The Sigmoid Notch View for Distal Radius Fractures

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Purpose This study defines the sigmoid notch view of the distal radius. Specifically, we tested the null hypothesis that there is no relationship between the subchondral stripe of bone seen on a sigmoid notch view of the distal radius and the articular surface of the sigmoid notch.

Methods We used 44 wrist specimens for anatomic and fluoroscopic analysis. We measured the articular depth of the sigmoid notch from its deepest point and classified the shape of the sigmoid notch. We then placed a radiopaque marker at the nadir of the articular surface and quantified the fluoroscopic depth of the sigmoid notch. A sigmoid notch view, which was a tangential fluoroscopic view of the volar and dorsal lips of the sigmoid notch, was obtained. The relationship of the articular surface to the stripe of subchondral bone seen on this view, called the sigmoid stripe, was determined.

Results Anatomic analysis revealed sigmoid notch types with proportions similar to those in previous descriptions. The marker for the articular surface was superimposed or just ulnar to the sigmoid stripe in all specimens. In flat face and ski slope notches, this was coincident with the volar and dorsal lips of the sigmoid notch. In C- and S-type notches, there was a measurable distance from the articular surface marker to the edges of the bone of the volar and dorsal lips of the sigmoid.

Conclusions The articular surface marker at the nadir of the sigmoid notch is always coincident or ulnar to the sigmoid stripe in the sigmoid notch view.

Clinical relevance Surgeons can use the sigmoid notch view as a reliable method to (1) evaluate the integrity of the articular surface, (2) ensure hardware is not placed in the distal radioulnar joint, and (3) guide placement of volar locking plates in the coronal plane. *(J Hand Surg Am. 2018;43(11):1038.e1-e5. Copyright © 2018 by the American Society for Surgery of the Hand. All rights reserved.)*

Key words distal radioulnar joint, distal radius fracture, sigmoid notch, volar lunate facet.

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DISTAL RADIUS FRACTURES are the most common fracture of the upper extremity requiring surgery; the wide spectrum of injury severity and the complexities of fracture presentation often necessitate effective and informative diagnostic imaging to guide fracture management, including surgical approaches and fixation strategies.[1,2] Complications of volar plating include flexor tendon rupture, extensor tendon rupture, and intra-articular hardware placement.[3–6] Intraoperative fluoroscopic

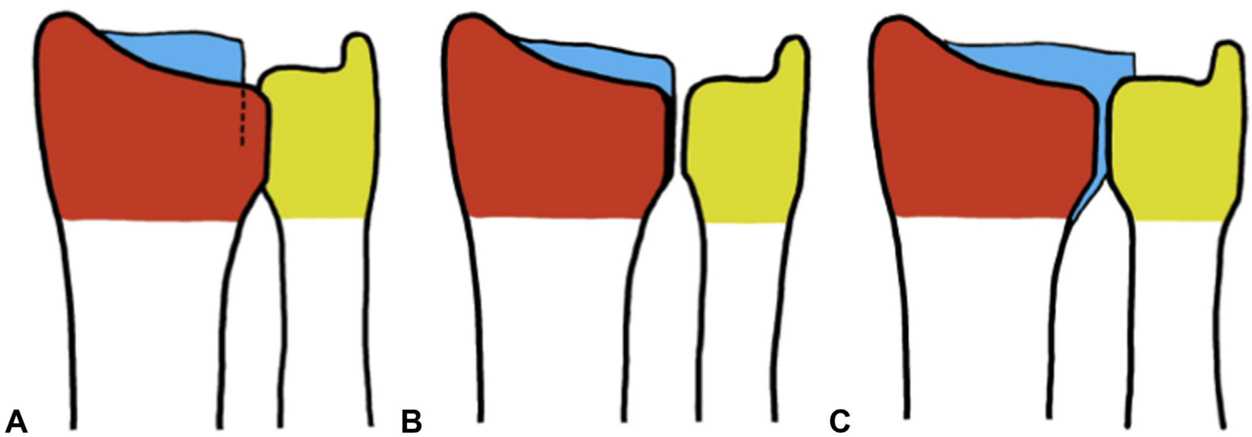

FIGURE 1: A The distal radius with the forearm pronated, with the volar lip of the sigmoid notch overlying the distal ulna. **B** The sigmoid notch view with the volar and dorsal lips tangential to the fluoroscopy beam and coincident subchondral bone from the volar and dorsal lips creating the sigmoid stripe. **C** With the volar lip supinated with the dorsal lip of the sigmoid notch overlying the distal ulna.

