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Retrograde headless compression screw fixation of olecranon stress fractures in throwing athletes: a novel technique

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Background: An olecranon stress fracture (OSF) is a rare injury most commonly seen in high-level overhead throwing athletes with no clear consensus on surgical treatment. The most common surgical treatment described in the literature is cannulated screw fixation but there have been high rates of reported hardware irritation and need for subsequent hardware removal.
Hypothesis/Purpose: This study describes a novel surgical technique in the treatment of OSFs in high-level throwing athletes using retrograde headless compression screws. We hypothesized that patients would have excellent outcomes and decreased rates of hardware irritation postoperatively.
Methods: A retrospective review of competitive-level throwing athletes who sustained OSFs that were treated operatively using a novel technique using retrograde cannulated headless compression screws to avoid disruption of the triceps tendon. Postoperative outcome measures obtained included the Disabilities of the Arm, Shoulder and Hand score, Mayo Elbow Performance Score, Simple Elbow Test score, Single Assessment Numerical Evaluation score, Visual Analog Scale, arch of motion, and time to return to sport as well as level returned to. Radiographs were obtained routinely at 2-week, 6-week, 12-week, 6-month, 1-year, and 2-year follow-up.
Results: Five of 5 patients who met inclusion criteria were available for final follow-up. Mean age at time of surgery was 20 years (range 17-24). Mean follow-up was 17 months (range 4-33). All patients were baseball players, 4 of which were pitchers and 1 position player. All patients were able to return to sport at the same level or higher at a mean of 5.8 months (range 3-8). Postoperatively, mean arch of motion was 138°, Visual Analog Scale score was 0, Single Assessment Numerical Evaluation score was 90, Disabilities of the Arm, Shoulder and Hand score was 2.0, Mayo Elbow Performance Score was 100, and Simple Elbow Test score was 12. There was no incidence of hardware removal.
Conclusion: This study presents a novel surgical technique in the treatment of OSFs in high-level throwing athletes. The results presented demonstrate that this technique is safe and effective for getting athletes back to play quickly without any complications of hardware irritation which has previously shown to be a significant problem in prior literature.

An olecranon stress fracture (OSF) is a rare elbow injury seen most commonly in overhead throwing athletes.[5] While there are some case reports of OSF in other nonthrowing athletes such as gymnasts, wrestlers, weight lifters, and divers, baseball players are thought to be the most susceptible population.[3,9,13,15,16,20] Incidence has been reported as high as 58% of all stress fractures in baseball players with the pitcher position being the most at risk.[7] OSF in throwing athletes is thought mainly to be caused by microdamage from rapid and repetitive valgus extension, tensile forces from the triceps during throwing acceleration, and potentially poor throwing mechanics.[1,8]

Both nonsurgical and surgical treatments of OSF have been described in the literature, however, due to the rarity of the injury and the relatively small case series available in the literature; no single best treatment or surgical technique has been defined. Nonsurgical treatment typically consists of throwing rest followed

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by rehabilitation and correction of throwing mechanics.[1] However, with risks of up to a 33% failure rate with nonoperative management as well as potentially increased time to union when compared to operative management, many patients will elect for early surgery.[2,17] The most common surgical treatment described in the literature is cannulated screw fixation but there have been high rates of reported hardware irritation and need for subsequent hardware removal which often times can further delay return to play.[4,11,14,18]

This study describes a novel surgical technique in the treatment of OSFs using retrograde headless compression screws. We hypothesized that this technique would lead to excellent outcomes, reliable bony union, decreased rates of hardware irritation postoperatively, and potentially accelerate the time to return to play for these high-level athletes.

Materials and methods

Approval for this study was obtained from our institutional review board. Using a prospectively collected database, we searched to identify all patients who underwent ORIF for an OSF from 2016-2021. Seven potential patients were identified for inclusion. Criteria for inclusion included any patient who was an overhead athlete that was treated surgically for an OSF in their throwing arm with our proposed novel technique. Exclusion criteria were any patient with an OSF who was not a throwing athlete or was treated with an alternative surgical technique. All patients with a prior history of surgery on the same elbow were also excluded. A total of 5 patients were identified who met inclusion and exclusion criteria. Two patients were excluded due to use of an alternative surgical technique.

