JSES International 9 (2025) 244–249

Contents lists available at ScienceDirect

JSES International

journal homepage: www.jsesinternational.org

A single-surgeon experience with the internal joint stabilizer of the elbow across 56 cases

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ARTICLE INFO

Keywords:
Elbow dislocation
Elbow instability
Hinged external fixator
Internal joint stabilizer
Terrible triad

Level of evidence: Level IV; Case Series; Treatment Study

Background: Recurrent instability continues to plague outcomes of elbow trauma. Adjuvant stabilization—whether internal or external—is intended to acutely stabilize the elbow and off-load the repair construct(s) during early mobilization. Our objective was to report clinical outcomes for a single-surgeon consecutive series using the internal joint stabilizer (IJS) of the elbow. Furthermore, we intend to describe technical points that have been gleaned from the experience which may provide guidance.
Methods: A retrospective follow-up was performed for cases of elbow instability treated with the IJS (Skeletal Dynamics, Miami, Florida, USA) from 2016-2023 with a minimum requirement of 6 months of follow-up. Clinical outcomes and complications including recurrent instability were compiled.
Results: Of 87 potential cases, 56 met the inclusion criteria. Simple dislocations (30%) and terrible triad injury (21%) were the most common injury patterns. The mean Mayo Elbow Performance Score was 81 and the mean Disabilities of the Arm, Shoulder, and Hand score was 22.5. Recurrent instability occurred in 5.3% of cases. The mean time to removal was 21.1 weeks.
Discussion: Our utilization of the IJS of the elbow has evolved from simple dislocations to complex instability cases. Results demonstrated satisfactory clinical outcomes with low rates of recurrent instability and revision. The ability for early mobilization was a critical determinant for using an IJS in these cases. This advantage carried particular importance in cases that presented subacutely following an extended course of immobilization. Our protocol for removal timing is applied on a case-by-case basis and involves identification of sufficient rehabilitation and clinical stability.

Historically, achieving elbow stability was problematic following traumatic ligament disruption, with or without fracture.[21,27] When evaluating treatment options, the surgeon must be conscious of the risk of stiffness following lengthened periods of elbow immobilization.[5] Thus, methods that restore stability and allow early motion should be prioritized to provide the highest likelihood of a satisfactory outcome.

Recurrent instability continues to plague outcomes of elbow trauma. Stambulic et al[26] identified recurrent instability as one of the most common reasons for revision surgery following terrible triad injury. This is consistent with Jung et al[13] who reported instability in 19% of terrible triad cases, with 80% of those requiring revision surgery. The review and treatment algorithm by Giannicola et al[8] for chronic elbow instability highlighted the need for external stabilization following appropriate repair of osseous and/or ligamentous structures. Adjuvant stabilization—whether internal or external—is intended to acutely stabilize the elbow and off-load the repair construct(s) during early mobilization.[16,19]

The initial report on internal stabilization by Orbay and Mijares[15] described an intraoperatively constructed Steinmann pin device. This concept evolved into the internal joint stabilizer (IJS) of the elbow. Currently, evidence for the IJS is comprised of small sample reports across a relatively short period of application. The initial IJS systematic review compiled 171 cases across 9 retrospective series, the largest being 30 cases.[11] These reports provided a foundation to understand early outcomes and potential complications. As experience increases, larger sample reports across a broader temporal period will provide understanding for the evolution of surgical techniques and case application.

Our objective was to report clinical outcomes for a single-surgeon consecutive series using the IJS. Furthermore, we intend to describe technical points that have been gleaned from the experience which may provide guidance.

This study was approved by TTUHSC IRB E23078.

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https://doi.org/10.1016/j.jseint.2024.08.204

Methods

Case identification

Following institutional review board approval (E23078), a retrospective review was performed for all cases of elbow instability that were treated with the IJS (IJS; Skeletal Dynamics, Miami, FL, USA) from 2016-2023. Procedure codes were used to collect cases then surgical notes and imaging were examined for confirmation and case details. Inclusion criteria were all IJS cases with appropriate clinical and radiographic data, and a minimum follow-up of 6 months. Cases of elbow stabilization with external fixators were excluded. Acute and chronic presentation of elbow instability was included.

