Corrected Parasagittal Direct CT Imaging of the Temporomandibular Joint

With arthroscopic correlation

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Direct CT studies of the temporomandibular joints, using axial, coronal, and condylar axis corrections for parasagittal views perpendicular to the long axis of the condyle head to provide detailed CT examination of the bony structures and associated soft tissues. Images of selected patients are correlated with arthroscopic evaluation and treatment, yielding a unique perspective for evaluation of the imaging method and the joint itself. Based on these findings, a hypothetical mechanism of TMJ derangement is proposed.

KEY WORDS: • ARTHROSCOPY • COMPUTERIZED TOMOGRAPHY • • RADIOGRAPHY • TEMPOROMANDIBULAR JOINT •

Imaging of the temporomandibular joint is still in its infancy. Although this joint is arguably the most complicated in the body, it has received widespread clinical and research attention for only a relatively short time. Although transcranial films and tomographic views have been in use for some years, contrast arthrography was not described until 1978; Computerized Tomography (CT) studies specifically for evaluation of the temporomandibular joint were first described by SUAREZ IN 1980.

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Numerous articles followed, advancing the techniques of axial scanning, coronal scanning, and computer reformatted sagittal depictions of the joint. A natural progression of thought led to the direct sagittal scanning of the TMJ at several academic centers, as well as at our community hospital.

The value of correcting sagittal radiographs for the condyle angles has been described by WILLIAMS (1983), AND WILSON AND WILLIAMSON (1976), but a search of the literature has not revealed any articles describing the use of this correction in direct parasagittal CT studies of the joint.

In 1983, Dr. Michael Alpern expressed his interest in exploring the use of CT as a method of evaluating the temporomandibular joint. He was persistent, and eventually my scientific curiosity was aroused. Our experience and interest in the techniques of CT scanning, combined with the concept of condylar axis correction in parasagittal studies of the joint, led to what we believe is a unique method of patient examination.

A wealth of arthroscopic experience was contributed to the team by Dr. Douglas Nuelle, who has developed an elegant technique of TMJ arthroscopy done in cooperation with Dr. Alpern. This has afforded us an exciting opportunity to correlate the imaging studies in vivo.

These studies have led us to the verge of a far greater understanding of the joint and its mechanics. We believe that these correlations of arthroscopic observations with prior diagnostic imaging offer a new way of looking at the joint that is relatively free of the artifacts of conventional radiography, surgery, and histologic study.

— Methods —

Selected patients referred for CT study by general dentists or specialists in our referral area were examined using a Philips Tomoscan 310 CT scanner. Prior to the development of this technique, we had installed an option called Macroview, which enables the scanner to achieve images with the highest resolution available.

An additional unique factory option, the Neuro Sagittal Scanning kit, was installed specifically to provide precise positioning for TMJ studies. The sagittal kit gives us a way to control the level of scanning more exactly than any of the several alternative methods described in the literature.

Initial clinical evaluations were performed by Dr. Alpern or other referring dentist. These were supplemented by a questionnaire devised to provide the radiologist with the clinical information needed for optimal planning and interpretation of the examination.

A dried skull specimen was initially imaged to develop the data acquisition techniques for patient studies (Fig. 1). Of course, only bone window (density) techniques of image analysis were possible with the skull specimen; soft tissue optimization came only with studies on many patients and the adaptation of level detection mode as a form of computer highlighting of various specific densities.

Thus, the earliest patient studies were most useful for bone evaluation, but they were clinically worthwhile even at that early stage of development. As the procedure evolved, experience with the techniques enabled us to achieve progressively greater soft tissue resolution.

