Three-dimensional Radiographic Evaluation of Condyle Poles in "Closed-lock" Syndrome

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A radiographic study of 39 cases of "closed-lock" syndrome using three radiographic projections, finding approximately equal involvement of medial and lateral poles in long-standing cases.

KEY WORDS: · CONDYLE · TEMPOROMANDIBULAR JOINT · X-RAY ·

There is no lack of awareness of the importance of the temporomandibular joint among dental professionals, but much still remains to be learned about this enigmatic area. Screening of all patients for possible temporomandibular problems has been recommended (GRIFFITHS 1983), and a radiographic examination can be an important part of follow-up evaluation of the joint. Consistency and reproducibility are important factors in maximizing the utility and safety of X-ray diagnosis.

A reasonably normal range of mandibular movement should encompass an opening of at least 40mm and 8-10mm of lateral movement at the incisors (TANAKA 1984). Normal joints exhibit no sliding movement between condyle and disc, because the disc is firmly attached to the condyle head at its poles. It is this disc-condyle complex which articulates with the the posterior slope of the articular eminence of the temporal bone (THOMPSON 1985).

BELL (1984) states that deterioration of the attachment of the disc to the condyle poles must occur before gross displacement or sliding movements of the disc on the condyle are possible. Gross anterior displacement of the articular disc is therefore preceded by damage to the disc-condyle complex, with concomitant damage to the elastic retrodiscal lamina as well. Tanaka adds that at the same time there is progressive degeneration or breakdown of the ligament attachment to the poles, loss of contour of the disc, and subsequent remodeling or degeneration of the articulating parts.

PERRY (1982), in evaluating the limits of mandibular movements, states that they may be due to aberrations of the condyle-disc-fossa relationship, or more likely to muscle spasms (splinting) around a painful poorly functioning joint.

FARRAR ET AL. (1982) describe the course of internal derangement as a continuous process. The first sign is the anterior displacement of the disc from the articulating surface with posterior displacement of the condyle head. This displacement can lead

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to stretching of its posterior attachments. An opening click occurs as the condyle moves under the posterior band into the intermediate zone. The clicking usually begins as an early opening click, which can progress to an intermediate opening click and eventually a late opening click.

The more stretched and loose the disc attachments, the later the click occurs during opening. The disc is pushed anteriorly on opening, and may eventually function as a mechanical obstruction to opening, causing what is commonly called a "closed-lock" situation.

The maximum opening in a closed lock is 20-25mm, and the joint does not click (HELME 1983). There is a shifting toward the affected side on opening because of the restriction of anterior movement. Restricted movement is usually preceeded by a period of clicking, although clicking in the joint is not a reliable predictor of restricted movement.

A recent study by ROBERTS ET AL. (1985) confirms these limitations in unreduced disc displacement cases in which arthrographic diagnosis was compared with the range of mandibular motion.

The condyle may "lock" during these clicking stages (MCCARTY, 1980). In some cases, it may first "lock" intermittently and then progress to a chronic "closed lock."

There is severe limitation of movement in the acute stage, while in the chronic stage there is more opening due to the stretching of the bilaminar ligament. In the typical "closed-lock syndrome," the disc is displaced anteriorly throughout the opening and closing cycle, and the disc in this position prevents a normal range of condyle translation.

The purpose of the present paper is to study the question whether progressive changes occur at the poles when internal derangements advance through the stages of clicking, acute locking, and intermittent locking to chronic locking. An additional objective is to determine whether remodeling or degenerative structural changes which may occur in the condyle poles when a patient exhibits a "closed-lock" syndrome are radiographically discernible.

