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A Biomechanical Basis for Primary Arthroplasty of the Temporomandibular Joint

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Since the development of arthroscopic surgical techniques of the temporomandibular joint (TMJ), open arthrotomy and reconstructive arthroplasty are often considered overly aggressive for managing impairing TMJ derangements [1–3]. Surgeons who developed and refined arthroscopic techniques have appropriately tried to apply a less invasive surgical procedure [4–7]. Focusing almost entirely on the superior joint space, arthroscopy fundamentally addresses and assumes that the factors creating orthopedic instability, dysfunction, pain, immobility, and patient impairment are directly influenced by inflammatory adhesions and other pathologic factors, and remedied by operative procedures within the superior compartment [8–10]. Likewise, various inflammatory mediators in a deranged or arthritic joint can be managed through simple arthroscopic lysis and lavage, aiding in definitive pain management [11–14] but sometimes causing incomplete long-term management of orthopedic instability and immobility of the joint [15]. Consequently, the development of technological advances and improvements in microarthroscopic operative capabilities and the introduction of arthrocentesis into the clinical armamentarium [16–18] have almost created a managed surgical mindset that dictates arthrocentesis first, arthroscopy second, and finally, if the patient still shows no improvement, surgical arthroplasty.

The surgical literature does not show a definitive advantage of one technique over another, particularly in most retrospective studies that comprise most examples of research in the clinical literature [19]. Most reports of arthrocentesis involve short-term follow-up [20]. Likewise, the reported early successes of these interventions spawned an entirely new concept of TMJ orthopedic dysfunction [21] that attempted to challenge traditional understanding of how a TMJ derangement was dysfunctional [22].

Critics of this field often question any useful purpose of surgical intervention and call for studies with placebo controls [23]. A general 8% to 12% rate of unsuccessful initial surgical outcomes, regardless of surgical technique [24], may explain this position. Arthrocentesis failures are reported to be even higher when clinically significant derangement, condylar disease, or osteoarthrosis exists [25]. Payers of health care services believe these initial failure rates to be unacceptably high when overall nonsurgical and surgical patient care cost analyses are considered [26]. Separate evaluation of failures concludes that pain management and functional improvement rarely occurs with multiple surgical or therapeutic encounters [27]. Mercuri [28] even suggested that worthwhile improvement rarely occurs beyond two to three surgical interventions, regardless of the technique used. Any more than this rarely improves orthopedic function or subjective pain.

Nevertheless, a comparative meta-analysis of the nonsurgical and surgical literature by nonclinicians suggests surgery is specifically effective in significant-type cases of arthropathy, and successes underestimated. Reston and Turkelson [24] concluded that surgery seems significantly beneficial when absolutely no response or, at best, marginal response to nonsurgical treatment

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occurs. However, better-designed random clinical trials are needed with better categorization of preoperative diagnoses for evaluating all available surgical procedures. To improve initial surgical results to a high 90th percentile of long-term success, surgeons must use a procedure that addresses all potential orthopedic disease at the first surgical encounter. Current literature suggests that successful initial outcomes appear to be Wilkes stage–specific for arthroscopic and open arthrotomy techniques. Initial unsuccessful outcomes are more prevalent at the stage III level of derangement only to improve again at stages IV–V [29–31].

A fundamental misunderstanding may exist of contributing pathologic conditions, causes, and biomechanical principles of diseased and operated TMJs that are significant and influence initial failure. The ability of arthroscopy to manage adhesive capsulitis of the superior compartment of the TMJ is well documented [32–35]. However, the TMJ is a complicated two-compartment, four-surfaced joint system in which disease or injury to any component could result in painful, dysfunctional, and progressively impairing derangement.

This article discusses surgical management of clinically significant derangements of the TMJ and addresses basic biomechanical principles of normal and pathologic TMJ orthopedics, the significance of longstanding joint derangements, and what conditions supersede all others and dictate that open arthrotomy and reconstructive arthroplasty should be the definitive initial surgical procedure.

Biomechanics for temporomandibular joint surgeons

General plane motion and shear mechanics

According to established classical physical law (Newton's third), any and all forces of directed motion in any mechanical system are balanced by equal and opposing forces generated and exerted on structures within the system. From an orthopedic and biomechanical perspective, muscular forces that generate static loading, rotation, and translation of the TMJ condyle are balanced by equal and opposing forces generated in the disc/capsule and the peripheral attachments to the condyle and fossa. These reactive forces are created in an opposite direction to all force vectors generated during these static, rotation, and translation force loads exerted within the system.

From an orthopedic standpoint, the magnitude of translation that occurs in the TMJ distinguishes it from other orthopedic systems. Whenever a mechanical system exhibits rotation and translation simultaneously, it exhibits general plane motion (GPM). Translation occurs along a fixed plane and rotation occurs about an axis perpendicular to the fixed plane. However, the articulating surfaces of the TMJ are not flat but curved. Hence, from a purely mechanical standpoint, the joint is an example of curvilinear GPM and all potential paths of displacement must occur along functionally coordinated and congruent curved paths [36]. For optimal joint function, all motion must be coordinated among all four curved articulating surfaces (fossa, superior disc surface, condyle, and inferior disc surface) with no impedance occurring along these congruent paths. This function is necessary because in curvilinear GPM, infinite individual intersecting planes of motion are created and intersect during the full range of motion. There will be an infinite number of potential points of contact located along three dimensional planes of motion (Fig. 1).

When opposing force vectors remain balanced or complimentary during collisions of the many congruent curved planes of movement, the laminar pattern of fibroblasts within the TMJ disc/capsule remain laminar. However, when congruency is lost, competing vectors with different accelerations or velocities are created. By physical law, this result can create potentially destructive intrinsic forces within the disc/capsule complex, primarily shear and destabilizing torques (Fig. 2).

Surgical specimens clearly show the destructive nature of inherent, unstable shear (Fig. 3). Coupled with other destructive forces created in chronic joint instability and mechanical dysfunction, diseases of the inferior and lateral joint compartments

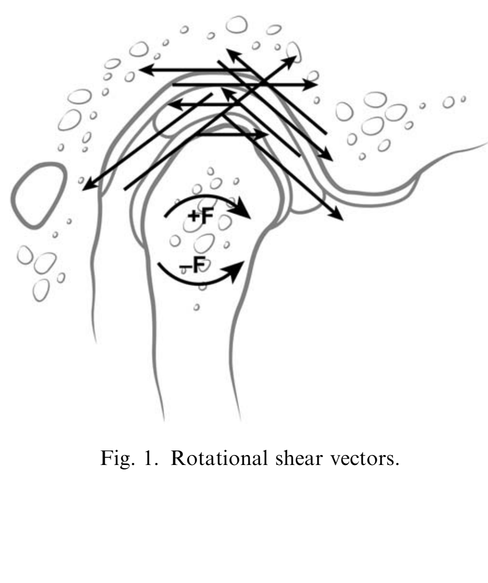

Fig. 1. Rotational shear vectors.