Injury patterns

Cases were stratified by injury pattern using commonly accepted descriptive terms (simple dislocation, terrible triad), and the recently described classification for transulnar fracture dislocations—Monteggia, basal coronoid, and transolecranon.[3] Simple dislocations were defined as ulnohumeral dislocation without concomitant fracture. Dislocations with concomitant fracture which did not fit into these classifications were described according to the disrupted structures, that is, dislocation with coronoid fracture and dislocation with radial head fracture.

Assessment and treatment

Our protocol to determine the need for the IJS consisted of preoperative and intraoperative means. Preoperative radiographic evaluation determined the presence of ligamentous and bony disruption including the radial head, the coronoid, and the collateral ligaments. Preoperative clinical evaluation included presence of gross instability and a history of instability. In simple elbow dislocation, criteria used to determine the need for surgical stabilization included patient characteristics, and injury course and severity. The variables evaluated were history of prior instability event, length of time from index injury, the magnitude of the injury pattern, and the time requirement for restoration of motion. In complex elbow injury, these factors were assessed in addition to the reparability of the bone. In cases that presented subacutely with extended immobilization, the need for early motion was a critical consideration. Subacute presentation was defined as 3-6 weeks following the index injury. Intraoperatively, stability assessment was performed following treatment of the disrupted structures. The elbow was ranged in flexion extension then varus and valgus stresses were applied. Criteria used to indicate the IJS were the presence of instability as the elbow neared terminal extension (approximately 30°) and ulnohumeral asymmetry on fluoroscopic evaluation.

The IJS was used in cases that demonstrated instability following treatment and in cases where a tenuous ligament repair needed protection during early motion. All cases began staged mobilization at 5-10 days postoperatively—depending on severity of injury, concomitant trauma, and patient characteristics. Our preferred protocol was to use a splint for 5-7 days postoperatively to improve the short-term patient comfort.

Case data

The following case characteristics were collected: patient age and gender, injury pattern which indicated stabilization, and the follow-up term. The following clinical outcome data were collected: a numeric Mayo Elbow Performance Score (MEPS), a Disabilities of the Arm, Shoulder, and Hand (DASH) score, and a visual analog scale score for pain during normal daily activities.

Complications

Revision surgery was defined as any secondary procedure relating to the index pathology not including routine device removal. This included early symptomatic removal. Patients were counseled about routine device removal which was scheduled based on recovery and patient tolerance. Where possible, removals were identified as symptomatic and asymptomatic.

Implant-related complications were symptomatic hardware removal, device dissociation, and recurrent instability. Symptomatic hardware was defined as pain or discomfort localized to the IJS. Generalized elbow discomfort that did not solely localize to the IJS position were not considered symptomatic removals. Device dissociation was defined as radiographic evidence of deformation or discontinuity of the IJS. Recurrent instability was defined as clinical evidence of instability or radiographic evidence of a change in ulnohumeral congruency from the immediate postoperative position. Notably, device dissociation may be identified in cases without evidence of recurrent instability.

Nonimplant-related complications were ipsilateral neurological symptoms, and radiographic evidence of heterotopic ossification, and degenerative joint disease.

Statistical analysis

Continuous data were reported as a mean and standard deviation. Dichotomous data were reported as a mean and range.

Results

The chart review identified 87 IJS cases with 21 (27%) being lost to follow-up (Fig. 1). Of the remaining 66 cases, 9 cases did not have the minimum follow-up requirement, and 1 patient remained in a coma. A total of 56 cases provided outcome data—44 (56%) contributed clinical outcome scores and removal data and 12 (15%) contributed removal data. Acute presentation was most common (n = 32, 57%) and subacute presentation (n = 17) comprised 30% of the series.

Case indications are shown in Table 1 in descending proportion. Simple dislocations (30%) and terrible triad injury (21%) were the most common injury patterns. The mean arc of elbow motion prior to device removal was 95 (± 7.2) degrees and post removal, the arc was 110 (± 9.4) degrees. The mean MEPS was 81 and the mean DASH score was 22.5 (Table 2).

Recurrent instability occurred in 5.3% of cases (N = 3). Six cases (11%) had device dissociation, with 5 of the 6 occurring in the first 2 years of device usage. Dissociation occurred due to screw loosening at the connecting joint in 5 cases and in 1 case, the axis pin loosened from the connecting arm. Two of the 6 (33%) cases with device dissociation had recurrent instability. There were 3 revision cases (5.3%). One case was revised due to traumatic elbow dislocation and 2 were revised due to device dissociation.

