INFLUENCE OF THE INNERVATION OF THE TEMPORO-MANDIBULAR JOINT CAPSULE ON MANDIBULAR BORDER MOVEMENTS

by

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Experiments carried out on the knee joint of cats (*Skoglund,* 1956) have shown that joint receptors of the Ruffini type are optimally sensitive in certain positions of the joint; furthermore, different groups of receptors fire in different sections of the movement range. Other animal experiments (*Ekholm, Eklund & Skoglund,* 1960) indicate that stretching of the medial collateral ligament in the knee joint elicits reflex effects in the flexor and extensor muscles of the joint. It has also been assumed that such reflexes would be elicited via tension receptors in the ligament, thus serving as a ligamento-muscular protective reflex. *Ekholm et al.* (1960) as well as *Stener & Petersén* (1962) were apt to think that pain receptors could contribute to the elicitation of these reflexes.

Nerve endings, both free and complicated ones; were found to be present in the temporo-mandibular joint capsule and its lateral ligament (*Thilander,* 1961). Injection of small amounts of anesthetics into the lateral part of one or both capsules caused a significant impairment of the mandibular position sense. It was concluded that this impairment was due to blocking of the receptors and afferent nerves of these structures.

Posselt (1952) showed that border movements of the mandible in normal individuals were reproducible. His findings would seem to support those of *Aprile & Saizar* (1947) and *Årstad* (1954). The participation of the temporo-mandibular joint cap-

sule and its ligaments in limiting posterior movements of the mandible have been discussed by *Boucher & Jacoby* (1961). They found the gothic arch tracing for individuals under influence of general anesthesia and curare to be posterior to tracings recorded by conscious individuals. *Boucher* (1961) by severing the temporo-mandibular ligament and capsule unilaterally found no change in the posterior relationship of the mandible; nor was the retruded position shifted to one side. He concluded from these results and from investigations in rats (*Boucher,* 1960), that neither the temporo-mandibular ligaments nor the capsule are responsible for limiting the posterior border movements of the mandible.

The present investigation attempts to establish whether a block of receptors and afferent nerves of the joint capsule and its lateral ligament would influence

1) the movement area on the median plane, including especially the terminal hinge movement, the gothic arch and the maximal opening,

2) the reflex (automatic) closure, and

3) the "guided closure".

MATERIAL AND METHODS

The subjects investigated were nine probationer nurses and one male dental student aged 19—24 years. All had normal occlusions with no signs of temporo-mandibular joint disorders. Sex, age and some occlusal characteristics of the experimental subjects appear from Table 1.

For the registrations each subject was placed in a dental chair with the back of the neck on the head rest, so that the Frankfort plane formed an angle of approximately 30 degrees in relation to the horizontal plane.

The recording appliance was similar to the one used by *Posselt* (1952), except that the means of fixation to the dental arches was an Occlusolator clutch (Fig. 1), one in the upper and one in the lower jaw. The movement area on the median plane was recorded by a stylus in fixed connection with the mandible on the above mentioned recording apparatus 6 cm in front of the facial aspects of the lower incisors.

Table 1

Sex, age and some occlusal characteristics of the experimental subjects.

Subject No.	Sex	Age	Angle class	Number of teeth	Vert. overlap	Horis. overjet
1. (B.L.)	F	21	I	28	2.0 mm	0.5 mm
2. (M.N.)	F	21	II	30	4.5 mm	5.0 mm
3. (E.O.)	F	19	I	28	1.5 mm	2.0 mm
4. (B.L.L.)	M	24	I	30	0.0 mm	0.0 mm
5. (M.A.)	F	19	I	28	3.0 mm	3.0 mm
6. (K.A.)	F	20	I	26	3.0 mm	1.0 mm
7. (K.M.)	F	20	I	28	1.5 mm	2.5 mm
8. (E.N.)	F	22	I	28	2.0 mm	2.0 mm
9. (G.S.)	F	19	I	27	2.0 mm	2.5 mm
10. (M.O.)	F	20	I	29	4.5 mm	1.0 mm
Total 10	9 females 1 male		9 Cl. I 1 Cl. II			
Average		20.5		28	2.7	2.2
Range		19—24		26—30	0—4.5	0—5.0