landmarks for proper plate placement to minimize risks of tendon rupture and intra-articular hardware placement have been described previously.[3,7–9] Current methods to evaluate for hardware within the sigmoid notch of the distal radioulnar joint (DRUJ) have limitations. For example, the skyline view requires rotating the forearm and extending the wrist to obtain an axial view of the wrist, a position that may be challenging to obtain during distal radius fracture reduction and fixation.[10]

The anatomy of the sigmoid notch of the DRUJ was previously shown to be variable.[11] Intra-articular fractures of the lunate facet have been treated with anatomic reduction and fixation using volar plates, screws, wire-form devices, or other types of fragment specific fixation.[12,13] Although these fracture fragments are relatively small, they can lead to wrist instability if not adequately fixed. Recognition of anatomic considerations, such as the depth of the sigmoid notch, is required to prevent hardware from penetrating the DRUJ while ensuring adequate fracture fixation. Anatomic landmarks have been described to guide plate placement during fixation of distal radius fractures, such as a description of plate placement in the sagittal plane[14] or plate placement in the coronal plane to minimize flexor tendon irritation.[8] There is a clinical need for reproducible landmarks to guide plate placement about the DRUJ.

Live fluoroscopy has been described to evaluate screw penetration into the DRUJ[10]; however, there are no descriptions of anatomic landmarks to inform decision making when using this approach. For example, because the sigmoid notch can be concave in some patients (C type, for example), a screw placed on the overlying bone of either the volar or dorsal lips of the sigmoid notch may always appear intra-articular despite live fluoroscopy. This is in contrast to using live fluoroscopy on a convex structure (the femoral head, for example) in which live fluoroscopy can be used for an approach–withdrawal technique to ensure hardware is maintained within the convex structure. We describe a simple approach to view the sigmoid notch of the distal radius tangentially, to evaluate the articular surface for intra-articular hardware, and to guide screw placement about the volar ulnar corner of the distal radius.

We found that when viewing the volar and dorsal lips of the sigmoid notch tangentially, a stripe of subchondral bone can be visualized reliably at the sigmoid notch. This study tested whether there is a relationship between the subchondral stripe of bone seen on a sigmoid notch view of the distal radius and the articular surface of the sigmoid notch. Our secondary hypothesis was that the sigmoid notch view and the sigmoid stripe could be used as a proxy for the articular surface of the sigmoid notch with a consistent spatial relationship. We describe an anatomic and fluoroscopic study that evaluated the shape and depth of the sigmoid notch of the DRUJ and describe the sigmoid notch view of the distal radius.

MATERIALS AND METHODS

We used 44 fresh-frozen, above-elbow specimens (17 male and 27 female), average age 75.8 ± 11.5 years (range, 43–93 years) for anatomic and fluoroscopic analysis. Prior work by Tolat et al[11] used a sample size of 50 specimens to identify and classify the

