Clinical Study on the Inter Articular Pressure of Temporomandibular Joint in the Patients with Temporomandibular Disorders

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CONTENTS

Ⅰ. Introduction

Active interarticular pressure results from the contraction of skeletal muscles.[1] Loading refers to the effect of active interarticular pressure on the joint surfaces due to muscle action as affected by resistance. As loading takes place some deformation of the articular tissue occurs as the synovial fluid is squeezed out. Excessive active interarticular pressure may be potentially damaging to the articular surfaces and constitutes overloading.

If loading of an articular surface is protracted, deformation of the tissue will continue to increase as the synovial fluid is expressed by compressive force.[2,3] The osseous articular surfaces have the propensity to remodel and therefore adjust to compressive force, provided it does not exceed the adaptability of the articular tissue;otherwise, degenerative change take place.[4] The articular disc, however, does not have this capability. It does not undergo cellular remodeling. Excessive pressure causes deformation or deterioration instead.[5]

To understand how the TMJ might be injuried or deranged we must know how the joint is loaded and under what functional conditions. Behavior of the condyle as it revolves and translates during function is clearly described in the multitude of studies over many years of tracking mandibular motion. So far, it can only be inferred that the human joint is loaded during tooth contact.[6]

Several investigators have sought to estimate the loading on TMJs. These studies can be conveniently divided into direct and indirect investigations. Mansour and Reynik(1975) measured bite forces in one subject and, using cephalometric landmarks, calculated moments about the condylar axis[7]. Hylander (1979) placed strain gauges below the TMJ ligament in *Macaca fascicularis* and *Macaca mulatta* and recorded bone strain during incisal biting, mastication, and isometric biting on a force transducer[8,9]. Brehnan et al(1981) placed a strain gauge on the articular surface of the condyle in *Macaca arctoides* and made recordings of one animal during incisal biting, mastication, and opening of the mouth.[10] Hatcher, et al. compared three-dimensional mechanical and mathematical models of the human skull altering masticatory load, muscle attachment direction and muscle force[13].

Invasive techniques for measuring TMJ forces directly by bone-strain gauges in monkeys have not been refined for use in human subjects[8,9,19,11]. Mathematical and mechanical models have been used to estimate joint forces in man. However, because of the complexity of the stomatognathic system, direct measurements are needed to substantiate these models[12,13].

The relationship of the interarticular pressure to the function and physiology of other joints such as the knee has been investigated widely. Although Roth, et al. have measured synovial hydrostatic pressure within the temporomandibular joint of the pig, *Sus scrofa domesticus*, utilizing "wick method" for the determination of fluid pressure in 1984[18], little information is available in the literature regarding synovial fluid pressure in the temporomandibular joint.

Measuring the synovial fluid pressure of the TMJ, under a variety of conditons, may provide some insight into not only the unique biology of this joint but to an understanding of some particular aspects of TMJ disease, as well as perhaps shedding some light on control TMJ disorders. The purposes of this present study is to record synovial fluid pressure during mandibular movement in human subjects who have temporomandibular disorders directly after arthrography taking.

II. Materials and Methods

1. Subjects

The 10 patients participating in this study were selected from those visiting during July—september, 1992 in the Department of Oral Medicine at the University of Dankook. Eleven temporomandibular joints of 10 internal derangement patients were subjected. These joints had one or more following symptoms;pain during function, noise, limitation of mandibular movement and had no masticatory muscle symptoms. Arthography was required for all of them to differentiate joint conditions. All subjects were female, and aged 19 to 56 (average age was 31.18).

