The Important Role of Motion in the Rehabilitation of Patients with Mandibular Hypomobility: A Review of the Literature

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ABSTRACT: The orthopedic literature has clearly demonstrated that the physical stimulus of motion is essential for the maintenance of the structural and functional integrity of synovial joints. As a result of this information, rehabilitation with passive motion has become an extremely important part of the rehabilitation of synovial joints throughout the body, especially when there is limited range of motion. This same biological principle must be applied to the temporomandibular joint, especially when there is limitation in mandibular mobility. The effects of limited joint mobility, as well as passive motion, on the articular and extra-articular components of synovial joints is reviewed in detail. The clinical application of these principles in the management of temporomandibular disorders is emphasized.

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Mandibular hypomobility is a common symptom in patients suffering from temporomandibular disorders as well as a variety of pathologies of the masticatory system. The causes of mandibular hypo-mobility are multiple and can be related to intra-articular or extra-articular conditions. Examples of common intra-articular pathologies which can cause mandibular hypo-mobility include synovitis, osteoarthritis, internal derangement, fibrosis, bony ankylosis and systemic arthropathies which affect the temporomandibular joint. Extra-articular disorders which are commonly associated with mandibular hypomobility include muscle disorders (eg., myofascial pain dysfunction syndrome), fascial space infections, coronoid hyperplasia, trismus secondary to dental injections, fibrosis following radiation therapy, and tumors involving the head and neck region. Traumatic injuries to the mandible can frequently cause both intra-articular damage (hemarthrosis or intracapsular condylar fracture) as well as extra-articular injury to the surrounding muscles, ligaments and tendons. Regardless of the cause of mandibular hypomobility, the effects of the relative lack of the physical stimulus of motion on the temporomandibular joint and surrounding tissues are significant.

The temporomandibular joint is a synovial joint and functions according to the same biological rules as other joints in the body. Therefore, the vast body of research on the effects of mobility versus hypomobility of other joints can be applied to the temporomandibular joint and its surrounding soft tissues. Knowledge of the biological effects of motion on joints has significant implications for the management of patients suffering from mandibular hypomobility and offers the potential for new conservative treatment options. Patients who have mandibular hypomobility secondary to a temporomandibular disorder are often treated with acceptable conservative modalities such as warm moist soaks, soft diet, appliances and medications (anti-inflammatories and muscle relaxants). Although physical therapy will help to restore mobilization of the masticatory system, home rehabilitation regimens are necessary for the full beneficial effects of motion to be realized. For patients with more extensive temporomandibular disorders who undergo surgery, it is well known that the surgical procedure, no matter how skillfully performed, will fail if rehabilitation with passive motion regimens is not emphasized.

Temporomandibular joint arthroscopic surgery has been shown to be an extremely effective surgical modality in the management of patients with significant pain and severe limitation in joint mobility. Several theories have been proposed to explain the effectiveness of arthroscopic surgery, including: lysis of adhesions, removal of inflammatory mediators, debridement and removal of osteoarthritic tissue and byproducts of cartilage degradation, altered disk mobility and position, and the removal of a vacuum effect in the superior joint space. Recent investigations have given support to these theories, and it appears likely that arthroscopic surgery produces a combination of effects which can explain its efficacy. With our experiences with arthroscopic surgery over the past decade, it appears that there has been greater emphasis on the restoration of joint function than the precise restoration of gross anatomic relationships. The success of arthroscopic surgery seems to rely more on the restoration of joint mobility rather than on disk reduction. A common link in the various theories which have been proposed to explain the effectiveness of arthroscopic surgery is thai they can all be related to joint mobilization.

With this background in mind, it seems appropriate to propose new theories lo explain the importance of motion of the temporomandibular joint:

1. Lack of mobilization has profound effects on the temporomandibular joint and contributes significantly to the pathogenesis of temporomandibular joint disease.
2. The restoration of temporomandibular joint mobility has profound effects on the maintenance and integrity of cartilage and synovial tissues.

This paper will review the orthopedic literature supporting these theories and will provide case reports in which passive motion was used extensively in the rehabilitation of patients with mandibular hypomobility.

Materials and Methods

The Effects of Immobilization on Synovial Joints

The relative value of rest versus motion in the management of musculoskeletal conditions has been the subject of scientific investigations over the past few decades. This recent orthopedic literature has clearly demonstrated that immobilization has deleterious effects on the morphologic, biochemical and biomechanical characteristics of the components of synovial joints, muscles and periarticular tissues.[1] Furthermore, animal and clinical studies on the effects of continuous passive motion have demonstrated a significant stimulation of healing of articular cartilage, tendons and ligaments as well as the prevention of intra-articular adhesions and joint stiffness.[2]