— Materials and Methods —

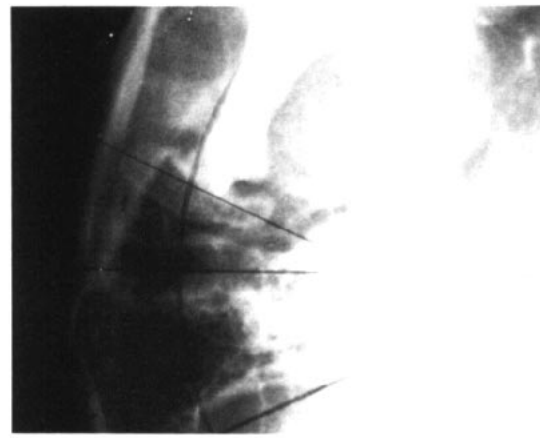
The study population consisted of those patients who were seen in the office of the Author since October, 1983 with symptoms of temporomandibular dysfunction. All had study casts, lateral and P-A skull radiographs, panelipse, temporomandibular joint radiographs, and extraoral and intraoral photographs.

The radiographic examination of the temporomandibular joint consisted of a submental-vertex (Fig. 1A) and horizontally-corrected parasgittal tomographs in closed (Fig. 1B), rest, and open positions. Since October, 1983, a transorbital projection (Fig. 1C) has also been used. Figure 1 shows the left temporomandibular joint of one of the chronic "closed-lock" patients in this study.

A Quint Sectograph is used in the study. The subject sits upright in this machine, with the head positioned in the head holder. Duplication of position is possible for follow-up. One hundred and fifteen (115) full series were taken between October, 1983 and September, 1985. Patient age ranged from 11 to 72 years. From this group of patients, 39 who exhibited symptoms of acute, intermittent, or chronic "closed-lock" syndrome were selected and divided according to duration of the unreduced condyle-disc relationships.

Those with less than two months duration are designated as acute. The chronic cases are considered to be those that were unreduced for more than two months; duration in the subjects in this study ranged upward to four years. The intermittent group experienced episodes of

Figure 1
Left
Temporomandibular Joint



1A
Submental-Vertex projection

1B
Horizontally corrected
Parasagittal Tomograph
with the Mandible closed

1C
Postero-anterior
Transorbital projection

"locked" jaw with recovery over the last few years.

All 115 radiographic records were evaluated with specific emphasis on changes in the morphology of the lateral and medial poles. Additionally, those changes that were seen in other areas of the condyles were also evaluated.

Variations from normal were diagnosed after the discipline of FARRAR ET AL. (1982), who reported that in the chronic phase the condyle begins to seat more superiorly into the stretched and herniated bilaminar ligament with resultant degeneration or remodeling changes superiorly (peaking) and ostephytic deformation anteriorly (beaking). Remodeling of the condyle poles is occurring at the same time, due to herniation of the attachment of the disc laterally and medially. They state that peripheral proliferation into these affected sites results in the remodeling. Nomenclature is also adapted from Farrar.

As a control for evaluation of the various radiographic projections, a dried skull was prepared in a manner somewhat similar to that described by ROSENBERG ET AL. (1982). Identification markers were placed on the right condyle as follows: on the lateral pole a horizontal wire, on the superocentral surface a vertical wire, and on the medial pole an oblique wire. The disc was simulated by wax about 3mm thick, and a 30mm space was used in the open position when taking the transorbital view. A full temporomandibular x-ray series was taken on this skull, including the basilar and transorbital exposures.

— Findings —

Population sample

The patient sample consisted of 115 cases (Table 1), of which 39 (33.9%) exhibited the "closed-lock" syndrome. Ten were acute, 12 intermittent, and 17 chronic. Of the total sample, 99 (86.1%) were females and 16 (13.9%)were males. Of the "closed-lock" sample, 35 (89.7%) were female and 4 (10.3%) were males. Females constituted 90% of the acute cases, 75% of the intermittent and 100% of the chronic cases. Of the total sample, 42 (36.5%) were dental Class I, 63 (54.8%) Class II, and 10 (8.7%) were Class III. In comparing the dental classification among the "closed-lock" group (Table 2), 16 (41.0%) were Class I, 19 (48.7%) were Class II and 4 (10.3%) were Class III.