The mean time to removal was 24.9 (range 3-232) weeks. The case with removal at 232 weeks postoperative presented to the emergency department with kidney pain, and the orthopedic department was consulted due to patient history of elbow trauma with retained stabilization device. The patient had not returned for the removal procedure due to satisfactory function and no device-related complaints. The DASH score was 15.9, the MEPS was 85, and the visual analog scale score was 2. When excluding this case, the mean time to removal was 21.1 weeks (range 3-75). There were 3 cases (5.3%) of symptomatic removal excluding 2 cases of infection and the 3 cases of recurrent instability.

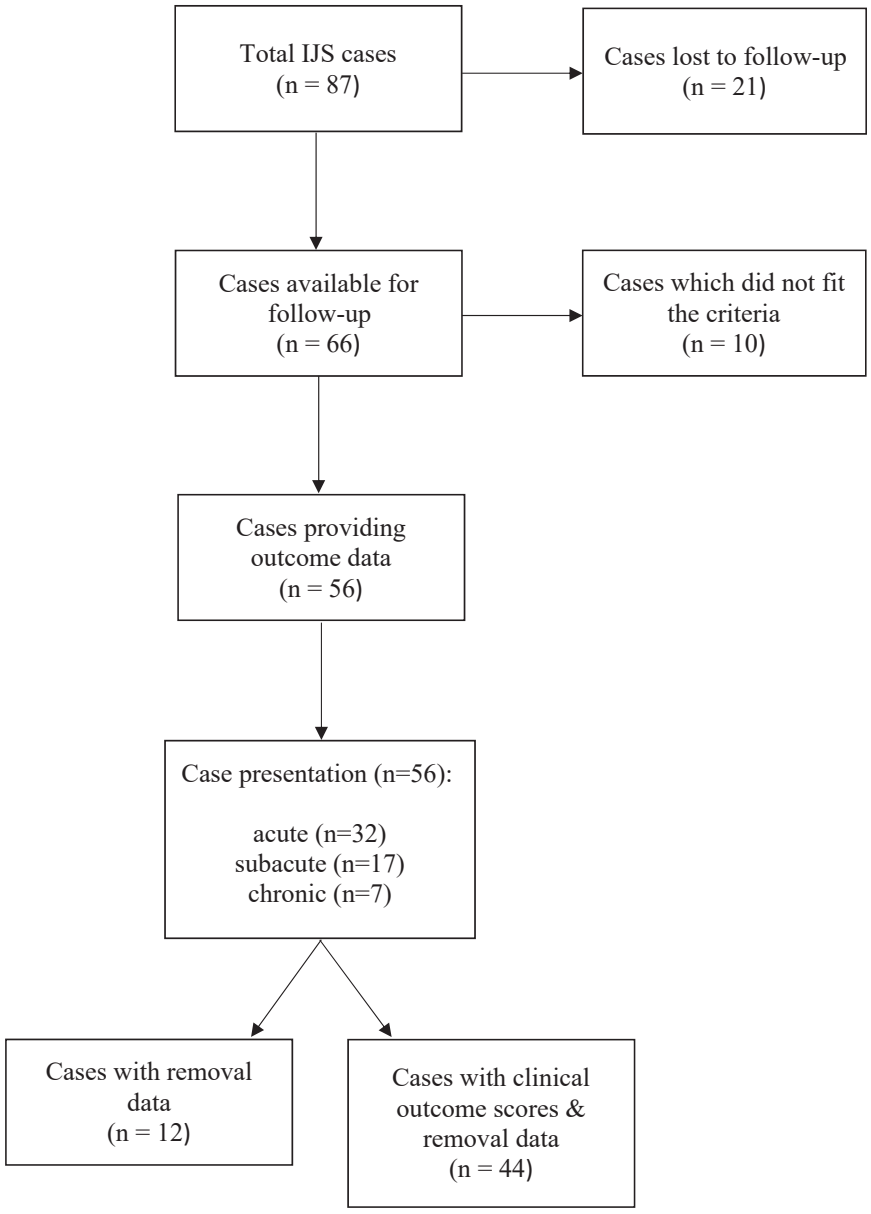

Figure 1 Flowchart of case inclusion for the internal joint stabilizer of the elbow including delineation for cases with radiographic contribution and those with clinical outcome score contribution. *IJS*, internal joint stabilizer.