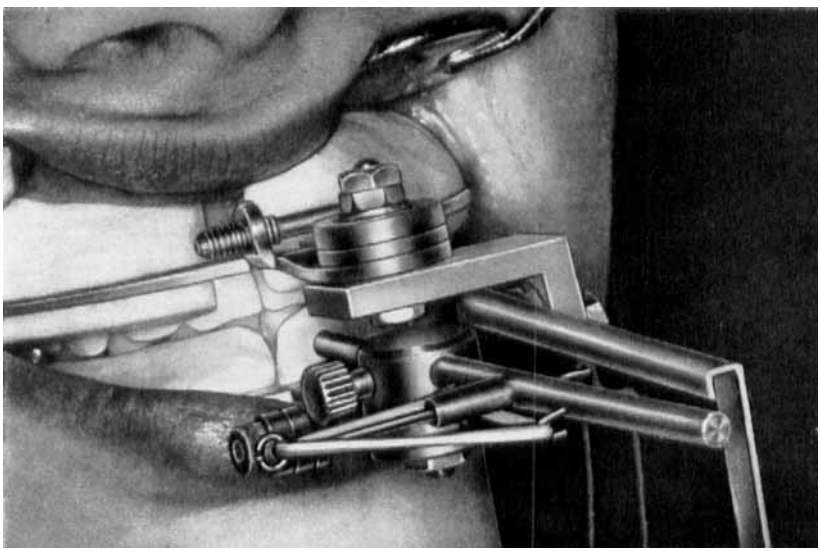

Fig. 1. The device for graphical tracing of the movement areas on the median plane. The stylus and the upper part of the tracing table is seen to the right. This device is fixed to the arms of the Occlusolator clutch which embraces the acrylic blocks visible labially to the upper and lower teeth.

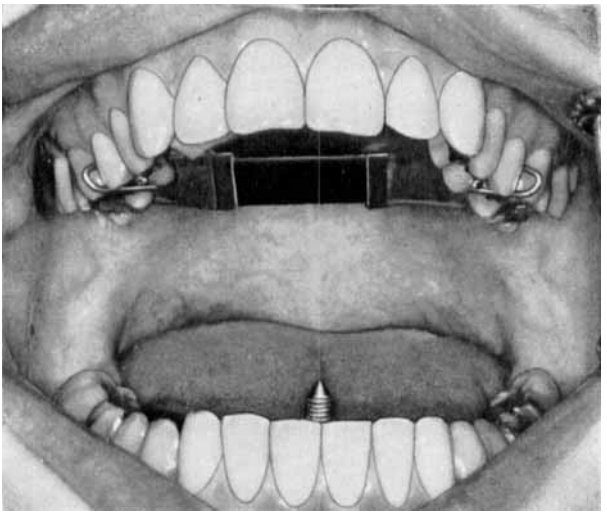

Fig. 2. The intra-oral tracing device *in situ*. The device comprises a lower plate with a pointed tracing screw which can mark the waxed exchangeable glass slides in the middle of the upper acrylic plate.

The gothic arch and various closures were recorded intra-orally by means of an intra-oral tracer of the type used by *Posselt* (1952). (Fig. 2).

Each series of registrations was made before and after injection of 0.3 cc Xylocaine laterally in the capsule. The injection technique was described previously (*Thilander*, 1961). The injections were made uni- and bilaterally. Further, on every second subject the same amount of physiologic saline solution was injected bilaterally as a check. The sequence of all the experiments varied. However, sufficient time was allowed to elapse between the experimental series (2—4 hours after anesthesia) so that the single recording would not be influenced by the conditions from the previous experiment.

Registrations, *extra-orally* under each experimental condition, comprised five registrations of the movement area on the median plane. The waxed glass slides were etched by means of fluoride and measurements were made on the etched slides.

The square sizes of the movement areas were measured by means of a planimeter. Double registrations of 20 areas were

made to determine the error of the measurements. This error was found to be small (0.47 mm^2, or 0.77 % of the mean of the square size of the areas) and can thus be disregarded.

The anterior border opening and the terminal hinge movement were measured metrically. The extent of the anterior border opening indicated maximal opening.

The experiments carried out *intra-orally* appear from Table 2. The differences on the small glass slides were measured according to the methods previously applied by *Posselt* (1952). Double registrations were made in order to investigate the error of the method as well as the error of measurement. These errors were small (0.12 and 0.09 mm, respectively) and can be disregarded.

Table 2

Type of intra-oral graphic registrations.

1. Arrow point tracing, passive with head reclined 30 degrees.
2. Arrow point tracing, active with head reclined 30 degrees.
3. Contact to the glass slide on terminal hinge closure.
4. Contact to the glass slide on repeated habitual closures.
5. Contact to the glass slide on "guided closure", i.e., passive relaxed closure guided by the hand of the operator.