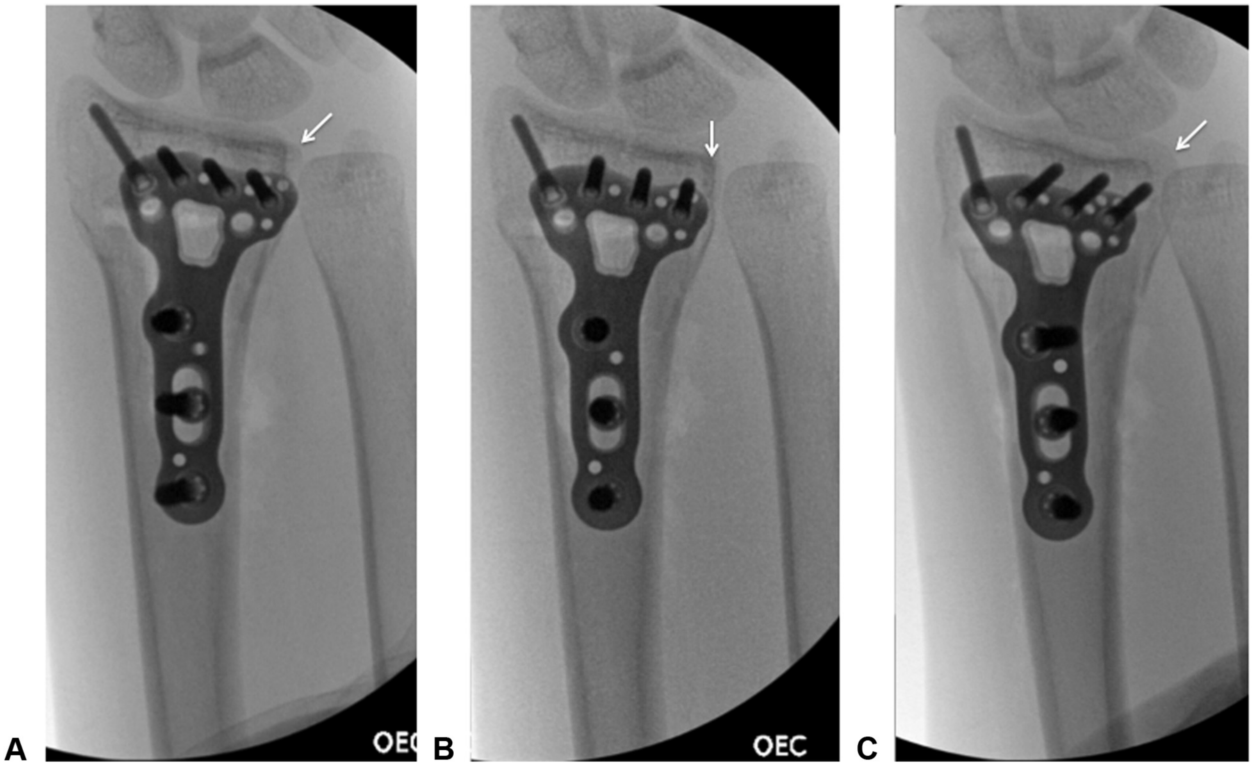

FIGURE 2: Clinical case demonstrating fluoroscopy of the distal radius **A** with the forearm slightly supinated, **B** the sigmoid notch view and sigmoid stripe (vertical arrow) with coincident volar and dorsal margins of the DRUJ, and **C** with the forearm slightly pronated.

shapes of the sigmoid notch. We used a similar sample size to ensure we included all sigmoid notch shapes in our study. All specimens had been screened fluoroscopically for DRUJ arthritis or a previous distal radius or ulna fracture that would alter DRUJ anatomy.

Anatomic analysis

First, we approached the distal ulna through the fifth extensor compartment and resected the distal ulna. This provided direct access to the sigmoid notch. Using a caliper sensitive to 0.1 mm, we measured the depth of the sigmoid notch from its deepest point (nadir) to a line connecting the volar and dorsal edges of the fibrocartilaginous lips of the sigmoid notch.[11] We placed a metal ruler against the fibrocartilaginous lips to identify their edges and create this line. This accounted for increased depth created in the sigmoid notch by the fibrocartilage, such as that which occurs in the shoulder and acetabulum. Next, we classified the shape of the sigmoid notch by visualization and palpation according to the previously described classification system by Tolat et al[11] of "flat face," "ski slope," "C-type," and "S-type" notches. Flat face and ski slope were defined as having no depth to the sigmoid notch.