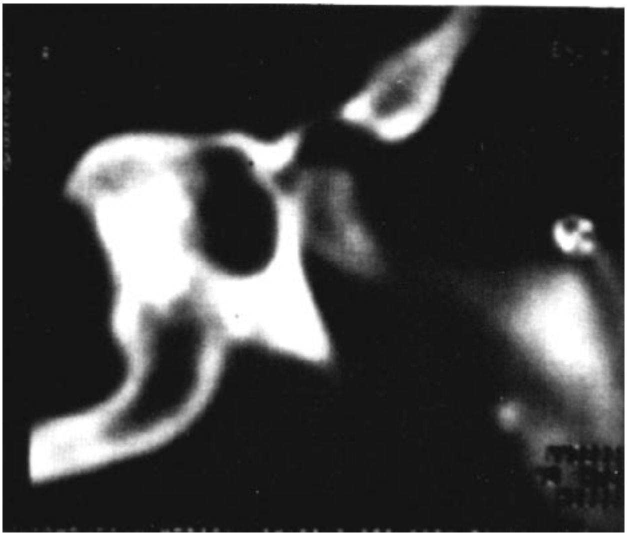

Fig. 1 Our first CT study corrected for condylar angle, performed on a dried skull.

Our first patient study was performed in February of 1984. We have since performed more than 145 studies, nearly all bilateral.

— Results —

The early stages of development of the techniques independently devised at our institution essentially paralleled those described in the current literature.

Of those patients who had discernible soft tissue about the condyle, very nearly all of those with TMJ pain and dysfunction were found to have varying amounts of "abnormal" precondylar soft tissue density located anterior to the mandibular condyle (Fig. 2). Current conventional wisdom holds that this material represents a displaced joint meniscus.

In addition, many patients were found to have bony deformities, with the radiographic changes mimicking the familiar degenerative changes common to the other joints of the body (Figs. 3-5). Peculiar condylar erosions were also encountered (Figs. 6 and 7). Other patients came to us with more hollowed-out defects of the condylar cortex (Figs. 8-11).

Some examinations done after the "first click" on opening demonstrated what appeared to be "recapture of the disk" as described in the literature (Figs. 12 and 13).

A particularly disturbing observation was made in one patient who manifested progressive condyle erosion observed only after the initiation of an accepted form of conservative splint therapy (Figs. 14 and 15). Several other patients on splint therapy were reevaluated in order to discern the effect of the splint. The splints did not always do what they had been expected to do.

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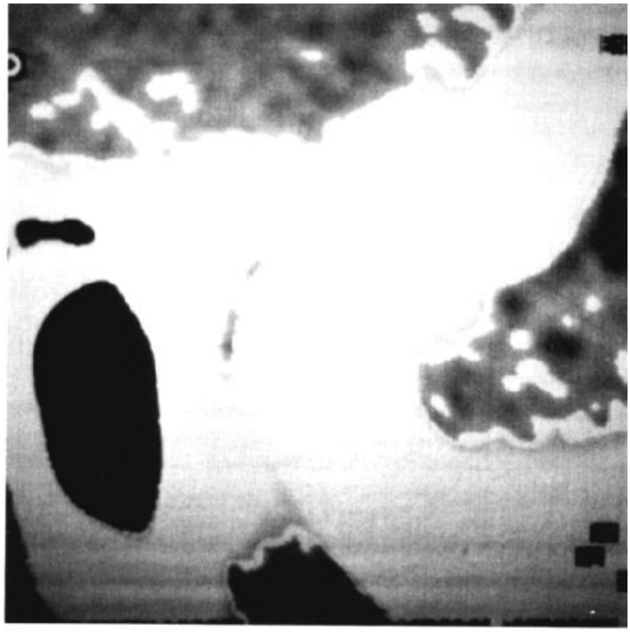

Fig. 2 An example of level-detection mode to outline precondylar soft tissue.