Animal studies involving immobilization of knee joints of rats[v5] dogs,[6] rabbits[7-'5] and monkeys,[16] have demonstrated the deleterious effects of immobilization on the 1. synovium, *2.* articular cartilage, 3. muscles, 4. ligaments, *5.* bone and *6.* periarticular connective tissues:

1. Synovium: gross and microscopical changes associated with prolonged immobilization include proliferation of fibrofatty connective tissue into the joint space with obliteration of joint space, adhesions between synovial folds and tearing of cartilage surfaces by adhesions associated with forced manipulation.[1-1,17]
2. Articular Cartilage: thinning of articular cartilage,[5-1*] loss of matrix staining characteristics,[5-"1] pressure necrosis at areas of cartilage-to-cartilage compression,[16] fibrillation and cartilage erosion,[14] adherence of fibrofatty connective tissue to cartilage surfaces.[1-17]
3. Muscles: muscle atrophy, decrease in muscle fiber diameter, reduction in blood vessels, decrease in contractile protein and metabolic proteins within muscle.[1>:1]
4. Ligament: random disorganized deposition of fibrils and cells (as opposed to the normal parallel array of deposition stimulated by physical forces) resulting in reduced ability of ligament to resist tensile forces.[1]-- destruction of ligament fibers at insertion site with weakness due to osteoclastic activity of bone.-[1]
5. Bone: generalized osteoporosis of cancellous and conical bone.[:i] subchondral bone invaded by proliferating primitive mesenchymal tissue from the marrow spaces.[1]
6. Periarticular Connective Tissue:
   Collagen: reduced collagen mass, increased degradation compared to synthesis, production of less

mature collagen with decreased strength, aberrant cross links between adjacent collagen fibers, shortened tendons or fascia.'•[24-27]

Glycosaminoglycans: reduced total GAG, reduced hyaluronic acid, reduced chondroitin 4 and 6 sulfate, reduced dermatan sulfate.'-25,28-30 *Water,* reduced water content.[29,31] The overall effects of immobilization on the structure and function of synovial joints are profound. Ultimately, the lack of physical stimulus of motion impairs the home-ostasis of the joint. Motion enhances the movement of synovial fluid and provides transynovial nutrient flow to cartilage and ligaments.[32,34] Deprivation of motion alters the morphologic, biochemical and biomechanical characteristics of synovial joints by causing articular cartilage degradation, intra-articular adhesions, weakening of ligaments, atrophy of muscles, subchondral bone resorp-tion, alterations in the strength and amount of collagen, reduced water and glycosaminoglycan content resulting in impaired lubrication.[1]-[26]

The Effects of Joint Mobilization

Animal and clinical investigations into the use of continuous passive motion (CPM) have demonstrated that CPM is superior to immobilization in stimulating healing of articular cartilage, regeneration of articular tissues and in preventing joint stiffness.[2] Rabbit studies have been conducted in which full thickness articular cartilage defects were created in knee joints, penetrating the subchondral bone. The knees of experimental animals were placed into CPM, intermittent active motion and immobilized groups and evaluated grossly as well as under light microscopy up to four weeks postoperatively. The results showed that the CPM group had demonstrated significantly more frequent healing of defects into hyaline cartilage than the other two groups. The authors concluded that CPM stimulated metaplasia of mesenchymal tissue to hyaline cartilage.'[5]-[36] Experimental models involving a surgically created fracture through the medial femoral condyle of the rabbit knee joint have demonstrated that 80% of CPM treated knees had healed cartilage without any evidence of post-traumatic arthritis compared to non-CPM treated knees, most of which developed severe degenerative arthritis.'[7] Other studies involving CPM have demonstrated its effectiveness in clearing an experimentally induced hemarthrosis in a rabbit knee, compared to immobilized knees.'[11] Human clinical investigations using CPM devices for ankles, knees, hips, fingers, elbows and shoulders have been conducted in patients following open reduction for the treatment of fractures or following arthrotomy procedures for the treatment ol arthroputhies and/or arthritis.-' Aside from the beneficial effects of the stimulus of mobility on joint healing, these patients also experienced relative freedom from pain.

Current Literature on the Role of Mobilization of the TMJ

Although the orthopedic literature has much information on the morphologic, biochemical and biomechanical effects of mobilization versus immobilization of synovial joints, there is a relative paucity of information on this subject in the dental literature. This is of particular concern since immobilization of the mandible with maxillomandibular fixation has been common in the management of patients with fractures of the maxilla and mandible, as well as in the treatment of patients undergoing orthognathic surgery. In spite of this, there have been recent investigations which have demonstrated that the effects of immobilization of the temporomandibular joint are clearly the same as that of immobilization of other synovial joints. In an excellent review article, Ellis[26] has proposed that immobilization of the mandible causes atrophy and weakness of the muscles of mastication, degenerative changes of the articular cartilage, loss of water, aberrant collagen fiber cross-links and degradation of proteoglycans of the periarticular connective tissues. The net effect of these changes is an increase in joint stiffness.