Finally the angles formed by right and left posterior lateral border (gothic arch) movements obtained by intra-oral tracings Nos. 1 and 2 (Table 2) were measured. Direct enlargements were obtained in a dark room projector on photographic paper with an enlargement of 20 times. Both "legs of the angle" were extended by pencil lines on the photographic paper. This construction which entails some difficulties with regard to the sometimes indistinct copies of edgings were made twice and the medium angle measured.

RESULTS

The movement area on the median plane. – In all cases the movement area on the median plane recorded extra-orally increased after uni- and bilateral injection. Since the registrations were performed 6 cm in front of the lower incisors, the area recorded is larger than the one recorded at the incisal point.

Table 3

Increase in per cent of movement area in the median plane and length of terminal hinge and anterior border opening paths (maximal opening) with local anesthesia of the joint capsules as compared to the respective size and lengths without anesthesia.

Subject No.	Movement area			Terminal hinge movement			Anterior border opening			Maximal opening		
	1 % Xylocaine		Saline solution	1 % Xylocaine		Saline solution	1 % Xylocaine		Saline solution	1 % Xylocaine		Saline solution
	Unilat.	Bilat.		Unilat.	Bilat.		Unilat.	Bilat.		Unilat.	Bilat.	
1	3.4	5.7	0.7	—0.3	1.7	±0	1.3	2.0	—1.0	2.3	2.7	0.3
2	5.8	11.6	—	0.7	3.3	—	0.3	4.0	—	±0	3.7	—
3	10.4	20.9	—1.0	2.0	2.7	0.3	3.0	4.7	±0	1.7	4.0	—0.3
4	4.0	10.0	—	4.3	5.0	—	4.3	6.0	—	5.3	6.3	—
5	17..0	34.0	—1.3	5.0	8.7	—0.3	4.7	5.0	—0.3	3.7	4.0	—0.3
6	7.0	11.6	—	2.0	3.0	—	3.0	3.7	—	1.7	2.3	—
7	13.6	21.2	1.0	3.0	4.0	0.7	1.7	2.3	±0	1.3	1.7	0.3
8	9.6	12.3	—	1.3	2.0	—	1.7	4.0	—	1.3	3.7	—
9	20.0	31.1	±0	3.7	4.7	±0	5.7	6.7	0.3	5.0	5.3	0.3
10	4.0	10.0	—	—0.7	2.7	—	2.7	3.7	—	1.0	1.7	—
Mean	9.48 %	16.84 %	—0.12 %	2.30 mm	3.78 mm	0.14 mm	2.84 mm	4.21 mm	—0.20 mm	2.33 mm	3.54 mm	0.06 mm
± ε Mean	1.83	3.03	0.46	0.52	0.64	0.18	0.53	0.46	0.24	0.56	0.47	0.15

Therefore, the percentage increase was determined. Compared with the normal conditions (that is, with no injection) this increase was for unilateral injection 9.48 ± 1.83 per cent and for bilateral injection 16.84 ± 3.03 per cent (Table 3). It was evident that the only part of the movement area that was increased was the inferior (caudal) part (Fig. 3). This was evident from

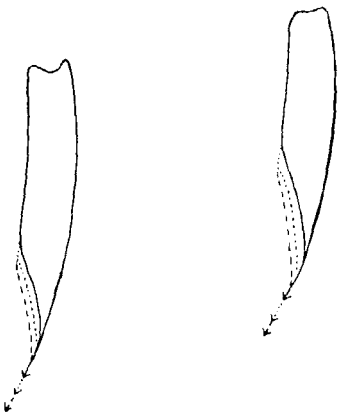

Fig. 3. Two movement areas recorded on the glass slide shown in Figure 1. Cases 1 and 4. The fully traced lines show the movement area on the median plane without local anesthesia.

..... indicates unilateral anesthesia.

– – – — indicates bilateral anesthesia.

observations of transfers of the movement areas in the three experimental conditions to one tracing. This could easily be made since all the glass slides are identically oriented in relation to the occlusal plane (through the Occlusolator clutch).

The terminal hinge path of movement was elongated by 2.10 ± 0.60 mm for unilateral and 3.78 ± 0.64 mm for bilateral anesthesia. The anterior border opening movement was elongated by 2.84 ± 0.53 mm and 4.21 ± 0.47 mm, respectively in both experimental conditions. The maximal opening movement was elongated by 2.33 ± 0.56 mm and 3.54 ± 0.47 mm, respectively, after uni- and bilateral injection (Table 3). The elongation of these movements resulted in an increase of the area. These values correspond to the lengths of the actual paths of the incisal point; for the elongation for these extra-oral measurements have been

calculated by registering also the exact maximal opening at the incisors.