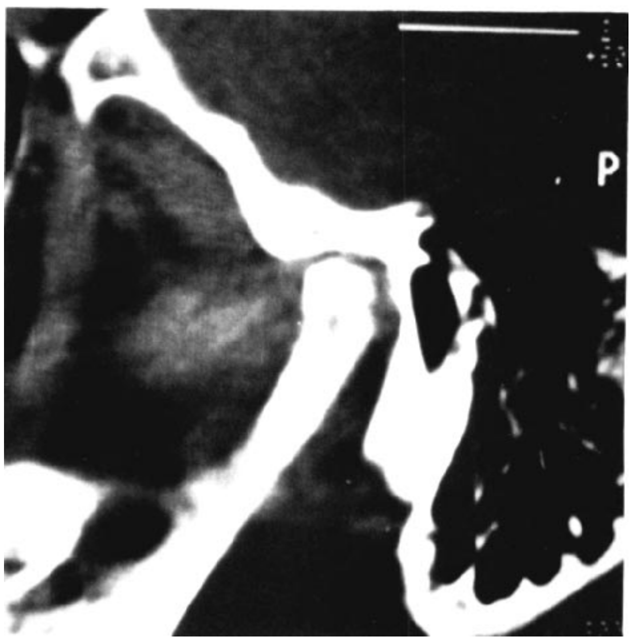

Fig. 3 Parasagittal scan of a right TMJ with marked degenerative bony changes.

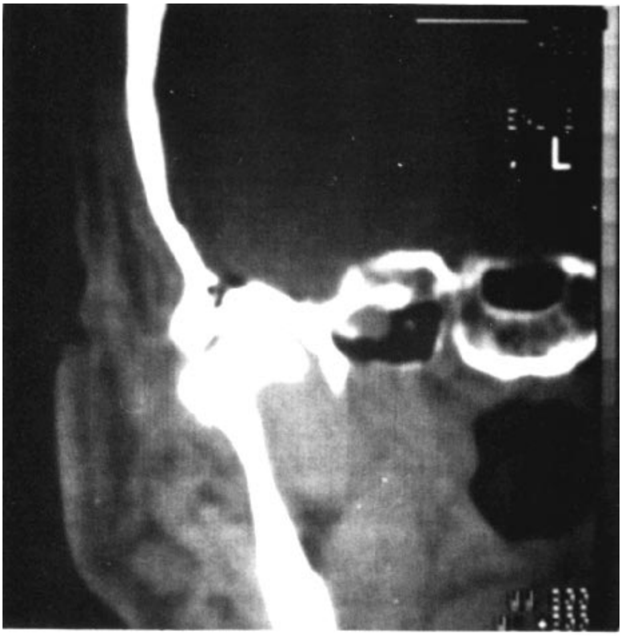

Fig. 4 Coronal view of right TMJ shown in Fig. 3.

Fig. 5 Coronal view of left TMJ of patient shown in Figs. 3 and 4.

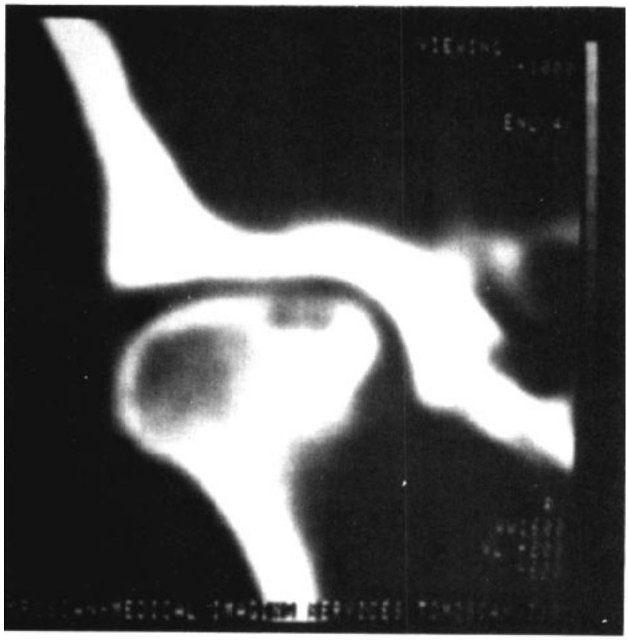

Fig. 6 Coronal view of a left mandibular condyle with a curious duplex erosion.