Apparatus for measuring the interarticular pressure

Manometer*(Fig. 1) was used to measure the interarticular pressure. The specifications of this manometer were as follows

Range of measure
  low;0—19.99 mbar G
  high;0—100.0mbar G
Maximum overpressure
  1000 mbar G
Accuracy
  0.2% F.S(15—25′c), 0.3%F.S.(0—15′c, 25—50′c)

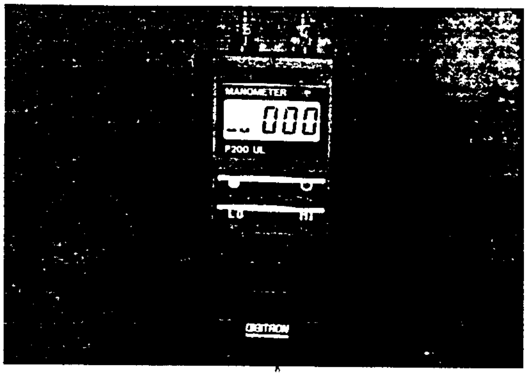

Figure 1. P200 UL Digital portable manometer of DIGITRON Instrumentation Limites, Made in U.K.

2.Methods

Prior to measuring the interarticular pressure, arthrography was performed. With the patient in a side back position, the head was placed on the examination table in the same position as for a transcranial projection. The preauricular region was cleansed with soap and antiseptic solution, anesthetized with lidocaine and draped. The lower cavity is cannulated in its posterior recess with 23 gage scalp vein set. Water—soluble iodine contrast medium, about

0.5cc, was injected under fluoroscopic observation into the lower cavity. Joint movements were studied and recorded to dignose joint disease. After arthrography, syringe containing contrast medium was removed gently and the manometer was connected to the cannula.(Fig 2) Measuring the interarticular pressure during opening and clenching was performed at every 5 seconds for 5 to 7 munutes. The patient was forced to move his mandible until the hydrostatic interarticular pressure was stabilized after the contrast media was resorbed. And then, the interarticular pressure was measured every 5 seconds during opening and clenching several times.

The results were analyzed statistically with one factor ANOVA and Paired t-test.

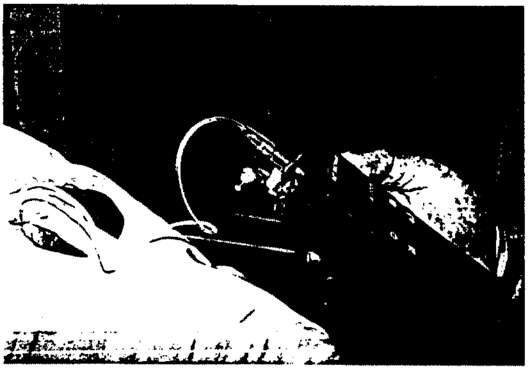

Figure 2. Recording of interarticualrsynovial fluid pressure after arthrography.

Ⅲ. Results

Distribution of site, age, diagnosis, amount of maximum opening, interarticular pressure at clenching and opening is shown at Table 1. Subjects were divided into three groups according to diagnosis confirmed by arthrography. Five subjects were belong to disc diplacement without reduction group, 3 subjects to perforation group, and 3 subjects to adhesion group. Adhesion, however, could not be detected arthrographically, so the diagnosis of adhesion was supported by clinical examination. Average interarticular pressure during opening was 55.16±98.07 mbar, and during clenching was 245 ±72.7 mbar. In total subjects, interarticular pressure during clenching was significantly larger than pressure during opening at significant level 99%(Table 2). Average interarticular pressure during clenching and opening of each group is shown at Table 3 and figure 1. There was significant difference between the interarticular pressure during opening and clenching in disc displacement wighout reduction group only ($p=0.371$). Differences among the means of the interarticular pressure in all groups during opening(Table 4) and clenching (Table 5) were tested by one way ANOVA test. Significant differences can be seen between disc displacement without reduction group and adhesion group.

