



# Intraoperative periprosthetic humeral fracture during reverse shoulder arthroplasty: a sequelae of prior biceps tenodesis

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Intraoperative periprosthetic humeral fractures are a rare but debilitating complication of reverse shoulder arthroplasty and can occur during multiple stages of the procedure. Prior biceps tenodesis has been found to reduce cortical humeral strength and predispose the patient to humeral fracture. We present a case of a 68-year-old female with a previous history of biceps tenodesis due to an irreparable rotator cuff tear. Months later, and after symptoms persisted, a reverse shoulder arthroplasty was performed. During the surgery and while performing final reduction, a fracture line was observed involving the hole used for the previous tenodesis procedure. The fracture was repaired, and the patient reported favorable outcomes. We report several factors that might have contributed to sustenance of this intraoperative fracture including prior biceps tenodesis, use of a press fit humeral stem, and the sex of the patient.

**Level of evidence:** V.

**Keywords:** Shoulder; Tenodesis; Suture anchor; Humeral fracture; Arthroplasty

Intraoperative periprosthetic humeral fractures have been reported to occur in 1.5% of shoulder arthroplasties [1]. They can occur during humeral preparation, implant insertion, or shoulder reduction. Reverse shoulder arthroplasty, introduced in 1987, gained popularity for treatment of cuff tear arthropathy, proximal humerus fracture and revision shoulder arthroplasty [2]. With these rising trends, multiples studies have assessed the rate and risk factors of fractures associated with reverse shoulder arthroplasty. To our knowledge however, there have been no reports of intraoperative humeral fractures during reverse shoulder arthroplasty, associated with prior biceps tenodesis.

## CASE REPORT

The patient was a 68-year-old female who underwent shoulder

arthroscopy and biceps tenodesis for a painful irreparable rotator cuff on January 29, 2019. The patient provided consent for her case to be reported in this study; as such all relevant data were deidentified, anonymized and included in this case presentation. Tenodesis was performed in a subpectoral position using an all-suture anchor with a 1.8-mm-pilot drill hole to minimize bone loss. The patient failed to improve significantly, and we proceeded with a reverse prosthesis on March 10, 2020. X-ray imaging performed prior to the reverse shoulder arthroplasty clearly revealed the tenodesis hole of the prior procedure (Fig. 1).

Arthroplasty was performed through a deltopectoral approach using the Aequalis Ascend Flex reverse shoulder system from Wright Medical (Memphis, TN, USA). The surgery was uneventful, and the final reduction was performed using a 6-mm insert for the humeral tray (smallest option). After reduction was

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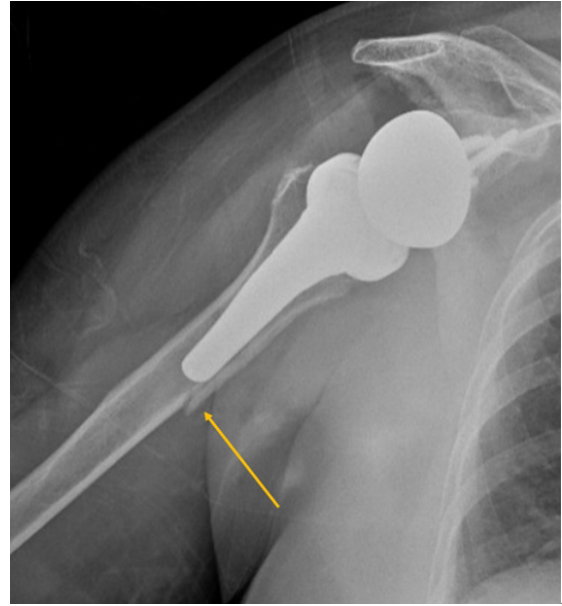
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**Fig. 1.** X-ray showing the biceps tenodesis hole (arrow) prior to reverse shoulder arthroplasty in the patient.



**Fig. 2.** Intraoperative X-ray showing an oblique fracture of the humerus (arrow) in the patient.

achieved, the humeral stem was unstable, and an oblique fracture line was identified involving the site of the osteotomy and exiting through the hole used for anchoring the biceps. An intraoperative X-ray of the shoulder is shown in Fig. 2. The stem was removed, and the fracture was fixed by cerclage using two non-absorbable sutures. The stem was inserted and found to be stable before and after reduction with a 6-mm liner. The procedure was uncomplicated, and the patient wore an arm sling for 2 weeks. Follow-up at 5 months from surgery revealed a stable implant with a good location and good bone healing (Fig. 3).