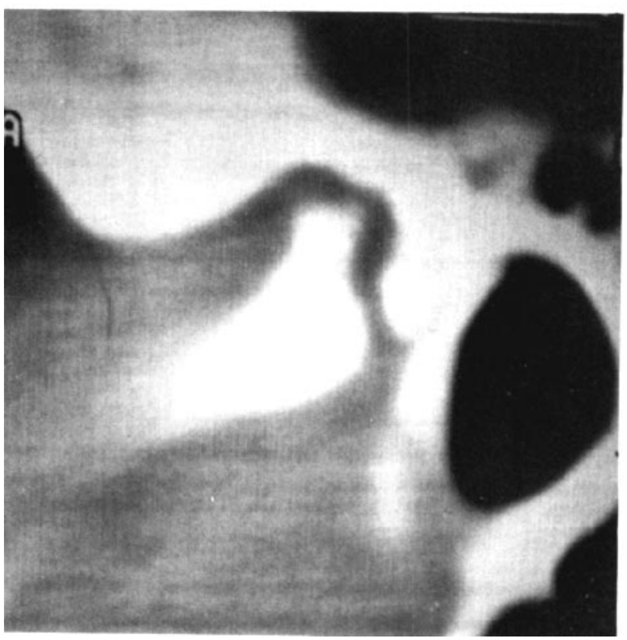

Fig. 7 Parasagittal view of another patient showing marked erosive changes with reciprocal bony remodeling.

Fig. 8 Peculiar "bird's nest" deformity, visualized with bone window technique

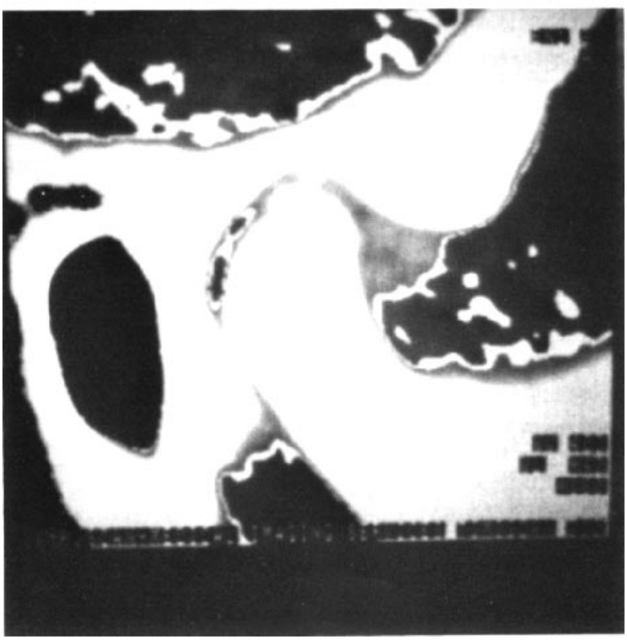

Fig. 9 The same joint seen in Fig. 8, visualized from the same CT exposure with soft tissue window technique