Dried Skull

The identification markers were invaluable in evaluating the various x-ray projections on the dried skull. The submental-vertex projection was found to be an important prerequisite for obtaining quality tomographs and accurately determining the angulation of the condyle with the ramus. Studies by BECKWITH ET AL. (1980) found that the condyle angulation can vary from 22° to 45° (mean 24°). The submental-vertex view can also be used to assess the symmetry of the condyles as well as variations in the medial and lateral poles.

In evaluating the tomographic projections, it was found that if they had not been corrected for the condyle angulation, superimposition of structures caused difficulty in reading the film, confirming the findings of WILLIAMS (1983) and BUSSARD ET AL. (1984) that accurate lateral tomographs are possible only by first using a submental-vertex view to determine the actual horizontal angle of the condyle head.

With the information obtained from the submental-vertex view, the angulation and depth of cut were determined for corrected orientation of the lateral tomograph. Different depths of cut are obtained by adjusting the focal plane. A technique for obtaining a lateral tomograph with correc-

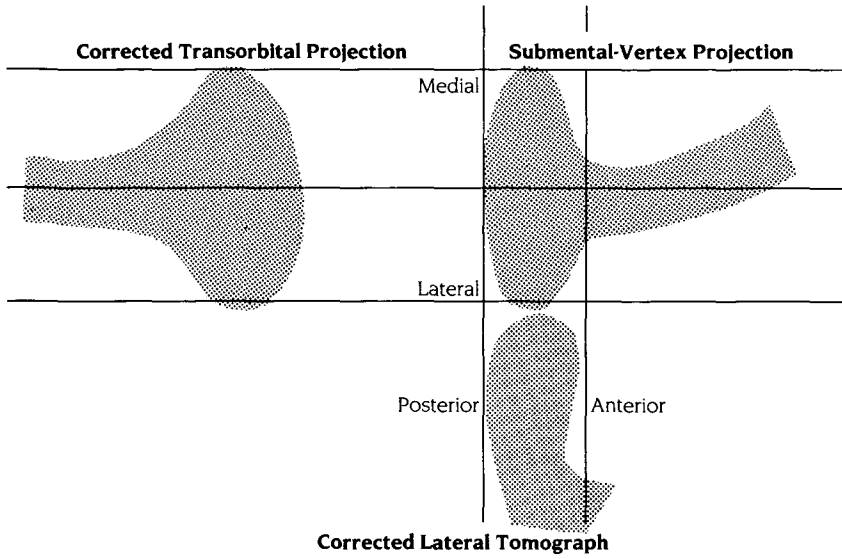


Figure 2
X-ray views showing all three dimensions of the condyle

Table 1

Age, Sex, and Dental Classifications of the total sample

Age	Sex	Total Sample Number	Dental Class I	II	III	"Closed Lock" Acute	Int.	Chronic	Total
10-19	M	5 (4.4%)	2	3	0	0	2	0	2
	F	16 (13.9%)	7	7	2	1	1	0	2
20-29	M	5 (4.4%)	1	3	1	0	1	0	1
	F	37 (32.2%)	11	23	3	6	7	4	17
30-39	M	3 (2.6%)	2	1	0	1	0	0	1
	F	32 (27.8%)	11	21	0	1	1	11	13
40-49	M	2 (1.7%)	2	0	0	0	0	0	0
	F	10 (8.7%)	3	4	3	0	0	1	1
>50	M	1 (0.9%)	1	0	0	0	0	0	0
	F	4 (3.4%)	2	1	1	1	0	1	2
All		115	42	63	10	10	12	17	39
		100%	36.5%	54.8%	8.7%	8.7%	10.4%	14.8%	33.9%

tion of both the horizontal and vertical angulations has been described by WILCOXON ET AL. (1985), but no attempt was made to correct for vertical angulation of the condyle in this study.

The transorbital projection is obtained with the jaw open, so that the condyles are below the eminence. The transorbital view is essential for evaluating the lateral and medial poles, and the superior surface of the condyle. This projection is taken in a posteroanterior direction. It was found that adjustment of angulation based on the submental-vertex view was also important for obtaining an accurate and readable transorbital film.

With the dried skull we found that a complete three-dimensional view of the condyle head (Fig. 2) requires all three projections, the submental-vertex, corrected tomographs and a corrected transorbital.