## DISCUSSION

Pathologies targeting the long head of the biceps (LHB) are observed frequently and concomitantly with rotator cuff tear [3]. Indications for tenodesis have been inconsistent in the literature. Nevertheless, the procedure can be recommended when there is partial tearing, instability, or tenosynovitis of the LHB tendon [4]. Other conditions include SLAP tear and LHB pain upon physical examination [4]. In the setting of irreparable rotator cuff tears, a study by Walch et al. [5] explored the outcomes of 307 arthroscopic biceps tenotomies following irreparable full-thickness tears and reported favorable results with a low rate of complications. Moreover, the American Academy of Orthopedic Surgery recommends biceps tenodesis or tenotomy with low strength for patients with irreparable rotator cuff tear similar to our patient [6].



**Fig. 3.** X-ray of the shoulder at 5-month follow-up showing a stable implant in a good location with good bone healing.

Tenodesis techniques involve the usage of metal anchors or bone tunnels, and this can create areas of potential weaknesses that predispose the proximal humerus to fracture under stress. Previous cases have described such a complication post biceps

tenodesis, and these have been presented in Table 1 [7-13]. It had been suggested in cadaveric literature that interference screws in biceps tenodesis procedures provide better fixation compared to all-suture anchors. However, more recent studies concluded that both techniques are reliable for both supra-pectoral and subpectoral tenodesis [14,15]. Nevertheless, the rate of fracture-related complications is higher with interference screws, which employ bi-cortical drilling, compared to all suture anchors where smaller bore-drill holes are used to minimize bone loss [14,15]. Given that our case involved an elderly woman with a high risk of osteoporosis, we opted to perform tenodesis using an all-suture anchor.

Humeral fractures following tenodesis can occur days to months following the procedure due to trivial trauma or triggers (Table 1) [7-13]. The size of the hole relative to bone diameter has been found to have an antagonistic effect on bone strength [16]. Studies on femur models have shown that drill holes can decrease torsional bone strength by up to 40% for small holes and as much as 62% in larger holes (one-fifth of the bone diameter) [16]. In tenodesis procedures that utilize interference screws, even a 6.5-mm drilling hole could reduce the torsional strength of the humerus by 30% compared to that of the controls [17]. In our case, the patient had previously undergone a biceps tenodesis using an all-suture anchor; even though this technique minimizes bone loss compared to interference screws, the intervention can produce compromised bone integrity and increased risk of fracture during insertion of the reverse shoulder arthroplasty prosthesis. Another highly possible contributing factor was the use of a press fit humeral stem. As demonstrated in a cadaveric study by Lee et al. [18], sequential cylindrical reaming required to achieve substantial cortical contact preferentially removes the anterior and posterior cortices. This creates weak areas prone to fracture during stem impaction or shoulder reduction intraoperative. The association between press fit implants and intraoperative humeral fractures was demonstrated in a study by Athwal et al. [1]. This was supported by the higher rate of postoperative periprosthetic fractures in patients with uncemented stem fixation reported by King et al. [19] even though statistical significance was not achieved. In our case, the proximal humeral fracture occurred during reduction, which further suggests that the biomechanics of injury were due to an unbalanced force transmission during press fitting and stem impact rather than torsional stress reduction as seen in other reported cases in the literature, where more bone-compromising techniques were used during biceps tenodesis (Table 1).

Other factors might have contributed to this complication. The patient's female sex could have predisposed her to fracture. One