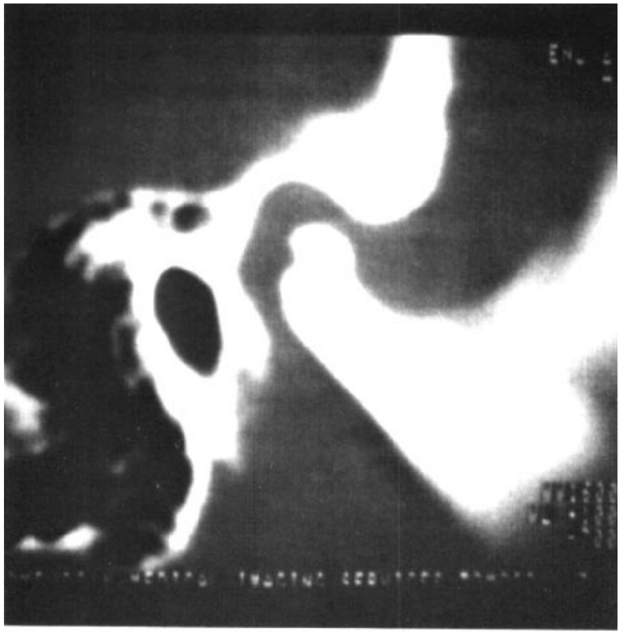

Fig. 10 Posterior erosion, visualized with bone window technique

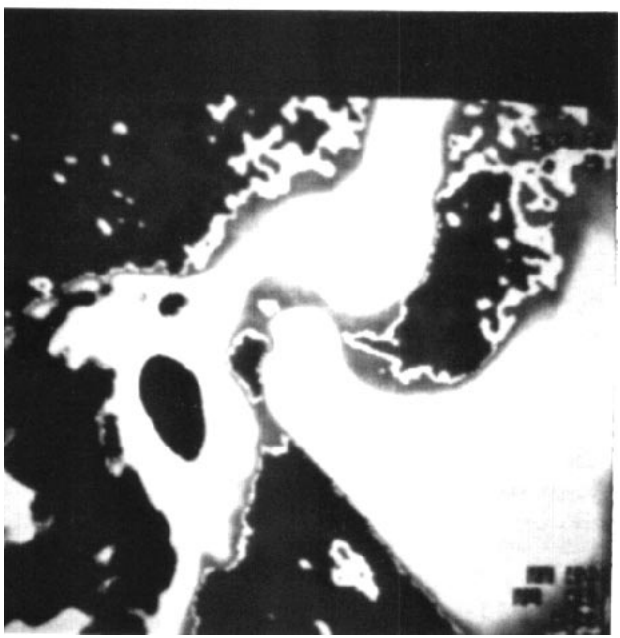

Fig. 11 The view seen in Fig. 10, visualized with soft tissue window technique

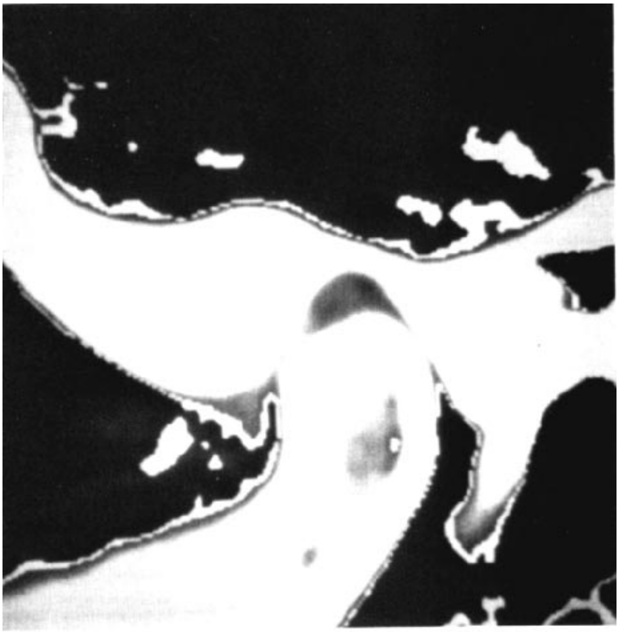

Fig. 12 Our first case of apparent "anteriorly displaced disk with reduction," with the condyle in the fossa.

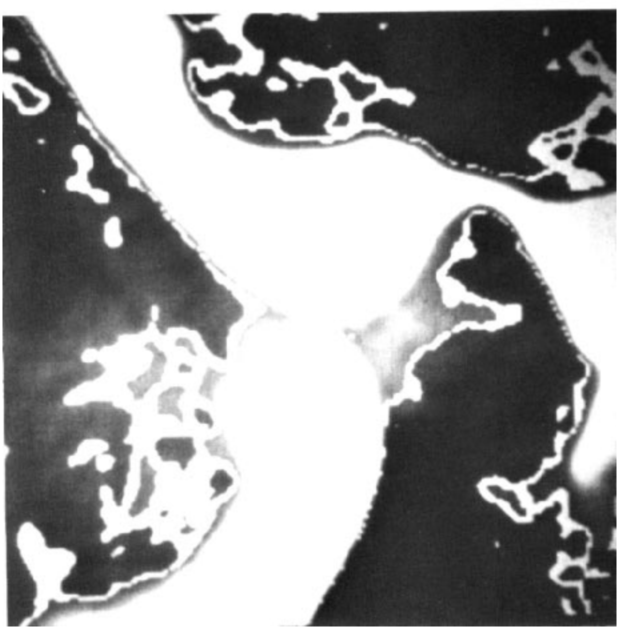

Fig. 13 The joint shown in Fig. 12, with the jaw open to the first click. Note the prominent appearance of the soft tissue density posterior to the condyle.