Animal studies have been conducted in rabbits and monkeys demonstrating the morphologic, histologic and biochemical effects of immobilization on the temporomandibular joint. Lydiatt and Davis[39] studied the histologic effects of immobilization of the rabbit temporomandibular joint for periods of 10-28 days. Significant thinning and degeneration of the articular cartilage of the condyle were observed as early as ten days following immobilization. As the duration of immobilization increased to 28 days, the degenerative changes were progressive, demonstrating a fibrous layer with thinning, hyper-cellularity, and flattened nuclei. Glineburg, et al.[4]" demonstrated the effects of immobilization of the TMJ on Macaca cynomaolgus monkeys as well as the effects of remobilization. After eight weeks of immobilization, microscopic examination of the articular condylar cartilage demonstrated extreme thinning at the expense of the zone of hypertrophy. Safranin O staining was significantly diminished, indicating loss of glycosaminoglycans from the cartilage matrix. The degenerative changes seen as a result of immobilization were similar to those seen in osteoarthritis. Subsequent remobilization for two weeks, two months, four months and eight months and microscopic examination revealed a progressive increase in cartilage thickness and a return of Safranin O staining in all zones. This indicated that wiih remobilization, there was a return in glycosaminoglycan content of the condylar cartilage, suggesting that the degenerative changes resulting from immobilization are reversible. Robinson[41] demonstrated that mature mandibular condylar cartilage of the marmoset is capable of regeneration. He created a standardized full thickness defect of the condylar articular cartilage of marmosets and used histological, autoradiographic and immunocytochemical methods to identify tissue morphology, cell proliferation and cartilage matrix components following healing periods of three days to one year. The results demonstrated the reappearance of glycosaminoglycans, notably chondroitin sulfate and keratan sulfate in the repairing defects as early as 2-4 weeks following wounding. The presence of keratan sulfate (KS) was significant in that it has been suggested that KS may play a role in collagen fibrillogenesis.[42] Robinson also demonstrated the production of types I and II collagen as well as the accumulation of aggregated proteoglycans by eight weeks postoperatively. By six months, all tissue elements of the condylar cartilage had reformed and remained intact for the period of the study of one year. Robinson concluded that following experimental injury to the marmoset mandibular condyle, the condylar cartilage is capable of regeneration as long as TMJ function occurs.

Clinical studies on the use of mobilization techniques in the treatment of patients with temporomandibular disorders are sparse. Clark[43] reviewed the use of physical medicine procedures for three major categories of temporomandibular disorders: intracapsular disorders, myogenous pain and dysfunction and mandibular mobility disorders. In general, the literature supported the use of physical medicine procedures such as exercise therapy and mobilization following arthroscopic surgery for locking, for localized TMJ pain associated with restricted motion, myogenous pain and dysfunction, trismus and splinting of the masticatory muscles, and for acute mandibular mobility disorders associated with joint adhesions. Clark emphasized the need for early physical medicine intervention in cases of acute mandibular hypomobility.

There are a variety of reports in the literature advocating the use of passive motion devices designed to mobilize the temporomandibular joint, primarily as rehabilitation following surgery.[44-48] These investigators generally support the use of passive motion of the temporomandibular joint based on the principles described in the orthopedic literature.

***Clinical Applications** of Passive Motion in the Treatment of Patients with **Mandihitlar** H\pomohility* Unfortunately, the clinical use of passive motion devices for mandibular rehabilitation has been greatly under-utilized. Most often passive motion has been considered for use in patients who have undergone surgical procedures and thus, the benefits of passive motion in the rehabilitation of nonsurgical patients has not been realized. This is unfortunate, because the literature has demonstrated that lack of motion itself can have serious consequences on the maintenance of the structural integrity of the temporomandibular joint. Therefore, new treatments which emphasize passive motion in patients with mandibular hypomobility are indicated in both nonsurgical as well as surgical cases.

Physical therapy is an extremely important therapeutic modality in providing passive motion and rehabilitation of joint and muscle function. However, even the most compliant patients are usually able to be seen by the physical therapist a maximum of 3-4 times weekly. Although, this is an essential part of the patient's rehabilitation, it only ensures passive motion of the mandible occurs 3-4 times per week. Therefore, in addition to physical therapy, an essential component to the patient's rehabilitation is frequent mobilization exercises at home.

A wide range of devices have been used for temporomandibular joint mobilization and these have ranged from the simple to the extremely complex. The use of fingers and stacked tongue blades for jaw stretching represent the most simple techniques used for promoting TMJ mobilization. The most complex devices provide passive motion through motorized and/or computer driven mechanisms. The key element for success of a mandibular mobilization regimen is patient compliance. Regardless of what technique or device is recommended, if the patient's mandible does not get mobilized, due to lack of compliance, the rehabilitation regimen will fail. Thus, home regimens that promote patient acceptance resulting in frequent mandibular motion are extremely important.