Table 1. Distribution of site, age, diagnosis, amount of maximum opening, interarticular pressure during clenching and opening.

	site	age	Diagnosis	Maximum opening	Pressure at clenching	pressure at opening
sample 1	Lt	20	DD w/o Red	41	382.0	55
sample 2	Rt	49	DD w/o Red	26	226.5	74.5
sample 3	Lt	25	DD w/o Red	39	657.5	119
sample 4	Rt	20	DD w/o Red	40	233.0	115.5
sample 5	Rt	34	DD w/o Red	38	276.0	156
sample 6	Rt	56	Perforation	45	184.0	123.5
sample 7	Lt	20	Perforation	40	350.3	47.5
sample 8	Lt	19	Perforation	51	147.0	72
sample 9	Rt	44	adhesion	23	65.7	−207.5
sample 10	Lt	23	adhesion	44	54.5	−6.5
sample 11	Lt	33	adhesion	41	122.5	66.5
Mean±S.D.		31.18±13.18			245±172.7	55.16±98.07

(unit;mbar)

Table 2. Table showing the mean interarticular pressure of total interarticular pressure of total subjects during clenching and opening.

	Mean±S.D.	P value
Clenching	245±172.7	P=0.0022
Opening	55.16±98.07	

Table 3. Paired t−test between interarticular pressure during clenching and opening of total subjects according to diagnosis.

	Clenching	Opening	P value
DD w/o Red	355±180.19	104±39.79	0.0371
Perforation	227.11±108.3	81±38.79	0.2037
Adhesion	80.9±36.46	−49.17±141.9	0.2108

(uint;mbar)

Table 4. Results of one factor ANOVA for the interarticular pressure during clenching according to diagnosis.

	DD w/o Red (355±180.19)	Perforation (227.11±108.3)	Adhesion (80.9±36.46)
DD w/o Red			
Perfortion	−		
Adhesion	*	−	

*;P<0.05

Table 5. Results of one factor ANOVA for the interarticular pressure during opening according to diagnosis.

	DD w/o Red (355±180.19)	Perforation (227.11±108.3)	Adhesion (80.9±36.46)
DD w/o Red			
Perfortion	–		
Adhesion	*	–	

*;P<0.05

IV. Discussion

There were some investigations about interarticular pressure of synovial fluid of other joint and temporamandibular joint. in 1984, Roth, et al. measured interarticular synovial fluid pressure in the TMJ of pig[18]. In their study, interarticular synovial fluid hydrostatic pressure was subatmospheric with the jaw in the resting position(mean= −3.8 mm Hg). And fluid pressure increased as a response to operator−manupulated jaw position and returened to original levels upon release. In this study, recordings of interarticular pressure was significantly higher than those of their study. The means of interarticular pressure during opening and clenching were 55.16mbar(41.4mmHg) and 245mbar(183.88 mmHg). It is believed that these high pressures of human subjects in this study, comparing the Roth's study of animal subjects, were due to the contrast media remained in the lower cavity. Roth et al reported that the average hydrostatic pressure with the jaw in the rest position was subatmospheric and the pressure during active opening was lower subatmospheric than that in the rest position in their study. Although the interarticular pressure in the rest position was not measured in this study, it is suggested that interarticular pressure during opening was also subatmospheric if the contrast media were not used. Further research, therefore, is required to investigate the interarticular pressure in the rest position of human subjects, using same method without contrast meida.

In Hylander's study using bone strain gauge in monkey, TMJ is loaded with compressive forces during mastication, isometric molar, and incisor biting. Loads are larger on the contralateral side during mastication and isometric molar biting.[8,9] Hohl and Tucek (1982) implanted a force−recording condylar −neck prothesis in a baboon. The results of these investigations confirm the belief that the condyle, at least in these primates, is loaded during several function activities of the mandible.[11] The interarticular pressure was significantly higher during clenching than opening in this study. This result indicates that the synovial fluid pressure of TMJ is increasing as the condyle is loaded during clenching.

Roth et. al. reproted that fluid pressure on active opening before chewing was decreased under the pressure of rest position, although fluid pressure on passive opening was not decreased. In this sutdy, the fluid pressure on maximum opening was also decreased obviously. It is, therefore, confirmed that the pressure on opening is released more than that of rest position, although it is active movement. The actual biologic significance of the decreasing pressure response, observed as the experimental animal opened its mouth to receive food in Roth's study and the human subjects opened maximally in this study, is not presently understood. It seems, however, that a more negative pressure within the cavity of the TMJ would promote fluid trasnsport into the joint space from extracapsular tissues, eliciting only a transient decrease in pressure.