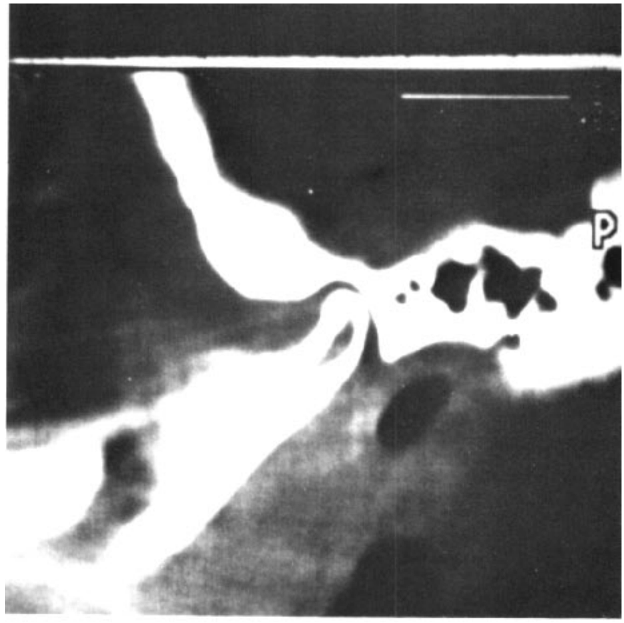

Fig. 14 Symptomatic patient, initial CT study. Splint therapy relieved symptoms temporarily.

Fig. 15 Follow-up scan 8 months after that shown in Fig. 14, after symptoms had returned. Note the marked loss of bony cortex about the posterior apex of the condyle.

— Discussion —

The current state of imaging of the temporomandibular joint is highly precise. However, arthroscopic findings are leading us to question the accuracy of some of the interpretations of these studies.

Arthrography has expanded the functional evaluation from the teeth and other external structures to the inside of the joint itself. This has provided images of band-like shadows about the joint that may click and move, or not move, in mysterious ways.

Anatomic correlations at conventional surgery are of questionable validity when we consider the field of view available to the surgeon, and the lack of opportunity for functional evaluation during the operative procedure. Pathologic sections are both static and liable to artifact formation as a result of preservation and sectioning.

CT studies are elegant and noninvasive, but we cannot use them to make histologic diagnoses or observe the joint in a dynamic state. Arthroscopy has yielded anatomic and functional information that indicates that the soft tissue density seen anterior to the mandibular condyle in these images is not the meniscus of the temporomandibular joint. Rather, the upper joint space in several such patients has been found to be contracted and immobile.

In these patients, the motion of the joint most likely occurs through acquired hypermobility at the lower joint space. In one case, a density thought to represent a displaced meniscus was seen at arthroscopy to represent degenerated and fibrillated cartilage that was adherent to the apex of the eminence. This material most certainly would hinder meniscal motion.

We have found that arthroscopic debridement and increasing joint mobility has served to alleviate symptoms rather dramatically in patients with adhesive capsulitis and a fixed disk.

Joint Dysfunction
an hypothesis

These findings have led to a new hypothesis for one mechanism of TMJ dysfunction. In the normal joint, the meniscus serves as a bearing surface that moves with the condyle. The translation of the disk from its normal closed position to an open-mouth position — and back — facilitates the proper gliding function of the upper joint and the hinge function of the lower joint. These mechanical functions may be retained in some cases even if the disk is anteriorly displaced, provided that the meniscus continues to move adequately (Figs. 16 and 17).

In the pathologic joint, however, I propose that something happens to impair disk motion. Fixed disks have been found in various positions, but I suspect that the disk most commonly becomes inhibited in its return to the closed position from its open-mouth position (Fig. 18). This can occur acutely, but more commonly it evolves over a period of months or years.

Even with impaired disk motion, the force of mastication will gradually move the condyle back up into the fossa with time, overriding the posterior band if necessary. As the motion of the meniscus (and therefore the upper gliding joint) is progressively impaired, the lower joint is forced to make up the difference.

In the acute case, the lower joint cannot adapt quickly enough, and an immediate problem becomes apparent. In the more chronic and insidious case, the lower hinge joint is slowly converted to a gliding joint. The success of this conversion determines how long the patient can remain compensated and relatively asymptomatic.