Preoperative, intraoperative, and postoperative information was collected from review of their electronic medical record. Patient demographics such as age, sex, arm dominance, and sport played were recorded. A trial of nonoperative management is typically recommended to all patients who include cessation from throwing and a rehabilitation program focused on rotator cuff strengthening and flexor-pronator mass strengthening. However, most patients who present with this pathology are high-level throwers, and the timeline for return to play is a critical part of decision-making as most cannot afford the potential time lost with failure of nonoperative management depending on where they are in their current season or offseason. Based on these factors, we believe surgical intervention can be offered on an individual basis after all factors have been considered and the risks and benefits of operative vs. nonoperative management have been fully discussed. With this particular cohort of patients, all 3 nonprofessional athletes underwent a minimum period of 3 months throwing rest with physical therapy but continued to have pain upon throwing and elected to proceed with surgical intervention at that time. The 2 professional athletes both had been pitching with pain for over a year and had completed intermittent rest and physical therapy in their offseason but continued to have pain and elected for surgical treatment at their initial visits.

Magnetic resonance imaging and computed tomography scans with 3-dimensional reconstruction were obtained preoperatively to confirm the diagnosis, rule out other elbow pathology, and for surgical planning. All operations were performed by the senior author at a single institution. Patient-reported outcome measures (PROMs) were collected at final clinical follow-up that included the Disabilities of the Arm, Shoulder and Hand score, Mayo Elbow Performance Score, Simple Elbow Test score, Single Assessment Numerical Evaluation score, and Visual Analog Scale score. Final clinical follow-up was determined to be final contact with the patient via telephone or in-person office visit. Postoperative range of motion (ROM), time to return to sport (RTS), and competitive level of play upon final RTS were also recorded. Radiographs were obtained routinely at 2-week, 6-week, 12-week, 6-month, 1-year, and 2-year follow-up.

Surgical technique

All patients were positioned in the supine position. The operative extremity was sterilely prepped and draped. After draping, a sterile tourniquet was applied. Using the preoperative magnetic resonance imaging, the incision landmark was planned out measuring the length from the tip of the olecranon and triceps footprint in the sagittal plane to the desired starting point of the retrograde screw (Fig. 1*A*). The desired starting point was also based on the angle of screw trajectory with the goal to be as orthogonal to the fracture as possible. Screw trajectory can vary based on the fracture pattern. Once desired starting point was identified, the projected screw length was also measured. Using a radiographic ruler, the incision landmark was measured out on the patient based on our preoperative planning (Fig. 1*B*). A percutaneous guidewire was then placed just ulnar to midline at the planned angle of screw trajectory in retrograde fashion. The position and orientation of the initial guidewire is then confirmed fluoroscopically. A second guidewire is then placed parallel and radial to the initial wire followed by a more radial and divergent third guidewire (Fig. 2). The second guidewire is then removed. The purpose of the second wire is to stimulate bleeding across the fracture site. Final positioning of the first and third guidewire is then confirmed fluoroscopically. Small percutaneous incisions are made over the wires and a cannulated depth gauge is used to measure screw length. To prevent any screw prominence, 2-4 mm is typically subtracted from the measurement depending on the positioning and prominence of the guidewires. Two mini headless compression screws with a 3.5-mm tip and 3.6-mm tail of appropriate length are then placed and sequentially tightened (Fig. 3). Both guidewires are removed and final fluoroscopic images are obtained (Fig. 4). The tourniquet is then deflated and hemostasis is achieved followed by wound irrigation and closure. Sterile dressings are then applied.

Postoperative rehabilitation

Patients were immobilized in a posterior splint with the elbow flexed at 90° for 7 to 10 days postoperatively to allow for soft-tissue healing. During the brief period of immobilization, the patient was encouraged to mobilize their fingers, hand, wrist, and shoulder. After splint removal, each patient began immediate passive and active ROM exercises both at home and in formal therapy with the goal of achieving full ROM by 6-8 weeks postoperatively. Strengthening began at 8 weeks with a focus on rotator cuff and flexor-pronator strengthening. A throwing program can begin at 12 weeks if the patient is pain free. All patients in this study were high-level baseball players and were cleared to progress throwing under the supervision of their therapist or throwing coach after 12 weeks. Time to starting throwing programs was often variable depending on whether the patient was in season or in their offseason.