**Table 1.** Cases of humeral fractures post biceps tenodesis reported in the literature

Study	Laterality	Patient	Type of procedure	Fixation/technique	Onset of fracture following tenodesis	Type of fracture	Mechanism of fracture/trigger
Friedel et al. (1995) [7]	Left	Male, 69 yr	Keyhole tenodesis	NA	6 wk	NA	NA
Reiff et al. (2010) [8]	Left	Female, 50 yr	Modified keyhole tenodesis	8-mm hole with two 2.7 mm holes	8 wk	Oblique	Pushed a door
Sears et al. (2011) [9]	Left	Male, 47 yr	Subpectoral biceps tenodesis	8 x 20-mm screw	6 mo	Spiral	Fell down a small hill
Dein et al. (2014) [10]	Right	Male, 34 yr	Subpectoral biceps tenodesis	NA	4 mo	Short oblique	Picked up a bag
Jacobs et al. (2020) [11]	Right	Male, 46 yr	Subpectoral biceps tenodesis	8 x 12-mm screw	10 mo	Spiral	Pitched a ball
	Right	Female, 60 yr	Subpectoral biceps tenodesis	NA	7 day	Comminuted but minimally displaced	Physical therapy exercises
Erdle et al. (2020) [12]	Left	Male, 41 yr	Subpectoral biceps tenodesis	8 x 12-mm screw	7 day	Spiral	Fell on stairs
	Right	Male, 39 yr	Subpectoral biceps tenodesis	8 x 12-mm screw	4 mo	Short oblique	Fell while playing soccer
	Right	Male, 40 yr	Subpectoral biceps tenodesis	Bicortical button inlay with a 6-mm near cortex tunnel, 3.2-mm far cortex tunnel	48 day (1.5 mo)	Short oblique	Fell from standing height
Ashmyan et al. (2021) [13]	Right	Male, 47 yr	Subpectoral biceps tenodesis	Bicortical button inlay with a 6-mm near cortex tunnel	4 wk	Transverse	Physical therapy exercises

NA: not applicable.

study published by Wagner et al. [20] explored multiple risk factors for fracture occurrence in revision reverse total shoulder arthroplasty. Female sex was considered to be a significant risk factor to fracture occurrence, probably due to the higher rate of osteoporosis in the female population, where osteoporosis is four times more prevalent compared to men [20,21]. While other cases reported in the literature involved only males, our patient was an elderly female, and her risk of osteoporosis was prominently high [21].

The periprosthetic fracture was fixed intraoperatively in our patient using a suture cerclage. Several studies have asserted and emphasized the efficiency and safety of using a suture cerclage rather than a stainless steel wire or other methods of fixation [22-24]. This was supported further by the uneventful postoperative course of our patient, who exhibited good bone healing and stability on follow-up (Fig. 3).

Few case reports presenting this postoperative complication exist in the literature. While our case presents that of only one patient, to our knowledge, it is the first to present a fracture after an all-suture anchor biceps tenodesis and during a reverse shoulder arthroplasty. Additional research and studies regarding the biomechanics of biceps tenodesis techniques are needed to better understand the sequelae of this procedure on humeral bone integrity and to help prevent such complications in the future.

## DISCUSSION

In conclusion, further studies are required to better evaluate the role of prior biceps tenodesis in fracture development and establish potential causality. Our report helps shed light on certain factors that influence postoperative course and reduce the rate of complications following biceps tenodesis. Biceps tenodesis techniques should be suited to individual cases to help preserve bone integrity in patients with high risk of osteoporosis. In addition, when operating on a patient with previous biceps tenodesis, additional care should be taken to help prevent perioperative fractures such as that reported in our case. Sex, prior biceps tenodesis, and fracture risk should be addressed when employing maneuvers that compromise bone integrity and apply stress on the proximal humerus. This highlights another area of interest of evaluation of methods of fixation and their effects on fracture development.

## NOTES

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### Author contributions

Data curation: SS, HB. Investigation: SS, HB. Methodology: HB. Project administration: HB. Supervision: HB. Visualization: HB. Writing – original draft: SS, MYF. Writing – review & editing: SS, MYF, HB.

### Conflict of interest

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### Data availability

None.

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## REFERENCES

1. Athwal GS, Sperling JW, Rispoli DM, Cofield RH. Periprosthetic humeral fractures during shoulder arthroplasty. *J Bone Joint Surg Am* 2009;91:594-603.
2. Dillon MT, Prentice HA, Burfeind WE, Chan PH, Navarro RA. The increasing role of reverse total shoulder arthroplasty in the treatment of proximal humerus fractures. *Injury* 2019;50:676-80.
3. Chen CH, Hsu KY, Chen WJ, Shih CH. Incidence and severity of biceps long head tendon lesion in patients with complete rotator cuff tears. *J Trauma* 2005;58:1189-93.
4. Creech MJ, Yeung M, Denkers M, Simunovic N, Athwal GS, Ayeni OR. Surgical indications for long head biceps tenodesis: a systematic review. *Knee Surg Sports Traumatol Arthrosc* 2016;24:2156-66.
5. Walch G, Edwards TB, Boulahia A, Nové-Josserand L, Neyton L, Szabo I. Arthroscopic tenotomy of the long head of the biceps in the treatment of rotator cuff tears: clinical and radiographic results of 307 cases. *J Shoulder Elbow Surg* 2005;14:238-46.
6. American Academy of Orthopaedic Surgeons. Clinical practice guideline on the management of rotator cuff injuries. American Academy of Orthopaedic Surgeons; 2019.
7. Friedel R, Markgraf E, Schmidt I, Dönicke T. Proximal humerus shaft fracture as a complication after keyhole-plasty: a case report. *Unfallchirurgie* 1995;21:198-201.
8. Reiff SN, Nho SJ, Romeo AA. Proximal humerus fracture after keyhole biceps tenodesis. *Am J Orthop (Belle Mead NJ)*