Fluoroscopic analysis: the sigmoid notch view

A Kirschner wire was placed from the radial cortex of the distal radius into the nadir of the sigmoid notch to the articular cartilage under direct visualization. The wire was placed so that it entered but did not extend beyond the surface of the articular cartilage of the sigmoid notch. Next, we obtained a sigmoid notch view of the distal radius. This was completed by supinating or pronating the wrist until the beam of the fluoroscope was tangential to the volar and dorsal lips of the sigmoid notch (Figs. 1 and 2). We then quantified the fluoroscopic depth of the sigmoid notch by measuring from the tip of the Kirschner wire in the seat of the sigmoid notch to the fluoroscopic ulnar edge of the volar and dorsal lips of the sigmoid notch on the sigmoid notch view (Fig. 3). The tip of the wire was then used as a fluoroscopic marker for the ulnar edge of the articular cartilage. Because the nadir of the sigmoid notch in this position is parallel to the fluoroscopy beam, a stripe of radiodense subchondral bone at the sigmoid notch is visualized. This is termed the sigmoid stripe and can be seen on the sigmoid notch view (Fig. 3). A radiographic marker with a standardized size was used to standardize for any magnification of the image. Through this approach, we quantified the depth of the articular

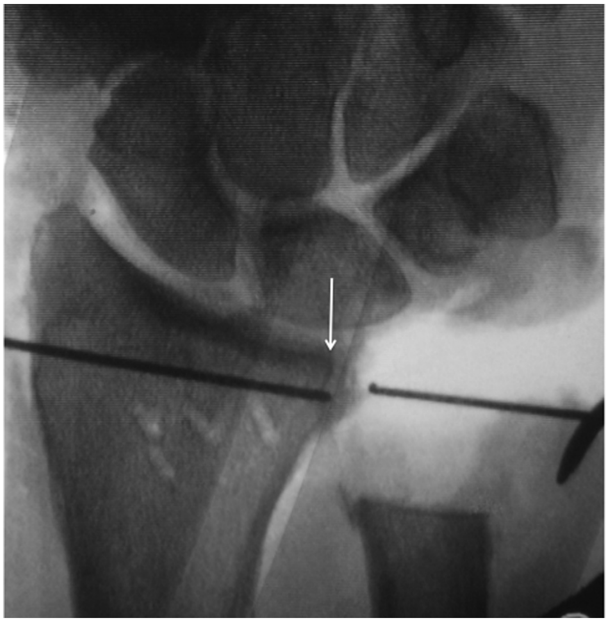

FIGURE 3: Sigmoid notch view of a C-shaped sigmoid notch. Note the distance from the edge of the volar and dorsal lips of the sigmoid notch and the nadir of the articular surface of the sigmoid notch (Kirschner wire through the radius). The arrow delineates the sigmoid stripe.

cartilage by measuring from the tip of the Kirschner wire to the subchondral bone of the sigmoid notch visualized on fluoroscopy. Sigmoid notch morphology and fluoroscopic analysis are presented using descriptive statistics.

RESULTS

Anatomic analysis

The sigmoid notch articular morphology of the 44 specimens was flat face in 22 (50%), ski slope in 2 (4%), C type in 14 (32%), and S type in 6 (14%). These findings were similar to those in the previous description by Tolat et al,[11] which found 42% flat face, 14% ski slope, 30% C type, and 14% S type. The average depth of the sigmoid notch from its deepest point (nadir) to the volar and dorsal edges of the fibrocartilaginous lips of the sigmoid notch was 3.65 ± 0.76 mm.

Fluoroscopic analysis: the sigmoid notch view

The tangential view of the sigmoid notch volar and dorsal margins (sigmoid notch view) displayed a longitudinal radiodensity of subchondral bone at the nadir of the sigmoid notch, which we termed the sigmoid stripe. In flat face and ski slope notches, the edges of the volar and dorsal margins were superimposed (coincident) on the tip of the Kirschner wire

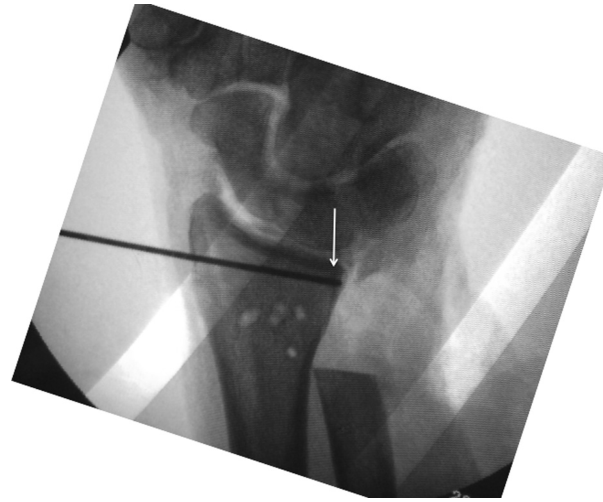

FIGURE 4: Sigmoid notch view of a flat face—shaped sigmoid notch. The articular surface of the sigmoid notch is just ulnar to the sigmoid stripe. The arrow delineates the sigmoid stripe.