Results

Five of 5 patients (100%) who met inclusion criteria were available for final follow-up (Table I). Mean age at time of surgery was 20 years (range 17-24). Mean follow-up was 17 months (range 4-33). All patients were baseball players, 4 of which were pitchers and 1 position player. One patient was a high-school athlete, 2 patients were Division-I collegiate athletes, and 2 patients were professional-level athletes; 1 in the minor league system and 1 in

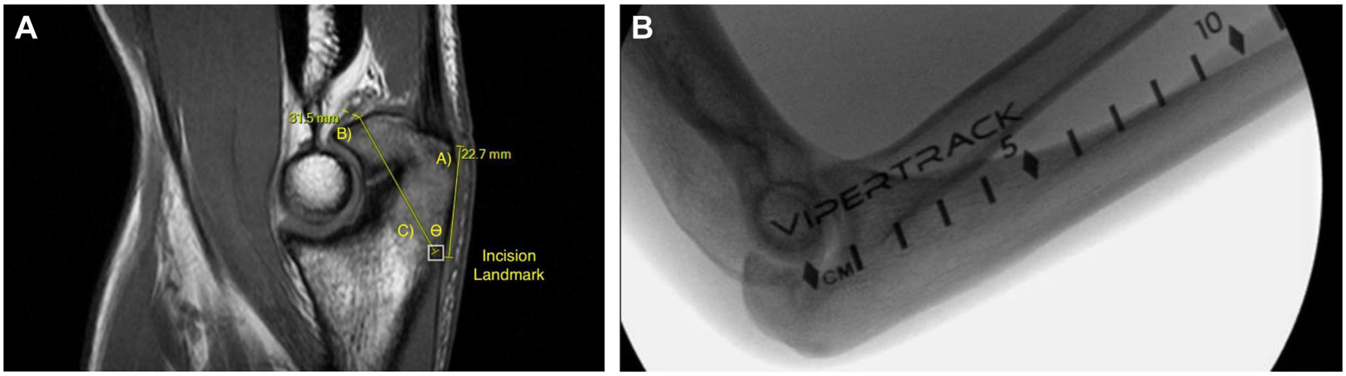

Figure 1 (**A**) Preoperative sagittal MRI measuring incision landmark from triceps footprint to desired starting point for screw. (**B**) Radiographic ruler used to plan out start point for K-wire based on preoperative MRI measurements. *MRI*, magnetic resonance imaging.

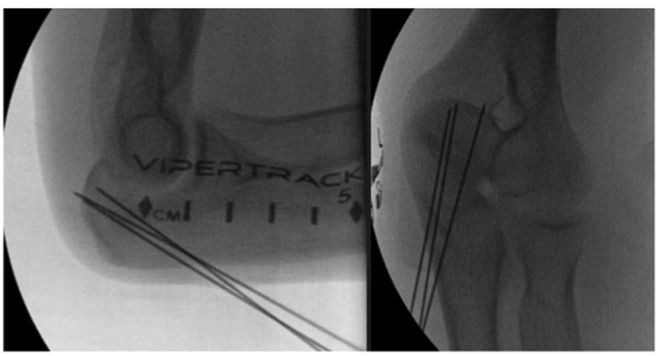

Figure 2 Percutaneous placement of 3 K-wires using fluoroscopic guidance.

Figure 3 Percutaneous placement of headless compression screws.

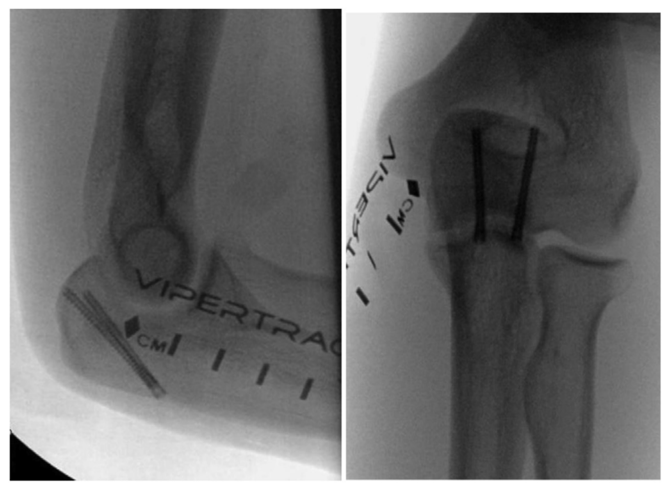

Figure 4 Final fluoroscopic images after placement of 2 percutaneous headless compression screws.

the major leagues. Mean time to beginning a pain-free and restriction-free throwing program was 5.8 months (range 3-8). All patients were able to RTS at their same level or higher.