"Closed Lock"

A. LATERAL AND MEDIAL POLES

1. *Acute.*

Of the ten patients exhibiting an acute closed situation, only two showed any joint modification. One, with medial pole change, had a past medical history of a condyle fracture. The other, a 63yr-old female, showed only a slight defect in the lateral pole.

2. *Intermittent.*

Twelve patients had a history of intermittent "closed-lock," and eleven of these showed defects in one or both joints. Only one patient in this group had no radiographic findings of joint abnormality.

Of those with abnormalities, two had unilateral and nine had bilateral defects. Ten medial poles and eleven lateral poles were affected. Only one patient showed defects of both the medial and lateral poles. Four (16.7%) of the 24 joints showed no abnormalities, and two of those were in one patient.

3. *Chronic.*

All seventeen "chronic lock" patients exhibited changes in one or both joints. Two showed unilateral changes affecting only one joint. Lateral poles were abnormal in 20 joints and medial poles in 19 joints. Both the medial and lateral poles showed changes in 8 (24%) of the 34 joints.

Figure 3 shows examples of the lateral and medial pole morphology as viewed on a transorbital projection.

B. RADIOGRAPHIC CHANGES OTHER THAN IN THE LATERAL AND MEDIAL POLES.

1. *Acute.*

All joints of acute patients demonstrated an internal derangement with posterior displacement of the condyle head. It is the Author's interpretation that posterior displacement of the condyle head exists when the condyle head is distal to a central location in the fossa, with a resultant large anterior space. No evidence of any degenerative or sclerotic changes to the articulating surface was evident in these acute cases.

2. *Intermittent.*

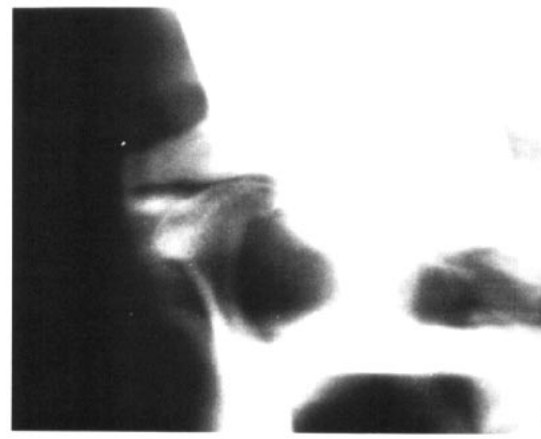
All joints of intermittent patients showed internal derangement or posterior displacement of the condyle. Seven (29%) of the 24 joints showed anterior osteophytic deformation. None showed peaking or changes in the superior surface of the condyle.

2. *Chronic.*

All joints of chronic patients showed posterior or internal derangement of the condyle. Twenty-five (74%) of the 34 joints showed anterior osteophytic deformation. Eight (24%) showed superior remodeling (peaking).

Figure 3
Transorbital Projection

3A
Remodeling of the Lateral Pole of the Condyle



3B
Remodeling of the Medial Condyle Pole

3C
Remodeling of the Lateral and Medial Condyle Poles

Secondary Findings

Three patients never exhibited a "closed-lock" or past medical history of trauma to their mandible or face. All three were females, and all presented with Class II dental malocclusions.

Table 2 shows the following defects in these joints. All six joints were affected; all exhibited clicking and posterior displacement of condyle heads. Five (83%) of the six joints exhibited anterior osteophytic deformation. Four medial poles and three lateral poles were affected. The degree of lateral and medial pole defect was similar to that seen on the chronic "closed-lock" cases.

— Discussion —

Unique findings of this study are that defects were found almost equally in the medial and lateral condyle poles. Secondarily, degeneration appears to be a progressive phenomenon. Finally, multiple radiographs, corrected for condyle angulations, are necessary to study all aspects of the condyle head.