Table I
Injury patterns and case characteristics for the internal joint stabilizer of the elbow.

*	Proportion of cases
Injury patterns	
Simple dislocation	30%
Terrible triad	21%
Trans-ulnar basal coronoid	16%
Dislocation + radial head fracture	12%
Dislocation + coronoid fracture	9%
Monteggia variant	7%
Transolecranon	5%
Case characteristics	
Male	63%
Acute presentation	57%
Subacute presentation	30%

*Dislocation refers to ulnohumeral joint, basal coronoid/Monteggia/trans-olecranon are trans-ulnar fracture dislocations classified according to Barlow et al *JSES*, 2023, subacute 3 to 6 weeks.

Discussion

Across 56 cases, clinical outcomes for the IJS were favorable with satisfactory function and low rates of implant-related complications including recurrent instability. The data demonstrated continued improvement in elbow range of motion following completion of treatment. It is certainly reasonable to suggest that suboptimal axis pin position and unintended device behavior may have occurred despite adherence to technique. However, we attribute the improvement in elbow motion to the extended recovery course that is common following elbow trauma. Across the current series, injury patterns treated with the IJS expanded as our understanding and comfort increased. Initially, the IJS was solely used for simple dislocations without concomitant fracture (Fig. 2). Currently, we use the IJS across a spectrum of simple to complex elbow trauma.

Table II
Outcome data including removal for the internal joint stabilizer of the elbow.

Sample	Follow-up*	MEPS	DASH	VAS	Recurrent instability	Removal (symptomatic)	Time to removal	Device dissociation
56/44	41 mo	81	22.5	3.3	5.3% (N = 3)	98% (5.3%)	21 wks	11% (N = 6)

MEPS, mayo elbow performance score; *DASH*, disabilities of the arm, shoulder, and hand score; *VAS*, visual analog scale.
*Data provided as mean; follow-up in months; MEPS, DASH, and VAS for pain during normal daily activities; time to removal in weeks; time to removal is the mean excluding the 232-week outlier.

Figure 2 (**A**) Anteroposterior and (**B**) lateral radiography demonstrating acute elbow dislocation. (**C**) Intraoperative fluoroscopy of the axis guide and (**D**) Kirschner wire guide for (**E**) wire placement across the ulnohumeral axis of rotation. (**F**) Fluoroscopic confirmation of final device position with concentric ulnohumeral joint.

Within the current series, elbow dislocation was the most common injury pattern treated with the IJS. The ability for early mobilization was a critical determinant for utilization in these cases. This advantage carried particular importance in cases that presented subacutely following an extended course of immobilization. The shared decision between patient and surgeon prioritized an accelerated restoration of motion. As stated by Anakwe et al,[2] simple elbow dislocations are not entirely benign injuries. In their series on simple elbow dislocations treated conservatively, Modi et al[14] reported that subsequent elbow stabilization was infrequent but performed nearly twice as often as joint contracture release. Schnetzke et al[23] determined that 19% of their simple elbow dislocation series had radiologic indicators of joint instability which has been previously identified as a harbinger for chronic instability.[10,22] The review by Breulmann et al[4] reinforced the importance of early postoperative mobilization to improve outcomes following surgical treatment of simple elbow dislocations.

Throughout the current series, we were able to identify points to improve surgical technique. Adequate exposure is needed to appropriately engage the trochlear axis guide. Often this involves additional release of the extensor origin and anterior capsule. When we have expectation for needing the IJS, we identify the axis of rotation and create the tract for the axis pin following initial exposure. If the device is not needed, the pin tract becomes the insertion site for the lateral collateral ligament (LCL). Consistent with prior literature, we reported cases with device joint loosening or disassembly.[7,20,25] These cases occurred early in the series, and we gleaned that the connecting joints must be adequately tightened. In our experience, “squeaking” signified a sufficient degree of tightness. Since this “technique” was applied, we have not had cases with device joint loosening or disassembly. Alignment of the splines at the locking joint is another important step for mitigating risk of loosening or disassembly. When coupling the device, the splines must properly interlock which we visually confirm noting that there is not a tip-to-tip relationship of the splines. There are few objective determinants of sufficient elbow stability. In our experience, inability to engage the trochlear axis guide may indicate an intact medial collateral ligament; thus, the IJS may not be