PROMs and active ROM were collected on 4/5 patients (80%). The 1 patient who we did not collect PROMs and ROM on was a professional-level pitcher who was in season and elected to follow-up via telemedicine visits. He began a throwing program at 3 months postoperatively and was activated from the disabled list for full pitching at 4 months postoperatively. Mean arch of motion was 138°, with all patients achieving complete extension or hyperextension except 1 patient who was found to be 10°-142° at final follow-up. Mean Visual Analog Scale score was 0, Single Assessment Numerical Evaluation score was 90, Disabilities of the Arm, Shoulder and Hand score was 2.0, Mayo Elbow Performance Score was 100, and Simple Elbow Test score was 12. One patient was noncompliant and sustained a periprosthetic fracture during an all-terrain motor vehicle accident 2 months postoperatively. This patient underwent hardware removal and open reduction internal fixation immediately after re-injury and had a slightly prolonged recovery compared to the rest of the cohort returning to throwing 8 months after the index procedure. However, the patient was able to start hitting only 3 months after reoperation and eventually returned to the same level of play. There were no other complications noted and all patients went on to final radiographic healing within 3 months postoperatively. Radiographs were obtained at 6-12–week intervals after 3 months postoperatively without any evidence of recurrence.

Discussion

This study presents the results of a novel surgical technique in the treatment of high-level baseball players with OSFs using 2 percutaneous retrograde headless cannulated screws for fixation. The proposed benefits of this technique are to avoid any violation of

Table I
Patient demographics and reported outcomes.

Patient	Age (yr)	Handedness	Position	RTS time (mo)	Total follow-up (mo)	Highest level of sport	VAS	SANE	DASH	MEPS	SET	Arc of motion
1	17	Right	Outfield	7	33	Division I	0	100	1.67	100	12	140°
2	18	Left	Pitcher	6	27	Division III	0	100	4.17	100	12	140°
3	24	Right	Pitcher	5	5	Professional	0	80	0	100	12	132°
4	24	Right	Pitcher	3	4	Professional	NC	NC	NC	NC	NC	NC
5	17	Right	Pitcher/Infield	8	16	High School	0	80	NC	NC	NC	140°

RTS, return to sport; *VAS*, visual analog scale; *SANE*, single assessment numeric evaluation; *DASH*, disabilities of the arm, shoulder, and hand; *MEPS*, Mayo elbow performance score; *SET*, simple elbow test.

the triceps tendon with placement of the screws, provide dual compression across the fracture site to maximize healing potential, as well as limit the incidence of hardware irritation and need for potential hardware removal later which has been documented in the literature to be as high as 33%-40% in this patient population.[11,14] While this is a relatively small case series, this study presents promising results for this technique with all athletes demonstrating excellent PROMs and returning to sport at their same level of play or higher with minimal complications.

Despite the fact that a majority of overhead-throwing athletes opt for surgical management of their OSF, with rates reported up to 76.9%, there is still no current consensus surgical treatment.[17] Several surgical techniques have been proposed such as tension band wiring with 2 Kirschner wires,[6,9] fracture site drilling,[10] bone grafting,[12,19] and most commonly fixation with a single cannulated screw.[4,11,14,18] Most of these studies are limited to small case series. Paci et al[11] reported on the largest case series to date looking at 18 OSFs treated using a single anterograde cannulated screw. They reported a 94% RTS rate at a mean of 29 weeks with an overall mean follow-up of 6.2 years. Similar to our study, they reported excellent PROMs; however, 6/18 patients (33%) required hardware removal and 2/18 patients (11%) presented with subsequent hardware infections. The authors speculated that the high rate of infection may be related to the subcutaneous nature of the screw head after fixation and that a headless compression screw may potentially decrease this risk and should be explored in future studies. Similarly, Rettig et al[14] reported on a series of 5 patients treated with a 7.0 cancellous screw and washer with or without 18-gauge tension banding with a 40% rate of hardware removal and 29.4-week mean RTS time. These high rates of hardware removal can lead to unnecessary morbidity and significant delays in RTS in a population where quick recoveries are much preferred and often times are the main reason for electing for surgical vs. nonoperative management despite the fact that a recent meta-analysis showed that RTS was actually shorter in patients treated nonoperatively (16.0 weeks vs. 25.7 weeks).[17] The authors of this study speculated that the difference is likely due to operative patients being delayed by complications and/or need for revision surgeries as well as added caution from surgeons placing longer restrictions on patients treated operatively.