TRANSITION FROM NORMAL TO "CLOSED-LOCK" SYNDROME

Changes in the head of the condyle, whether degenerative or remodeling, are related to the disturbances of the disc and its attachment to the condyle head. The anatomy of this area has been described by numerous authors (SICHER 1970, MORGAN 1982, THOMPSON 1986). The disc divides the joint into a superior and inferior space.

All translatory movements normally occur in the upper space and rotating movements in the lower space. The disc is attached to the condyle at its medial and lateral poles. It is contiguous posteriorly with the bilaminar zone, which consists of an upper laminar or loose fibroelastic tissue (elastin) and a lower of collagen fibers. Anteriorly, it attaches to the joint capsule and anteromedially to the superior head of the lateral pterygoid muscle.

MAHAN (1980) states that the superior head does not contract on mouth opening as does the inferior belly. It is only the tight attachment of the disc to the lateral and medial poles of the condyles that maintains the fundamental relationship between the disc and condyle during condyle translation.

In a healthy joint, as the condyle translates forward, the fibroelastic will hold the disc back between the condyle and articular eminence. However, during closure of the mouth the elastic tension is still present and the disc would tend to be displaced posteriorly without the contraction of the superior belly of the lateral pterygoid muscle to hold it forward during jaw closure. There is an equilibrium between the elastic tissue of the bilaminar zone and superior belly of the lateral pterygoid muscle when maximum pressure is applied. According to BELL (1983), the superior belly of the ptergyoid exerts anterior force on the disc only to the extent of muscle tone.

If the bilaminar zone is damaged and the tight attachments of the disc to the poles are loosened or torn, the normal tonus of the superior belly can displace the disc anteriorly. This would displace the condyle distally and produce an increase in the joint space seen anterior to the condyle on temporomandibular joint radiographs.

Radiography

In the acute "closed-lock" condition little radiographic change is found other than posterior displacement of the condyle head. In this study, the acute syndrome resulted from trauma (accident), stress, or iatrogenic factors such as third molar extractions which led to the imbalance of the disc-condyle relationship.

Table 2

Age, Sex, and Joint Findings in the 39 "Closed-lock" and 3 Non-locking Subjects

Patient	Age	Sex	Right TMJ	Left TMJ	Class	Clicking
Acute						
1	17	F	P	P	III	
2	29	F	P	P	II	
3	32	M	P	P	I	
4	20	F	P	P	I	
5	27	F	P	P	I	
6	33	F	P	P	II	
7	20	F	P	P	II	
8	21	F	P	P	I	
9	63	F	PL	P	I	
10	28	F	PM	P	II	
Intermittent						
11	25	F	LOP	LOP	II	R/L
12	27	F	P	LP	II	R/L
13	20	F	P	P	I	R/L
14	15	M	MP	MLP	II	
15	29	M	LP	LP	II	R/L
16	29	F	LOP	LOP	II	
17	17	M	LP	MP	I	
18	34	F	MOP	MOP	II	
19	14	F	MP	MP	II	
20	27	F	P	LOP	II	R/L
21	24	F	LP	LP	I	R/L
22	28	F	MP	MP	III	
Chronic						
23	34	F	LOSP	LOSP	I	
24	39	F	P	MOP	I	
25	24	F	MP	MP	II	
26	36	F	MLP	MLP	I	
27	34	F	LP	LP	I	
28	24	F	MOP	MOP	II	
29	43	F	MOP	MOP	II	
31	38	F	MOP	MOSP	II	
32	38	F	LOP	MLOSP	I	
33	21	F	LOP	LOP	I	
34	30	F	LOP	MLOSP	II	
35	32	F	OP	MLOP	II	
36	20	F	LP	LOSP	III	
37	72	F	MOP	LOP	I	
38	32	F	LOP	LP	III	
39	32	F	MLOP	MOP	I	
Non-classified						
40	26	F	MOSP	MOSP	II	R/L
41	30	F	MOP	MLOP	II	R/L
42	37	F	LP	LOP	II	R/L

Once reduced by short-term splint therapy, physical therapy, or medication, these should show no residual effects unless the ligamentous attachments have been herniated or torn.

