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, multiple 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.

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

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...
ing 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 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

**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.

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

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                 | NA                                   | NA               | NA                           |
| Reiff et al. (2010) [8]      | Left       | Female, 50 yr | Modified keyhole tenodesis | 8-mm hole with two 27 mm holes | 6 wk | Oblique | Pushed a door |
| Sears et al. (2011) [9]      | Right      | Male, 47 yr   | Subpectoral biceps tenodesis | 8 × 20-mm screw | 8 wk | Spiral | Fell down a small hill |
| Dein et al. (2014) [10]      | Right      | Male, 34 yr   | Subpectoral biceps tenodesis | 8 × 12-mm screw | 4 mo | Short oblique | Picked up a bag |
| Jacobs et al. (2020) [11]    | 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 × 12-mm screw | 7 day | Spiral | Fell on stairs |
|                            | Right      | Male, 39 yr   | Subpectoral biceps tenodesis | 8 × 12-mm screw | 4 mo | Short oblique | Fell while playing soccer |
| Ashmyan et al. (2021) [13]   | Right      | Male, 47 yr   | Subpectoral biceps tenodesis | Bicortical button inlay with a 6-mm near cortex tunnel, 32-mm far cortex tunnel | 48 day (1.5 mo) | Short oblique | Fell from standing height |

NA: not applicable.
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 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.

**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, Simonovic 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. Humeral 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. Supraperatorial 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.