The only known study to report on the use of a headless cannulated screw is by Fujioka et al[4] who reported on a series of 6 patients with a mean follow-up of 2.33 years. All patients were treated with an anterograde headless double-threaded cannulated screw. All patients were able to RTS at their same level of play at a slightly accelerated rate of 21.3 weeks postoperatively with no complications reported and no incidence of hardware removal. This is similar to our study as we demonstrated a mean 5.8-month or 25.2-week time to RTS. Our slightly longer RTS is likely due to the small size of cohort and our 1 complication who sustained a periprosthetic fracture as this required a secondary operation which led to a prolonged recovery. If we were to exclude this complication, the mean follow-up would have been 5.25 months or 22.8 weeks to RTS. Overall, when compared to the previously discussed studies, our RTS time was notably shorter. It should be noted however, our RTS time was calculated from the time of the index procedure to the time of initiating a throwing program which could explain the slightly shorter duration. Nevertheless, all patients were cleared to begin throwing after 12 weeks as all demonstrated signs of radiographic union and had no pain on clinical examination. Variabilities of when each athlete started their throwing program were largely dependent on whether or not they were in or out of season. The fastest recovery we observed was in the professional pitcher who began a throwing program at 3 months postoperatively and returned to game pitching at 4 months postoperatively. Although the numbers in these studies are small, the findings do suggest that headless screws whether retrograde or antegrade may eliminate the risk of hardware irritation and potentially accelerate RTS time. Furthermore, based on a previous anatomic study by Yamaguchi et al,[21] the blood supply to the olecranon is known to derive from vascular cascades on the medial, lateral, and posterior olecranon; another potential advantage of a retrograde technique may be preservation of blood supply which can be critical in treating this particular pathology.

In examining our 1 complication with a periprosthetic fracture, we believe this was caused secondary to noncompliance and the high-energy mechanism of injury. The patient was specifically advised not to participate in any sporting activity until 3 months postoperatively. We believe that this injury was likely to happen regardless of technique used. Nonetheless, it was a complication and warrants reporting and consideration for surgeons considering future use of this technique as it may be possible that the screws acted as a stress riser for fracture that may not have otherwise been the case if an alternative technique was used. While not necessarily relevant to this patient, we do recommend planning out screw trajectory in advance and adequate use of fluoroscopy as discussed in the surgical technique description to prevent repetitive drilling with the guidewires and minimize the risk of a stress riser.

This study is not without limitations. The study design is retrospective in nature without a comparison cohort and had a very small sample size. However, our study design and sample size are comparable to most other studies previously published. Additionally, follow-up was short at only 17 months. While we would have preferred longer follow-up, we believe this is less critical in fracture studies as there should be minimal changes in outcomes after radiographic union has been achieved and patients have RTS, which was seen in all patients studied. Additionally, long-term follow-up data are often limited when studying high-level athletes as they often times live out of state or frequently move as they graduate to the next level of play or change teams. Especially at the professional level, these patients will perform most of their follow-up with their designated team physician. Our 2 shortest follow-ups were 5 months and 4 months, both of whom were professional pitchers. Both were tracked online and continued playing for multiple years after their follow-up with our clinic. Nevertheless, longer term follow-up data are needed to confirm the longevity of this fixation construct.

Conclusion

This study presents a novel surgical technique in the treatment of OSFs in high-level baseball players. The results presented demonstrate that this technique is safe and effective for getting athletes back to play quickly without any complications of hardware irritation which has previously shown to be a significant problem in prior literature. While this is an uncommon problem, it remains challenging to treat with a high rate of postoperative symptomatic hardware requiring potential secondary surgery for removal. We believe this technique adds to the current body of literature and provides high-volume elbow surgeons an improved option to treating this complex pathology.

Disclaimers:

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Conflicts of interest:
Dr. John M. Itamura receives royalties from Arthrex, Shoulder Innovations, and Acumed.
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Patient consent: Obtained.

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