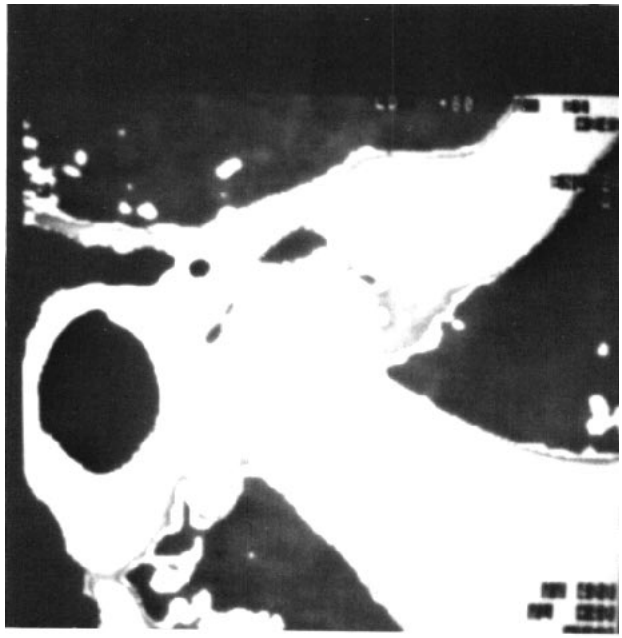

Fig. 16 Possible anterior disk displacement without definite disk fixation. Parasagittal scan in centric occlusion shows evidence of anterior prominence of the joint soft tissues, with absence of soft tissue density in the expected position of the posterior band.

Fig. 17 Open position, same joint seen in Fig. 16. The soft tissues appear to have moved with the condyle. This was found at varying degrees of opening.

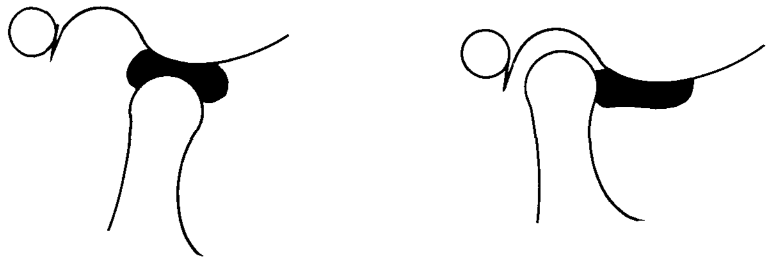

Fig. 18 Drawings illustrating functional effect of disk fixation in "open" position.

Left, Position of disk in open position.
Right, With the disk fixed in the "open" position, the condyle will eventually override the posterior band.

Some of these successfully adapted patients are likely those reported in "fixed lock" with a so-called nonreducible disk. Although subject to periodic exacerbation of their symptoms, these patients apparently can be rehabilitated "off the disk" and do reasonably well. Investigators have even reported microscopic adaptive changes of the bilaminar zone in response to its new function as a bearing surface.

In the opposite case, the disk may be fixed in its normal closed-mouth position, so that all translational motion must occur by the movement of the condyle against and over the disk within the lower joint space (Figs. 19-21).

The following mnemonic illustrates the conversion of joint functions by this pathology.

Gliding / **Hinge** ► **-FIXED-** / *GLIDING*

Note that this is not a simple inversion of functions; the upper gliding action and lower hinge actions are *both lost,* and replaced by abnormal fixation above and abnormal gliding below. The upper joint becomes truly immobile in adhesive capsulitis.

My examination of published arthrograms of patients stated to have fixed lock and no reduction of the disk suggests that the disk is fixed in a somewhat anterior position, with the condyle unable to pass over the thick posterior band. The posterior band area of the disk may even be deformed slightly by the impingement of the condyle head upon it.

Analysis of published arthrograms of patients with so-called reducible disks also suggests a fixed disk, but with condyle motion limited to the lower joint space.

The term "recapture" of the disk is erroneous, in that it is the condyle that is reduced or recaptured with respect to the fixed disk, as the condyle successfully overrides the posterior band. It is little wonder that these patients cannot function well when splinted in this position.

