did not physically penetrate the Silastic sheet, by reattaching to the pseudocapsule surrounding the sheet, the effect may have been the same as if they had

penetrated the barrier. The insertion of an inert barrier at the site of possible muscle reattachment still permits the muscle to function just as effectively, even though the muscle is not directly attached to the condyle.

One must be cautious when extending the findings of the study to clinical treatment in man. The experimental model used was not analogous to the human patient with a dislocation, as the rhesus monkeys presumably were normal. In addition, although basically similar, the temporomandibular joint regions of man and the rhesus monkey have certain morphological differences.<sup>25,29,30</sup> Nevertheless, certain conclusions may be drawn. According to the clinical criterion of a lack of recurrence of mandibular dislocation, the lateral pterygoid myotomy must be considered a successful procedure. However, biologically, this procedure may not be justified because of secondary morphological changes that may occur postoperatively from disruption of the lateral pterygoid muscle and the associated tissue and vascular supplies. In this instance, one type of pathologic condition may be substituted for another. The results of the study on the rhesus monkey indicate that other procedures may be preferable in the treatment of chronic mandibular dislocation.

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