(n = 24) (Fig. 4). In C- and S-type notches, the tip of the Kirschner wire was either superimposed or just ulnar to the sigmoid stripe, with a measurable distance of the wire tip to the edges of the bone of the volar and dorsal lips of the sigmoid notch (n = 20). This area ulnar to the sigmoid stipe was considered a safe zone for hardware placement, because it would be extra-articular. The average distance from the tip of the Kirschner wire to the fluoroscopic ulnar edge of the lips of the sigmoid notch in C and S notch types was 1.55 ± 0.48 mm (Fig. 3). This was thinner than the anatomic analysis because it did not account for the depth imparted by the fibrocartilaginous lips of the sigmoid notch.

DISCUSSION

The consistent correlation of fluoroscopic and anatomic landmarks of the sigmoid notch may be important for managing distal radius fractures and other conditions involving articular incongruity in the DRUJ. The results of this study inform multiple aspects of distal radius fracture care. First, standardizing the tangential view of the sigmoid notch to visualize the sigmoid stripe can inform the surgeon regarding a safe zone for screw placement near the sigmoid notch. The view allows the surgeon to align the plate and place screws as ulnarly as possible on the volar lunate facet to achieve fixation without violating the articular integrity of the DRUJ. It is possible that use of the sigmoid notch view concomitantly allows the surgeon to avoid improper radial placement of the plate, although further analysis is needed. Radial plate placement has been

implicated in flexor tendon irritation and injury and may be minimized by focusing efforts on relative ulnar plate placement. Furthermore, improper radial placement of the plate may leave a lunate facet fracture uncaptured and lead to escape of the fragment with subsequent carpal malalignment.

Second, screw placement through the ulnar-most plate hole can be critical in certain fracture patterns to achieve fixation of the volar lunate facet or sigmoid notch fragment.[15] Standard anteroposterior views of the wrist, however, do not ensure that the volar and dorsal lips of the sigmoid notch are tangential and superimposed on the image. We describe the sigmoid notch view in an effort to focus on this anatomy. If the anteroposterior view does not visualize the volar and dorsal lips of the sigmoid notch tangentially (Fig. 4A, C), the surgeon may not be able to draw conclusions as to the proximity of the ulnar screw to the articular surface.

Third, because the sigmoid notch can be concave in some patients (C type, for example), a screw placed on the overlying bone of either the volar or dorsal lips of the sigmoid notch may appear intra-articular when using live fluoroscopy. Using the sigmoid notch view and visualizing the sigmoid stripe allows the surgeon to place hardware radial to the sigmoid stripe, ensuring extra-articular placement of hardware. Whereas in C- and S-type notches there is bone more ulnar to the sigmoid stripe, in flat face and ski slope notches, the sigmoid stripe is always coincident with the volar and dorsal lips of the sigmoid notch.

Conclusions drawn from this study are limited by the accuracy and sensitivity of a mini fluoroscopy machine. Once anatomic reduction of a distal radius fracture is achieved, the sigmoid notch view can be used to evaluate for intra-articular hardware placement. Although further investigation is needed confirming the clinical applications of this view, this tangential view may allow the surgeon to evaluate the relationship of the most ulnar screw to the sigmoid stripe. In all notch types, hardware placed radial to the sigmoid notch will be extra-articular from the DRUJ. It may be difficult to classify the sigmoid notch type of a comminuted distal radius fracture that extends into the sigmoid notch, which limits the application of this fluoroscopic view in these cases. Overall, the sigmoid notch view may serve as a clinical technique for the surgeon to evaluate for intra-articular hardware in the DRUJ. Future investigation studying the use of these landmarks during clinical care is needed.

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