Case Reports

The following cases illustrate the use of mandibular mobilization regimens which were successful due to patient compliance. Case #1 represents a typical case of rehabilitation of temporomandibular joint mobilization, immediately following TMJ arthroscopic surgery, with a normal postoperative course. Case #2 demonstrates problems which were encountered with mandibular hypomobility following acute trauma, which was successfully treated with temporomandibular joint mobilization. Case #3 demonstrates a patient who developed an acute failure of temporomandibular joint translation, which necessitated the scheduling of arthroscopic surgery. However, in the preoperative period, a rigorous temporomandibular joint mobilization regimen significantly improved mandibular motion, ultimately resulting in the restoration of normal temporomandibular joint function, without arthroscopic surgical intervention. Case #4 involves a patient who had significant trauma to the temporalis muscle. Passive motion was used to restore a normal range of motion, even several months after the trauma. Case #5 represents a patient with an internal derangement who developed severe hypomobility. She was placed on an at-home passive motion rehabilitation regimen which restored mandibular range of motion and enabled this patient to avoid surgical interventions.

Case #/ - Osteoarthritis and Synovitis

A 46 year old white female presented to Columbia University School of Dental and Oral Surgery complaining of severe pain in her right and left temporomandibular joints which severely limited her jaw functioning. The patient indicated that she had symptoms of jaw dysfunction and pain intermittently for the previous ten years, however, over the past six months, her pain had become unbearable. She had sought the care of numerous dentists who had prescribed anti-inflammatory medication, muscle relaxants, physical therapy 2-3 times weekly (including passive stretch, distraction, myofascial release, heat and massage) and the fabrication of oral appliances. However, the symptoms over the past six months had remained significant, and resistant to conservative measures. A visual analog scale was used to subjectively rate her pain, which measured 8, on a scale of 0-10. The patient indicated that although she was capable of forcing her mouth open widely, this caused severe pain and therefore, she had to limit her jaw opening. The history also revealed that she had a severe bruxism habit at night and clenching during the day.

The clinical examination revealed both the right and left temporomandibular joints to be severely painful to palpation. The maximum interincisal opening distance was 45 mm with forced opening, however, this level of opening induced severe joint pain. Auscultation revealed crepitus bilaterally. Magnetic resonance images demonstrated osteoarthritis as well as anterior disk displacement with reduction present bilaterally. The clinical diagnoses were consistent with the following: synovitis right and left temporomandibular joints, osteoarthritis right and left temporomandibular joints, internal derangement right and left lemporomandibular joints, and myospasm/rnyalgia associated with bruxism and clenching. Because the patient was in severe pain and six months of appropriate conservative treatment failed to improve the symptoms, bilateral temporomandibular joint arthroscopies were recommended.

Diagnostic arthroscopic examination revealed the left temporomandibular joint to have the following: synovitis, osteoarthritis (Figures 1A and IB) and anterior disk displacement. The right temporomandibular joint demonstrated synovitis and osteoarthritis. Operative arthroscopic surgery was performed which included debridement of osteoarthritic tissue with a motorized shaver, lavage, and direct injection of inflamed synovial membrane with Celestone Soluspan (Schering Corp.. Kenilworth, NJ) suspension (Figure 2).

In the recovery room, the patient was immediately placed on a passive motion device, E-Z Flex (Fluid Motion Biotechnologies, Inc., New York, NY). This device has a hand pump which is controlled by the patient and provides passive motion to the mandible using a

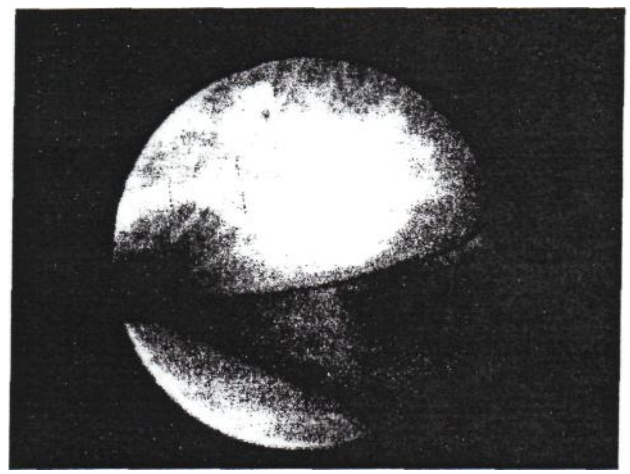

Figure 1A
Arthroscopic view of the left temporomandibular joint in Case #1 demonstrating synovitis involving the medial wall.