- 2010;39:E61-3.
9. Sears BW, Spencer EE, Getz CL. Humeral fracture following subpectoral biceps tenodesis in 2 active, healthy patients. *J Shoulder Elbow Surg* 2011;20:e7-11.
  10. Dein EJ, Huri G, Gordon JC, McFarland EG. A humerus fracture in a baseball pitcher after biceps tenodesis. *Am J Sports Med* 2014;42:877-9.
  11. Jacobs AN, Umlauf JA, Kniss JR. Proximal humerus fracture following arthroscopic biceps tenodesis. *J Orthop Sports Phys Ther* 2020;50:649.
  12. Erdle NJ, Osier CJ, Hammond JE. Humerus fractures after open subpectoral biceps tenodesis: three cases with 2-year functional outcome data and review of the literature. *JBJS Case Connect* 2020;10:e0033.
  13. Ashmyan RI, Kelly JP, Tucker MM, Baker CL 3rd. Humeral shaft fracture after open biceps tenodesis following use of continuous passive motion machine: a case report. *JSES Int* 2021; 5:546-8.
  14. Baleani M, Francesconi D, Zani L, Giannini S, Snyder SJ. Subprapectoral biceps tenodesis: a biomechanical comparison of a new "soft anchor" tenodesis technique versus interference screw biceps tendon fixation. *Clin Biomech (Bristol, Avon)* 2015;30: 188-94.
  15. Chiang FL, Hong CK, Chang CH, Lin CL, Jou IM, Su WR. Biomechanical comparison of all-suture anchor fixation and interference screw technique for subpectoral biceps tenodesis. *Arthroscopy* 2016;32:1247-52.
  16. Hipp JA, Edgerton BC, An KN, Hayes WC. Structural consequences of transcortical holes in long bones loaded in torsion. *J Biomech* 1990;23:1261-8.
  17. Beason DP, Shah JP, Duckett JW, Jost PW, Fleisig GS, Cain EL Jr. Torsional fracture of the humerus after subpectoral biceps tenodesis with an interference screw: a biomechanical cadaveric study. *Clin Biomech (Bristol, Avon)* 2015;30:915-20.
  18. Lee M, Chebli C, Mounce D, Bertelsen A, Richardson M, Matsen F 3rd. Intramedullary reaming for press-fit fixation of a humeral component removes cortical bone asymmetrically. *J Shoulder Elbow Surg* 2008;17:150-5.
  19. King JJ, Farmer KW, Struk AM, Wright TW. Uncemented versus cemented humeral stem fixation in reverse shoulder arthroplasty. *Int Orthop* 2015;39:291-8.
  20. Wagner ER, Houdek MT, Elhassan BT, Sanchez-Sotelo J, Cofield RH, Sperling JW. What are risk factors for intraoperative humerus fractures during revision reverse shoulder arthroplasty and do they influence outcomes. *Clin Orthop Relat Res* 2015; 473:3228-34.
  21. Alswat KA. Gender disparities in osteoporosis. *J Clin Med Res* 2017;9:382-7.
  22. Eyberg BA, Walker JB, Harmsen SM, Gobezie R, Denard PJ, Lederman ES. Suture cerclage for stabilizing the humeral shaft during shoulder arthroplasty. *JSES Int* 2020;4:688-93.
  23. Renner N, Wieser K, Lajtai G, Morrey ME, Meyer DC. Stainless steel wire versus FiberWire suture cerclage fixation to stabilize the humerus in total shoulder arthroplasty. *J Shoulder Elbow Surg* 2014;23:1568-74.
  24. Denard PJ, Nolte PC, Millett PJ, et al. A tensionable suture-based cerclage is an alternative to stainless steel cerclage fixation for stabilization of a humeral osteotomy during shoulder arthroplasty. *J Am Acad Orthop Surg* 2021;29:e609-17.