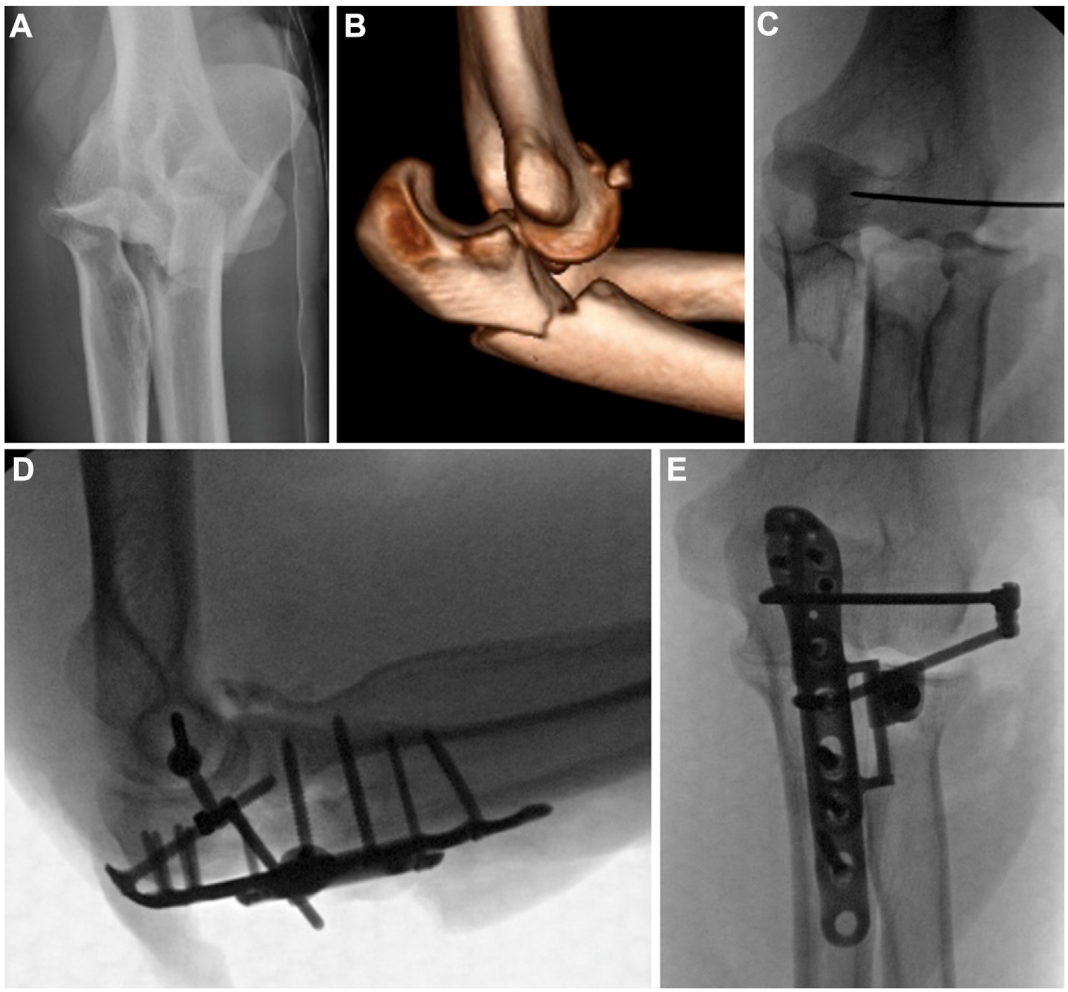

Figure 3 (**A**) Radiography and (**B**) computed tomography demonstrating Monteggia fracture dislocation. (**C**) Intraoperative fluoroscopy of wire placement across the ulnohumeral axis of rotation prior to fracture fixation, and (**D** and **E**) final fixation construct with the internal joint stabilizer placed on top of the proximal ulna plate.

needed. In these cases, elbow stability may be restored following repair of the LCL.