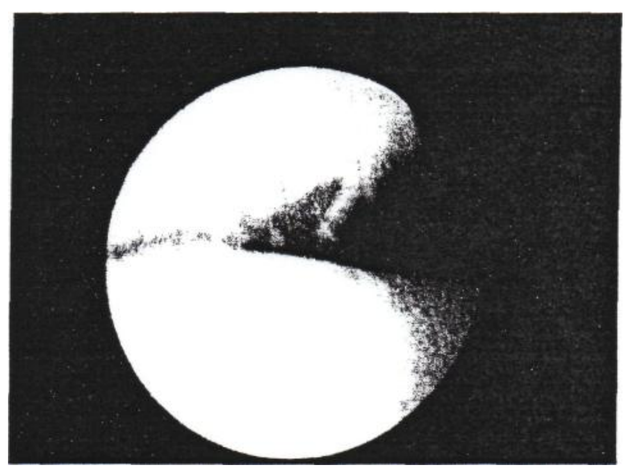

Figure IB
Anhmxcopic \ icw of the left lemporomandibular joint in Case ilcmonslratmt! osicoarthrilis of the articular eminence.

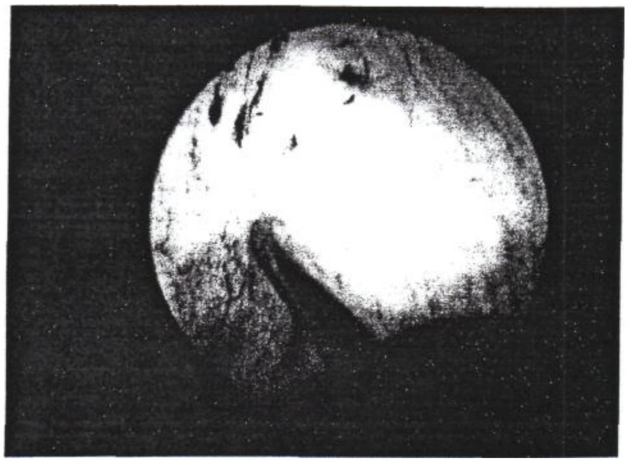

Figure 2
Arthroscopic view of the right temporomandibular joint in Case #1 demonstrating a direct steroid injection into the inflamed synovial membrane.

hydraulic mechanism. The patient performed five opening cycles every half hour in the recovery room (Figure 3). The postoperative rehabilitation regimen included E-Z Flex 5-10 minutes, ten opening cycles, 4-6 times daily. The patient was maintained on nonsteroidal anti-inflammatory medications, as well as the use of an oral appliance which she had been on preoperatively.

Postoperatively the patient improved significantly. The interincisal opening after one month was 47 mm, but without any significant pain. At four weeks, the visual analog scale revealed a pain level of 2. The patient was instructed to use the E-Z Flex 3-4 times daily for the first three months following surgery. She is currently 12 months following arthroscopic surgery and at her most recent examination, she had normal range of motion without pain. She continues to perform passive motion exercises at home on an as needed basis, if she notices any jaw stiffness.

Case #2 - Acute Synovitis Following Motor Vehicle Accident

A 29 year old white female presented to Columbia University School of Dental and Oral Surgery three days following a motor vehicle accident, which was accompanied by significant clenching of her teeth. The patient reported significant pain and decreased jaw opening since the accident. The patient, who was an operating room nurse, indicated that she had a history of osteoarthritis, synovitis and internal derangement of her temporomandibular joints, which had necessitated arthroscopic surgery over two years prior to this motor vehicle accident. She indicated that following the surgery, she had minimal symptoms and good jaw function until the motor vehicle accident. The patient indicated that she was in severe pain and on a visual analog scale (VAS) she rated her pain level as 8.

Clinical examination revealed an acutely painful right temporomandibular joint. The maximum interincisal opening was limited to 35 mm and induced severe pain of the right temporomandibular joint. The clinical diagnosis was consistent with an acute traumatic synovitis of the right temporomandibular joint. Her treatment consisted of a passive motion rehabilitation regimen, ten opening cycles, 4-6 times daily **(Figure** 4). In addition, she was placed on moist heat, a soft diet and nonsteroidal anti-inflammatory medication. One week later, the pain level

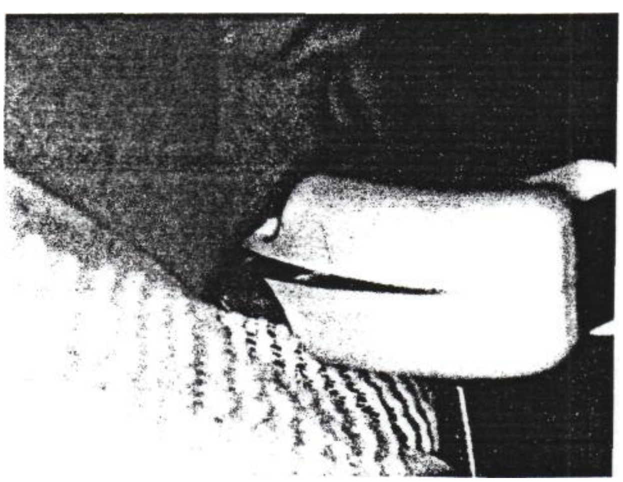

Figure J
The palienl was placed on E-Z Flex (Fluid Motion Biotechnologies. Inc.. New York. NY) rehabilitation in the recovery room. Early niohi-li/ution of the joinl is important following surgery or trauma to prevent ihe formation ol adhesions and clear hcmanhrosev