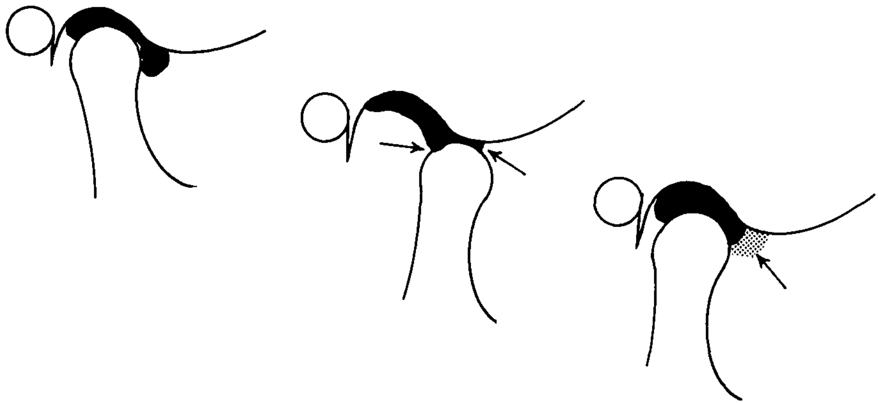

Fig. 19 **Drawings illustrating disk fixation in normal "closed" position.**

Left, **Normal disk position with teeth in occlusion.**
Center, **Forced motion of the condyle will stretch the lower joint structures and enlarge the lower joint capsule to accommodate an abnormal gliding function. Pain is a result.**
Right, **Over a period of time, as the condyle returns to the fossa, redundant capsular tissue remains in the precondylar area.**

—Figs. 20 and 21 appear on the next page

— Summary —

It is suggested that the above hypothesis will explain the dysfunction of a substantial number of TMJ patients. The articular meniscus or disk is inhibited in a fashion that prevents its proper motion, causing the joint complex to adapt by forcing the lower hinge joint to adopt a translational or gliding function.

Marked symptomatic relief has been observed in our patient group with mobilization of the upper joint and removal of joint debris arthroscopically. It appears that this mobilization of the disk allows it to function more normally, diminishing the abnormal strain on the painful lower joint capsular structures.

We cannot be certain that this has altered the original defect inhibiting disk translation, but time will tell how long this relief of symptoms lasts. Long-term follow-up of these patients is in progress.

The Authors wish to thank Cinda Rogahn, R.T., for her excellent technical assistance in the performance of the C.T. scans on our patients.

Fig. 20 Clinical case with fixed disk. Parasagittal scan in closed position, showing precondylar soft tissue, but also substantial soft tissue in the expected disk position.

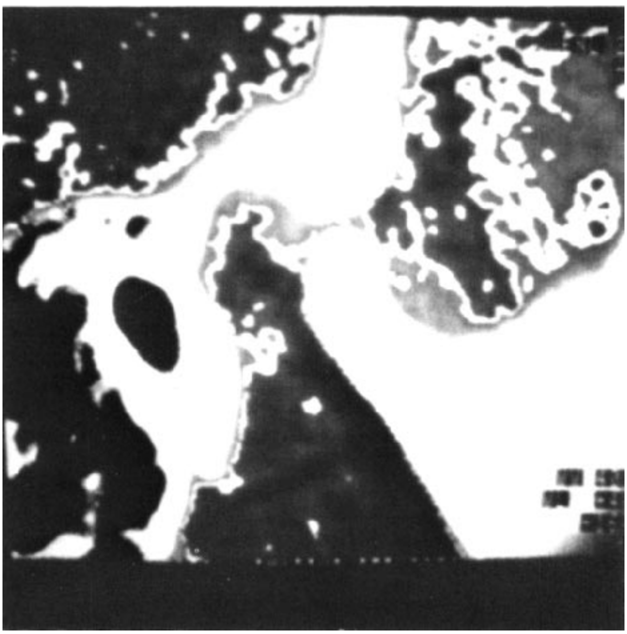

Fig. 21 Same joint as Fig. 20, with the mouth open, after click. Note the soft tissue remaining in the fossa. This was proven at arthroscopy to correspond to a fixed disk. The precondylar soft tissue is probably redundant joint capsule.

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