Injection of saline solution did not result in any increase of movement area in the median plane.

The gothic arch tracing. — The intra-oral registrations demonstrated that no differences of the gothic arch tracings were observed with and without injection. This means that the retruded position did not shift under the various experimental conditions. Neither was the angle of the gothic arch tracing influenced by anesthesia.

The reflex (automatic) closure and the "guided closure". — The range of points obtained by these closures were not influenced by the different experimental conditions.

DISCUSSION

In border movements of the mandible, the temporo-mandibular capsule and its ligament become somewhat tense (*Rees*, 1954). This seems to be most marked in the maximum opening position. It has already been mentioned that stretching of the medial collateral ligament of the knee joint in the cat elicits reflex effects in the flexor and extensor muscles of that joint. *Palmer* (1958) stated that an afferent flow from a joint can activate the muscles so as to protect the joint. On anesthetising the temporo-mandibular capsule with its lateral ligament a slight increase of the inferior (caudal) part of the movement area on the median plane was observed. It was felt that this was caused by blocking of the receptors laterally in the capsule. The afferent flow would therefore be decreased, so that the activation of the jaw muscles would not be the same as before anesthesia. This would suggest that in extreme opening movements (for instance, yawning) the receptors in the joint capsule elicit a protective mechanism reducing the risk of subluxation of the condyle.

The fact that local anesthesia did not influence the other recorded border movements of the mandible may mean that the lateral portion of the capsule in maximum opening position is stretched more than in other border positions.

When the capsule is anesthetised the free nerve endings laterally are, of course, also blocked. It is generally accepted that this type of nerve endings, with unmyelinated and myelinated fibres, is responsible for the perception of pain. As mentioned in the introduction to this paper, it has been found in other studies that pain may well be an important contributory factor in the reflex effects occuring in stretching of the ligaments. It is true that the subjects did not complain of pain in the joint at maximum opening position of the mandible, but it is indisputable that the position causes some discomfort. Such an extreme position is, of course, obtained spontaneously in special situations, such as in yawning. As *Zotterman* (1939) has shown, not only pain but also tickling and itching are sensations elicited by thin afferent nerve fibres. It may be assumed that in the maximum opening position a weak stimulus of the free nerve-endings occurs that is not manifested as pain but as a less distinct sensation of discomfort. Blocking of the free nerve-endings might thus account for the ability of the mandible to open wider after anesthesia.

It is unlikely that the increase in the opening movement is due to habituation. The sequence of the different experimental conditions was varied. Only under anesthesia, both uni- and bilateral, was a wider opening position consistently recorded, thus even if this situation was the first of the various experimental series to be recorded.

Nor it is likely that the increase in the opening movement after anesthesia was due to the jaw muscles being affected by the injection. While there is certainly some diffusion of the small quantity of anesthetic injected directly into the lateral part of the capsule, it is improbable that this was sufficient to result in significant blocking of the receptors of the lateral pterygoid muscle, which is the one that would be affected by an injection.

Thus, while the receptors in the temporo-mandibular joint capsule would seem to participate in the positional perception of the mandible (*Thilander,* 1961, *Ransjö & Thilander,* 1963, *Larsson & Thilander,* 1964), they would seem also to be capable of eliciting a protective mechanism in extreme opening positions of the mouth. This border movement is thus the only one that is influenced. What is important is the fact that the retruded position did not change under the various experiments.

SUMMARY

After blocking the receptors of the lateral part of the temporomandibular joint capsule by local anesthesia of one and/or both temporo-mandibular joint capsules, the movement area on the median plane and the gothic arch together with certain openings were recorded (graphically).

Measurements were made of graphically traced border movements on 10 subjects with normal occlusions, 9 females and 1 male, aged 19—24 years. Series of registrations were made before and after injection of 0.3 cc 1 % Xylocaine laterally in the capsule. The injections were made uni- and bilaterally. Further, on every second subject the same amount of physiologic saline solution was injected bilaterally.

The most important observation was that the degree of retrusion of the terminal hinge movement and the gothic arch or arrow point tracing did not change after anesthesia. However, the inferior (caudal) portion of the movement area on the median plane was found to exhibit a significant increase in size of the magnitude of about 10 or 15 per cent for uni- and bilateral injections, respectively. The end points of the reflex (automatic) closures and the "guided closures" did not change.