Additional defects were noted in intermittent locked patients. All showed posterior displacement, but only 29% showed osteophytic anterior changes. Changes in medial and lateral poles were about equally divided.

All chronic cases showed morphologic changes. Only 2 joints (6%) of the 34 showed neither lateral nor medial changes, but 8 (24%) showed changes to both poles. Again, the incidence of changes was almost equal between the lateral and medial poles.

In this study, a total of 29 (48%) medial and 32 (52%) lateral changes were seen in the intermittent and chronic cases. These findings are contrary to some prior reports. WATSON (1981 AND 1982) stated that the lateral pole is most often the first to show any change. Another study of dissections of cadaver joints showed primarily variation and degeneration of the superolateral and central surfaces of the condyle (ACKERMAN ET AL. 1984). The most common site of peripheral remodeling reported by FARRAR ET AL. (1982) was the anterolateral region of the condyle. The reasons for the differences in these various findings remain unresolved.

Remodeling

WILLIAMS (1983) and (FARRAR 1982, 1983) report that variations in the joint are due to articular remodeling in response to functional loads. Remodeling is a normal process that continues throughout life, maintaining an equilibrium between form and function. Excessive bone loss and degenerative changes can result from loss of this equilibrium. Table 2 shows a correlation between the disease state (acute, intermittent, or chronic) and the degree of morphologic change.

It should be noted that the remodeling that one sees in many cases is the successful adaptive change of the joints, not a degenerative breakdown. Whether these changes are degenerative or adaptive is difficult to differentiate radiographically.

WESTESSON (1985), in a study of 58 temporomandibular joint specimens, noted that anterior disc displacement precedes disc deformation. Those cadavers with normal disc positioning rarely showed morphologic changes. Joints with complete anterior positioning (unreduced) or locking showed disc deformation in 77% and irregularities in 65%. He advises early treatment to correct internal derangement and decrease the possibility of disc deformation.

Deformation of the disc is most extreme in unreduced joints, with a definite relationship between internal derangement and deformation. The amount of disc deformation due to dislocation is an important factor in whether the disc can be reduced and maintained. Those that have undergone a significant amount of distortion cannot be reduced and stabilized.

CARLSSON ET AL. (1979) state that the disc lacks the capability for remodeling, and that long-standing compressive forces at the lateroanterior head of the condyle can lead to degeneration and eventual perforation.

Data in the present study supports the concept that increasing damage can be expected with extended duration of joint dysfunction.

Radiographic Projections

The radiographic examination should be standardized as much as possible to optimize documention of future changes,

and the films should give clear images of the size, shape and position of the different structures of the joint in all three dimensions. The dried skull studies show that a submental-vertex, a corrected para-sagittal tomograph, and a postero-anterior transorbital projection with the mouth open give that three-dimensional picture.

At times, the anatomy of the condyle is obscured in a "closed-lock" patient by the articular eminence and the root of the zygoma. In this situation, GUSCHING (1983) and ROZENCWEIG (1975) have suggested arthrography as means to get better visualization of the superior articulating surface.

Arthography was not used in this study because even though it can demonstrate perforation of the disc or capsule, as well as condyle-disc displacement, it is a much more invasive procedure not without serious iatrogenic potential. MANZIONE (1984) states that not only is it invasive, but it cannot demonstrate bone anatomy with sufficient detail, so it must still be supplemented by tomographs.

Computerized tomography, in contrast to arthrography, is only radiographically invasive, but according to WILKINSON (1983) it is not suitable for showing opening and closing movements or disc dynamics.

Those procedures should probably be reserved for patients with severe pain and clinical symptoms in whom conventional radiography has failed to reveal any pathology or derangement.

— Summary —

This study demonstrates that the lateral and medial poles must be studied in evaluating "closed-lock" or internal derangement cases because changes in those structures do occur in these cases. The data shows that changes occur almost equally on the medial and lateral poles of the condyle.

Treatment of "closed-lock" cases should be instituted when detected, in an effort to reduce the displaced disc and hopefully improve the possibility for the most favorable remodeling of the joint.

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