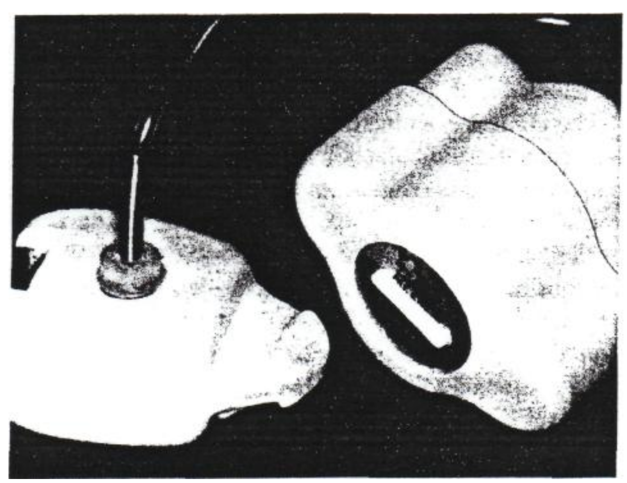

Figure 4
The E-Z Flex (Fluid Motion Biotechnologies. Inc.. New York. NY) passive motion device has an hydraulic mechanism. The patient squeezes the hand pump (on (he righl) and the platforms of the mouth-piece gradually separate providing gentle, controlled passive motion to the lemporomandibular joint and surrounding tissues.

(VAS) was 4, and the interincisal opening was 40 mm. She was instructed to continue her passive motion rehabilitation with E-Z Flex for three months. Four months following the motor vehicle accident, the pain level (VAS) was 3, and the interincisal opening was 40 mm. She is currently 24 months following the acute trauma, and her interincisal opening has been maintained at 40 mm without significant pain and better function.

Case #3 - Internal Derangement with Mandibular Hypomobility

A 14 year old white female presented to the Oral and Maxillofacial Surgery Faculty Practice at Columbia University, complaining of an inability to open her jaw for two weeks and pain in her right temporomandibular joint. The patient indicated that her only previous symptom was painless clicking of the right and left temporomandibular joints for approximately one year. The patient reported that two weeks previously, she awakened in the morning with her jaw stuck. For the following two weeks she had been under the care of several dentists and a physical therapist, who had implemented a regimen of passive stretching, myofascial release, moist heat, soft diet, non-steroidal anti-inflammatory medications, and an occlusal splint and physical therapy. However, in spite of appropriate reversible treatment, the patient' symptoms failed to improve. An MRI revealed anterior disk displacement without reduction of the right temporomandibular joint and arthroscopic surgery was recommended. She came to Columbia University for a second surgical opinion.

Clinical examination revealed the right temporomandibular joint to be painful to palpation. Maximum interincisal opening was 27 mm with deviation to the right. The right lateral excursion was 9 mm and the left lateral excursion was 8 mm and associated with significant right temporomandibular joint pain. Protrusive movements were associated with deviation of the mandible to the right. The occlusion was Class I and the muscles of mastication were not tender. Auscultation did not reveal any clicking or crepitus. A four-view TMJ panoramic radiograph revealed decreased translation of the right temporomandibular joint in the open view, but was otherwise unremarkable. A diagnosis of right temporomandibular joint internal derangement with closed lock was made, and treatment options were discussed. Although right temporomandibular joint surgical arthroscopy was discussed as an acceptable treatment option, because her symptoms had only begun two weeks previously, the patient was told to continue her conservative regimen and return in a few weeks. The patient returned four weeks later without any significant improvement in symptoms. and it was decided to first provide passive fluid motion therapy using E-Z Flex, prior to consideration of any surgical intervention. The patient was instructed to perform ten opening/closing cycles, four times daily.

The patient returned three weeks later with an increased interincisal opening of 31 mm and was encouraged to continue passive motion with E-Z Flex. The patient was maintained on the same regimen and three weeks later, her interincisal opening was 38 mm with a significant reduction in pain. The patient continued with passive fluid motion therapy, and after a total of three months, her interincisal opening was 40 mm. She was opening and closing without any pain and eating a normal diet. The patient gradually stopped using the device and six months following her initial appointment, her interincisal opening was 49 mm. One year following the onset of this episode the patient was without any temporomandibular joint dysfunction.