The increase in size of the movement area on the median plane including the length of the terminal hinge opening and the maximal opening is likely to be due to blocking of the nerve endings of the lateral part of the joint capsule and its ligament. The lateral ligament may cause a protective mechanism in extreme opening movements which is eliminated through local anesthesia.

RÉSUMÉ

INFLUENCE DE L'INNERVATION DE LA CAPSULE ARTICULAIRE DE L'ARTICULATION TEMPORO-MANDIBULAIRE SUR LES MOUVEMENTS LIMITES DE LA MANDIBULE

Après avoir bloqué les récepteurs de la partie externe de la capsule articulaire de l'articulation temporo-mandibulaire par anesthésie locale de l'une des capsules articulaires ou des deux, les auteurs ont enregistré (graphiquement) l'aire de mouvement dans le plan sagittal médian et l'arc gothique et certains mouvements d'ouverture.

Des mesures ont été faites sur les mouvements limites enregistrés graphiquement chez lo sujets, dont 9 du sexe féminin et 1 du sexe masculin, âgés de 19 à 24 ans, et présentant tous une occlusion normale. Des séries d'enregistrements ont été faites avant et après injection de 0,3 cc de Xylocaïne à 1 p. 100 dans la partie externe de la capsule. Des injections unilatérales et bilatérales ont été faites. De plus, chez un sujet sur deux, des injections bilatérales de la même quantité de soluté physiologique ont été faites.

L'observation la plus importante a été que ni le degré de rétropulsion du mouvement maximum d'ouverture pure, ni le tracé de l'arc gothique n'étaient mocifiés après anesthésie. Cependant, un agrandissement significatif de la partie inférieure de l'aire de mouvement dans le plan médian a été mis en évidence, agrandissement de l'ordre de 10 p. 100 pour les injections unilatérales et de 15 p. 100 pour les injections bilatérales. Les points terminaux des fermetures réflexes (automatiques) et des "fermetures guidées" étaient sans changement.

L'agrandissement de l'aire de mouvement dans le plan médian comprenant la longueur du mouvement maximum d'ouverture pure et le mouvement d'ouverture maximum peut probablement être expliqué par le blocage des terminaisons nerveuses de la partie externe de la capsule articulaire et de son ligament. Le ligament latéral externe déterminerait lors des mouvements extrêmes d'ouverture un mécanisme de protection qui se trouverait éliminé par l'anesthésie locale.

ZUSAMMENFASSUNG

DER EINFLUSS DER INNERVATION DER KIEFERGELENKSKAPSEL AUF DEN BEWEGUNGSUMFANG DES UNTERKIEFERS

Nach Blockierung der Receptoren des lateralen Anteils der Kiefergelenkskapsel mit Lokalanaesthesie eines/oder beider Kiefergelenkskapseln wurde das Bewegungsausmass auf der Medianebene und der Gothischen Bogen zusammen mit bestimmten Öffnungsbewegungen grafisch wiedergegeben.

Die Messungen wurden bei grafisch registrierten Grenzbewegungen an 10 Patienten mit Normalocklusion (9 weibl., 1 männl. Patient) im Alter zwischen 19 und 24 Jahren vorgenommen. Se-

rienregistrierungen wurden vor und nach Injektion von 0,3 ccm. 1 % Xylocain lateral in die Gelenkskapsel durchgeführt. Die Injektionen wurden uni- und bilateral ausgeführt. Ausserdem wurde bei jedem zweiten Patienten die gleiche Menge physiologische Kochsalzlösung bilateral injiziert.

Die wichtigste Beobachtung war, dass die hintere Scharnierbewegung und der Gothische Bogen sich nach Injektion des Anaesthetikums nicht verändert. Der caudale Anteil des Bewegungsfeldes registriert auf die Medianebene zeigte jedoch eine signifikante Zunahme in der Grössenordnung von 10 btw. 15 % für uni- bzw. bilaterale Injektion. Die Endpunkte der reflektorischen und der "geführten" Schliessbewegung veränderten sich nicht.

Die Grössenzunahme des Bewegungsfeldes auf der Medianebene einschliesslich der Länge der dorsalen Scharnieröffnungsbewegung und die maximale Öffnungsbewegung scheint von der Blockade der Nervenendigungen des lateralen Anteils der Gelenkskapsel und seines Ligaments abhängig zu sein. Das laterale Ligament scheint einem Schutzmechanismus bei extremen Öffnungsbewegungen darzustellen, der durch Lokalanaesthesie eliminiert wird.

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