EDITORIAL

The Convex-Concave Rules of Arthrokinematics: Flawed or Perhaps Just Misinterpreted?

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The *convex-concave rules* of arthrokinematics have been taught in physical therapy schools in the United States for about 30 years. The idea that the morphology of articular surfaces is strongly related to kinematics can be traced back to the works of MacConaill,[7,8] Maitland,[10] MacConaill and Basmajian,[9] and Steindler.[14] These early works, as well as those of others,[15] helped define the discipline of *arthrology*—the study of the structure and function of skeletal joints. The increased attention to arthrology as an academic entity over the last few decades has had a strong influence on the development of many aspects of sports, orthopaedic, and manual physical therapy.

The convex-concave rules purportedly help describe the roll-and-slide relationships that naturally occur between moving articular surfaces. There are 2 components of this rule, depending on whether the convex or concave articular member of the joint is considered the moving segment.[5,12] As a teacher of kinesiology and a physical therapist, I have always respected these rules, primarily because of their ability to assist with the mental imaging of joint motion (ie, "seeing" beneath the skin). Recently, I have been perplexed by questions from experienced physical therapists as to why the convex-concave rules are still being taught in college or continuing education venues, when research has shown that they are flawed.[1,6,13] Perhaps I am so hopelessly infatuated with, and blinded by, the educational charm and utility of the convex-concave rules that I fail to realize they are flawed. Are they? I don't think so, which is the topic of this editorial.

One common example of the application of the convex-concave rules is the arthrokinematics of abduction of the glenohumeral (GH) joint: the convex humeral head rolls superior relative to the glenoid fossa as a point on its articular surface simultaneously slides inferior. The "flaw" in this convex-concave rule, as it was explained to me, was exposed by a number of studies that measured the arthrokinematics of the GH joint. These studies,[1,6,13] performed on healthy subjects and similar to the study by Matsuki et al[11] published in this issue of the *Journal*, showed that the humeral head actually remains nearly stationary or, in fact, translates *upward* when performing 90° to 120° of shoulder abduction. This is apparently in direct conflict with the traditional "opposite" roll-and-slide pattern described for GH joint abduction. But an important aspect of these studies is often overlooked, which I contend has likely contributed to the misinterpretation of the convex-concave rule. Specifically, in all these studies, the net superior translation of the humeral head is only a few millimeters. To put this into perspective, consider an adult-size humeral head with a circumference of 16 cm. A motion of 90° of GH joint abduction occurring purely due to a rolling motion (with no concurrent inferior slide at the articular surface) would theoretically cause the humeral head to roll upward on the glenoid about 4 cm. Clearly, a significant, concurrent inferior slide of the humeral head must occur. This offsetting slide is an essential component of GH joint abduction, especially considering that the adult subacromial space is only about 1 cm in height. That the studies showed that the humeral head *only* migrates 1 to 3 mm upward is in itself proof of the existence of a significant, concurrent inferior slide during GH joint abduction. Although this is a relatively simple concept, it points out an elegant mechanical solution. In the case of GH joint abduction, the relatively large humeral head can roll and produce a large osteokinematic path of abduction, while simultaneously remaining within the confines of the relatively small glenoid fossa. This issue is especially important, given the musculotendinous structures located within the subacromial space, just above the glenoid fossa.

Other published kinematic studies of the GH joint also may appear to conflict with the arthrokinematics expected for a convex-concave surface movement. Studies published by Harryman et al[2] and Howell et al,[3] using healthy subjects, showed that the humeral head translates posteriorly between 2 to 7 mm on the glenoid during full GH joint external rotation. For similar logic to that described for GH joint abduction, the fact that the net posterior translation of the center of the humeral head is so small relative to the size of the humeral head and the amount of GH joint external rotation lends credence to the traditional convex-concave rule of arthrokinematics. A significant amount of concurrent anterior slide must have occurred to prevent the humeral head from literally rolling off the posterior rim of the glenoid.

It has also been explained to me that another flaw of the convex-concave rule relates to its clinical applications in manual physical therapy. Specifically, Johnson et al[4] showed that a *posterior* glide applied to the humeral head was more effective than applying an anterior glide for the purpose of increasing external rotation of the GH joint. The convex-concave rule suggests that the preferred direction of a manual glide to improve external rotation is anterior. This logic is consistent with a combined anterior slide and posterior roll during external rotation of the humeral head. My rebuttal to this argument is that the convex-concave rule was never intended to establish the direction of a manual glide, applied at a joint, that would best increase a targeted movement. The rule merely describes the arthrokinematic pattern that minimizes the inherent migration of the center of the convex member in the direction of the roll.

The specific direction of a glide applied to a joint for the purpose of improving motion is a separate issue, based primarily on the understanding of which part of the capsule, if restricted, would potentially limit the motion of interest. Traditionally, limited GH joint abduction has been associated with tightness of the inferior part of the capsule, a scenario often associated with an excessive superior migration of the humeral head, potentially causing subacromial rotator cuff impingement. In these individuals, it is logical to address the lack of motion through interventions that include inferior glide mobilization techniques of the humeral head, with the assumption that an inferior glide would best stretch the inferior capsule.

Similarly, it would be logical to assume that limitations of external rotation at the GH joint would be caused by restrictions within the anterior part of the capsule. In the study by Johnson et al,[4] the fact that a posterior glide administered to the humeral head was more effective than an anterior glide for gaining external rotation in persons with adhesive capsulitis may be related to factors not governed by the traditional convex-concave rule. Perhaps the capsular tightness associated with the patients' pathology caused the humeral head to migrate to a more anterior resting position than normal relative to the glenoid. The use of a posterior glide might have preferentially stretched parts of the capsule, allowing the humeral head to be more centralized relative to the glenoid. This new position might, in turn, have partially unloaded the anterior capsule, thereby allowing greater external rotation. Without objective data on which part of the capsule was most restricted and the position of the humeral head at the start and end range of motion, this scenario is purely a speculation, and others are possible.

Despite my position on this topic, I nevertheless find it very useful to consider the traditional roll-and-slide arthrokinematic patterns when evaluating any restriction in movement within an ovoid joint. In addition to helping visualize the likely arthrokinematics, the rules are often in agreement with the direction of the traditionally preferred manually imposed glide, such as a posterior glide to the talus to encourage greater dorsiflexion of the foot relative to the leg or a palmar glide to the proximal carpus relative to the radius to encourage greater wrist extension. That being said, my underlying point remains that the convex-concave rules of arthrokinematics, on their own merit, were not intended to serve as the unequivocal justification for deciding on the direction of the application of a manual glide maneuver. However, the rules can be a reasonable starting point for making such decisions, as long as factors such as the joint's resting position and local tensions within muscles, ligaments, or other connective tissues are considered.

Perhaps the term *rule* is too strong of a word when applied to the arthrokinematics described within this editorial. The term implies a strict and highly repeatable pattern of expected behavior, which is not the case. Perhaps referring to convex-concave *patterns* of kinematics is more forgiving, reducing the demands placed upon the premise of dictating clinical decisions. The convex-concave patterns are not flawed and, if interpreted correctly, serve as a cornerstone to understanding the essential mechanism of arthrokinematics. Let us appreciate the natural patterns of arthrokinematics for what they were intended to do, while respecting their possible limitations in directing treatment approaches. ◉

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