Case #4 - Muscle Disorder Following Trauma

A 52 year old white female presented to Columbia University complaining of limited jaw opening, headache and jaw pain on the left side. She reported that she was hit in the left temple region with a golf ball approximately five weeks prior to her presentation. Since that time, she had decreased range of motion and left temple pain. She had seen numerous dentists who instituted conservative treatment including moist heat, soft diet, NSAIDs, muscle relaxants and physical therapy (heat, massage, ultrasound and passive stretch). However, in spite of good conservative management, her symptoms increased, with a progressive decrease in jaw opening. The past medical history was non-contributory.

Clinical examination revealed tenderness in the left temporalis region, with a significant limitation in interincisal opening of 9 mm. There was a significant deviation to the left upon opening. Magnetic resonance images of the temporomandibular joints were normal. Facial bone radiographs and CT scans did not reveal any facial bone fractures. The CT scan did reveal significant edema of the left temporalis muscle (**Figure** *5)*. The diagnosis was traumatic injury to the left temporalis muscle, with hematoma formation, fibrosis and myospasm.

Treatment included physical therapy and jaw stretching exercises, as well as a continuation of her previous conservative treatment regimen, including the use of Flexeril (Merck & Co.. Inc.. West Point, PA) five mg by mouth at bedtime and ibuprofen 400 mg twice daily.

The patient's symptoms gradually improved, however after seven weeks her interincisal opening was only 26 mm. It was decided to.incorporate the passive motion rehabilitation into her treatment. This included the use of

Figure 5
CT scan of the patient in Case *#4* demonstrating edema of the left temporalis muscle following a direct traumatic injury to the region.

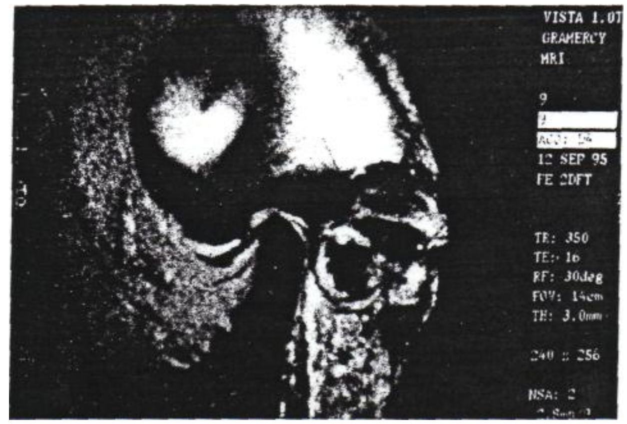

Figure 6 A
Magnetic resonance image of the patient in Case #5 demonstrating anterior disk displacement in the closed position.

E-Z Flex 5-10 minutes, four times daily. This was followed by a marked and immediate improvement in her symptoms. Within two weeks, the interincisal distance increased to 35 mm without pain and a return to normal diet. The patient continued on passive motion therapy for three months. At six months she had no dietary restrictions, no pain on palpation of the temporalis muscle, with an interincisal distance of 37 mm. The patient is currently two years following the acute trauma, and her interincisal distance is 42 mm and she has no pain. She has not required any further treatment.

Case #5 - *Internal Derangement with Mandibular Hypomohility*

A 28 year old white female presented to her dentist's office complaining of an inability to open her mouth and right sided jaw pain aggravated by attempted opening. She reported a history of bilateral jaw pain for two years, with occasional episodes of jaw-locking which resolved spontaneously. Her jaw locked five days prior to her visit, however, this episode did not resolve spontaneously and was associated with significant pain. The medical history was noncontributory.

Clinical examination revealed the right TMJ to have tenderness to palpation. The maximum interincisal opening was *22* mm with deviation to the right. A magnetic resonance image of the temporomandibular joints revealed a right sided internal derangement with anterior disk displacement without reduction. A joint effusion was also noted, and there was minimal condvlar movement between the open and closed views (Figures 6A and 6B). This confirmed a diagnosis of synovitis of the right TMJ as well as internal derangement. The treatment included the following: soft diet, NSAID (non-steroidal anti-inflammatory medication), and passive motion therapy with the E-Z Flex rehabilitation system, 5-10 minutes four times per day (Figure 7).

The patient returned in two weeks, with decreased pain and an increased range of interincisal opening of 35 mm. After four weeks of treatment the interincisal distance was 43 mm with mild pain of the right TMJ. By ten weeks, the interincisal opening was 49 mm, without deviation, and the pain was completely resolved. She stayed on the passive motion regimen four times daily for a total of three months. She is currently ten months following the initial presentation to her dentist and she has minimal pain, normal jaw opening, and she rates her condition