The relation of synovial fluid to the biology of other articulations has studied by a number of investigators. Investigation dealing with pathology associated with an abnormal fluid pressure in synovial joints have been widely reported. For example, Ekhlom and Narback studied the effect of strenous exercise on pressure volume reationshiops within the knee joint[19]. They held that pressures are generated which are high enough to interrupt the flow of blood to the joint, possibly causing ischemia to the synovium for short periods of time. Similary, Edlund[20] and Levick[21] describe a "breaking point phenomenon : within the rabbit knee joint. Accordingly, excessive intracapsular pressure may "break" the pulsatile flow (capillary flow) to the joint, providing a means for potential damage to the synovium.

The relationship of joint fluid pressure to chronic conditions such as arthritis has been investigated extensively as well. Caughey and Bywaters[22] determined that intra-articular fluid pressure was elevated in patients suffering chronic knee problems. Likewise, Geilberger monitored the intra-articular pressure of patients with chronic hip problems and found that the fluid pressure was significantly above normal. Jayson and Dixon conducted a series of investigations on patients afflicted with rheumatoid arthritis of the knee and discovered that interarticular fluid pressure of rheumatoid knees were significantly higher than controls and that increased intra-articular pressure could interfere with circulation to the synovium.[15,16,17]

Like preceding description, it is believed that interarticular pressure of synovial fluid is important to understand TMJ pathology on the basis of the result that marked rises in TMJ interarticular pressure were observed during clenching in this study. As a result, it is suggested that prolonged joint use, like bruxism or clenching habit, may cause sustained high pressure and the damage in the synovium of TMJ.

There was significant difference between interarticular pressure during opening and clenching only in disc displacement without reduction group of all groups in this study. In addition, the interarticular synovial fluid pressures of disc displacement without reduction group, during opening and clenching, were higher than those of adhesion group significantly, althought there were no significances between perforation and adhsion group, and between perforation and disc displacement without reduction group. It is believed that the sample size was very small in this study and significant differences, therefore, could be detected among the groups according to diagnosis, and between interarticular pressure during opening and clenching in all groups if the sample size were enough to large for the statistics.

This study can be a basic knowledge about interarticualr synovial fluid pressure of human TMJ in vivo. Our results point to the necessity of further study about condition which can affect interarticular pressure, like malocclusion, parafunction, head posture, etc. Effective treatment of temporomandibular joint disorders will likely be directly linked to carefully controlling the these conditions.

V. Summary and conclusions

To compare the interarticular pressure of temporomandibular joint during opening and clenching, we have measured interarticular pressure directly at 11 joints of 10 patients who have temporomandibular disorders after arthrography. The results are as followes

1. In total subjects, interarticular pressure is larger during clenching than opening.

2. Interarticular pressure of disc displacement without reduction group, during both opening and clenching, is larger than that of adhesion group.

On the basis of above results it is concluded that interarticular pressure of human temporomandibular joint is changing during mandibular function and is altered according to the intraarticualr condition.

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악관절장애 환자의 악관절내압에 관한 임상적 연구

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[국문抄錄]

1. 악관절내의 활막액의 압력을 측정하여 그 변화를 조사 비교함은 악관절의 독특한 생리와 병태생리적 기전을 파악하는데 도움이 된다. 뿐만아니라 악관절 장애를 진단하고 치료하는데 있어 새로운 해결 가능성을 제시하기도 한다. 따라서 본 연구에서는 악관절 장애환자 중 악관절 조영술로 악관절의 하관절강 압력계의 검침이 자입된 것을 확인 후 개폐구시 관절내압을 측정하여 비교분석한 결과 다음과 같다.
1. 전체 관절에서 이악물기시의 관절내압이 개구시 보다 증가하였다.
2. 관절내 상태에 따라 비교하면, 비정복성관절원판변위 환자군의 관절내압이 유착환자군보다 이악물기 및 개구시 모두 높았다.