The current literature demonstrates a wide spectrum of time for IJS removal. The seminal study by the device designer reported removal at 6-8 weeks postoperatively.[16] Pasternack et al[17] reported consideration for device removal began at 6 weeks. Fene et al[7] reported removal at a mean of 4 months. Furthermore, some studies reported that removal was routinely planned in all cases, while others specified that removal occurred in cases based on patient compliance and request.[28] We reported a mean device removal of 21 weeks across 98% of collected cases. We do not want removal to interfere with or negatively impact rehabilitation and motion recovery. Therefore, when planning device removal, we aim to identify plateau in recovery then proceed with removal. Currently, we remove the IJS following sufficient clinical evidence of healing and elbow stability. The long-term ramifications of device retention are unknown.

Our series demonstrated a recent evolution of IJS application in transulnar fracture dislocations. Early in our series, cases with a proximal ulna plate reduced available space for the IJS baseplate. In these cases, optimal baseplate position was determined individually based on the desired trajectory of screws which may vary due to patient anatomy and fracture pattern. Current technology now allows placement of the IJS baseplate on top of the proximal ulna plate (Fig. 3). Across this series, there were 10 cases (18%) with IJS implanted on a proximal ulna plate.

Our technique for repairing the LCL around the IJS axis pin has evolved. There was one failed repair likely due to mechanical interference with the device components. We aim to avoid an anterior repair position as the device motion primarily occurs anteriorly. When the device screws are fully tightened, we move the elbow through flexion extension to visualize the device's motion. Then the LCL is repaired posterior to the axis pin, which is a safe position avoiding the device's moving parts. We have not identified postoperative deficits in motion following this technique. This is consistent with prior investigations which have determined that the position of LCL humeral insertion is highly variable, and the goal of repair should be a position in close proximity to the isometric point.[1,9]

Appropriate management of the coronoid is increasingly recognized as a critical component of achieving a satisfactory outcome in complex elbow trauma.[3,12,21] Sheth et al[25] reported that their IJS case with recurrent instability had a coronoid fracture that failed suture fixation. Similarly, Pasternack et al[17] and Orbay et al[16] reported recurrent instability in cases with coronoid deficiency. Jung et al[13] reported that coronoid nonrepair was associated with recurrent instability following terrible triad injury. Our series contained one case of recurrent instability with failure of coronoid fixation, likely multifactorial in causation. Modern treatment algorithms emphasize fixation of the coronoid in the presence of large fragment size.[21] Notably, medial placement of the IJS is an

emerging concept with preliminary evidence.[18,24] Our series did not contain cases with medial placement of the IJS. Placed on the lateral aspect of the elbow and made of rigid material, the IJS provides the stability of the LCL complex and stability in other axes. Its application does not obviate the need for fixation of appropriate coronoid fragments.[6] On the other hand, the IJS is likely to offload a coronoid fixation construct during early mobilization.

We acknowledge limitations beginning with a single surgeon performing all cases across this series. Variation in surgical technique and patient population may yield different results. However, a single-surgeon series allows identification of trends and techniques which provide value. The retrospective nature increases the risk of reporting bias as cases lost to follow-up may be those experiencing poor results. The current series had a high rate of cases lost to follow-up which can be common in trauma series reporting. Furthermore, it is unknown whether these devices were retained or were removed elsewhere. Although we were able to trend the elbow range of motion preremoval and postremoval, other clinical outcomes were only collected at the final follow-up. Thus, we do not know whether this change in elbow motion has notable clinical impact. The sample size is the largest to date for the internal stabilizing device. Furthermore, the spectrum of cases from simple dislocations to complex fracture patterns improves the generalizability of the findings. Importantly, the series contained a high proportion of complex elbow trauma which may be at greater risk for recurrent instability.

Conclusion

Our utilization of the IJS of the elbow has evolved from simple dislocations to complex instability cases. The low rate of recurrent instability, the ability for earlier mobilization, and the satisfactory restoration of function has lowered our threshold to indicate the device. Our protocol for removal timing is applied on a case-by-case basis and involves identification of sufficient rehabilitation.

Acknowledgments

The authors appreciate the expertise of Gustavo Lacau, MD—he is a talented surgeon and teacher.

Disclaimers:

Funding: There were no grants, no funding, or support obtained for this project.
Conflicts of interest: Gil Gontre discloses a speaker's bureau relationship with Skeletal Dynamics. The other authors, their immediate families, and any research foundation with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

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