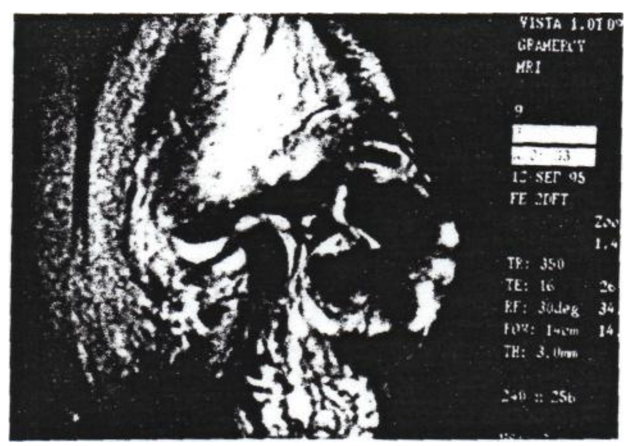

Figure 6B
Magnetic resonance image of (he patient in Case *ttS* with an open-moulh view. There is limited condylar movement, and antenordi.sk displacement without reduction. This T2 weighted image also reveals an effusion of fluid (high signal intensity! in the anterior superior joint space.

Figure 7
Patient in Case #5 during an E-Z Flex rehabilitation session.

as being much better. The patient occasionally uses the E-Z Flex on her own to help maintain her range of mandibular motion.

Discussion

The concept of passive motion has received acceptance in the medical/orthopedic community as a proven method of rehabilitation involving both natural and prosthetic joints.'-[13] Since the temporomandibular joint is a synovia! joint which behaves according to the same biological rules as other synovial joints, the same principles of joint motion and rehabilitation apply. However, widespread acceptance of the importance of passive motion in the treatment of a variety of temporomandibular disorders and injuries has not occurred. The passive motion devices previously available for use in temporomandibular joint disorders and injuries, have not been used routinely perhaps due to their complexity, high cost, and intimidating appearance.

The first case represents the routine use of a TMJ rehabilitation regimen following surgery, with immediate use of mobilization in the recovery room. The lack of pain and the control of mandibular opening using a fluid mechanism that is patient controlled helps to get the patient started on their rehabilitation immediately. In Case #1. passive mobilization immediately following arthroscopic surgery helped to promote movement of synovial fluid and prevent the formation of intra-articular adhesions.

The patient described in Case #2 is very interesting because she had severe mandibular hypomobility and pain, due to osteoarthritis, synovitis and adhesions, treated successfully with arthroscopic surgery. However, acute trauma due to a motor vehicle accident caused an acute exacerbation of her previous TMD symptoms. The very early intervention with passive fluid motion therapy, as well as nonsteroidal anti-inflammatory medication, resulted in a rapid resolution of her symptoms.

Cases #3 and #5 demonstrate the use of passive motion therapy in patients with internal derangements associated with an acute closed lock. Although these patients presented with severely restricted jaw opening and pain, they were able to maintain themselves on a home rehabilitation regimen. The clinical signs, MRIs and symptoms all demonstrated clear indications for arthroscopic surgery. However, the passive motion therapy was controlled by the patient, very gently, promoting compliance. Motion, along with continued conservative regimens, resulted in steady improvement, ultimately leading to normal temporomandibular joint function obviating the need for surgery. It is impossible to claim that passive motion therapy was the sole cause of the return to normal function in these patients. However, it is clear that passive motion therapy, based on orthopedic principles, along with the patients' compliance, played an important role in the healing process.

Case #4 demonstrates that mandibular hypomobility due to muscle disorders will also respond to gentle, passive stretching and rehabilitation regimens which restore motion. Although the patient in Case #4 had a severe injury of the temporalis muscle, which resulted in severe limitation of jaw opening, passive motion therapy assisted in improved range of motion and mandibular function. Following initial rehabilitation with passive motion, it is important for the treating clinician to gradually implement active motion, to restore muscle strength. This is generally done by gradually advancing the diet and active resistance exercises, often under the guidance of a physical therapist. Active motion is an extremely important part ofthe patient's rehabilitation, since atrophy of the masticatory muscles is the end result of significant periods of hypomobility which needs to be treated.

Although the use of passive motion devices, as described in these case reports, appears to be an important component in the management of patients with mandibular hypomobility, it is important for the treating clinician to thoroughly evaluate patients on an individual basis. Passive motion devices would be contraindicated in patients with acute mandibular fractures, significant periodontal disease, ill-fitting protheses. and in patients with osteomyelitis or osteoradionecrosis of the mandible. Additionally, it is important for the practitioner to establish a complete differential diagnosis, since conditions other than TMDs, such as head and neck tumors and deep facial infections, can cause mandibular hypomobility.

Summary

Based on the orthopedic literature, it is clear that the physical stimulus of motion is essential to maintain the health of synovial joints. Furthermore, limited mobility results in the acceleration of a variety of pathologic processes such as cartilage breakdown and the formation of adhesions. Based on the scientific literature and clinical experience, it is also clear that the use of passive motion to encourage early and effective TMJ mobilization is extremely important in the management of patients with mandibular hypomobility.

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