



Humeral fracture following subpectoral biceps tenodesis in 2 active, healthy patients

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Pathology involving the long head of the biceps tendon is a common and significant cause of shoulder pain. For active patients with refractory biceps tendinosis, tenodesis of the tendon to either soft tissue or the humerus is the preferred surgical treatment.^{2,7,9,11} Subpectoral biceps tenodesis to the humeral diaphysis with an interference screw has been gaining popularity as an effective method for treating biceps pathology, as clinical studies have demonstrated favorable outcomes with low rates of post-surgical complications with this technique.^{8,14}

This procedure involves drilling a cortical hole distal to the bicipital groove for placement of the tendon and bioabsorbable screw.⁹ The size, depth, and location of this hole create a stress riser effect in the humerus, which previously was thought to be insignificant; however, several case reports exist in the literature describing postoperative fracture through the humeral drill hole.^{3,4,16} This report presents 2 patients with postoperative humeral fractures involving the subpectoral tenodesis drill hole that occurred within 6 months of surgery. This finding suggests that this complication may be more prevalent in active patients than previously thought.

Case reports

Patient 1

A 47-year-old healthy, nonsmoking male laborer underwent an isolated, arthroscopically assisted subpectoral biceps tenodesis of

the left, dominant shoulder for painful biceps tendinopathy without rotator cuff pathology. The tenodesis technique consisted of creation of an 8-mm drill hole at the inferior edge of the pectoralis major tendon in the biceps groove. An 8-mm bioabsorbable screw and the tendon were then placed into the drill hole. During the postoperative period, resistive elbow flexion was limited to 2 lbs for 6 weeks, and then was progressively advanced. The patient's subsequent recovery was uneventful, and he resumed all activities at 4 months following the surgery.

At 6 months following surgery, the patient returned to clinic complaining of left arm pain after falling down a small hill. Radiographs obtained at that time demonstrated a proximal-third spiral humeral shaft fracture, which appeared to involve the cortical drill hole from the biceps tenodesis screw placement (Fig. 1, A, B). The patient could not tolerate fracture bracing and underwent an open reduction with plate fixation 4 weeks following the injury (Fig. 2, A, B). During time of reoperation, the fracture line was noted to include the cortical hole drilled for the tenodesis screw. Following surgical fixation, the patient was initially started on passive range of motion for 2 weeks and then advanced to active assisted motion for 6 weeks. The fracture subsequently united by 3 months and the patient resumed full activities by 6 months.

Patient 2

A 34-year-old healthy, nonsmoking male physician underwent a right arthroscopic superior labrum repair, rotator cuff tendon tear repair, and subpectoral biceps tenodesis. Again, the tenodesis technique consisted of creation of a cortical drill hole followed by placement of a bioabsorbable screw and tendon into the cortical hole. Record of this patient's postoperative restrictions and follow-up were not available to review. However, during the postoperative period, the patient described subtle pain over the lateral aspect of the arm that began at 3 months after surgery during normal postoperative rehabilitation.

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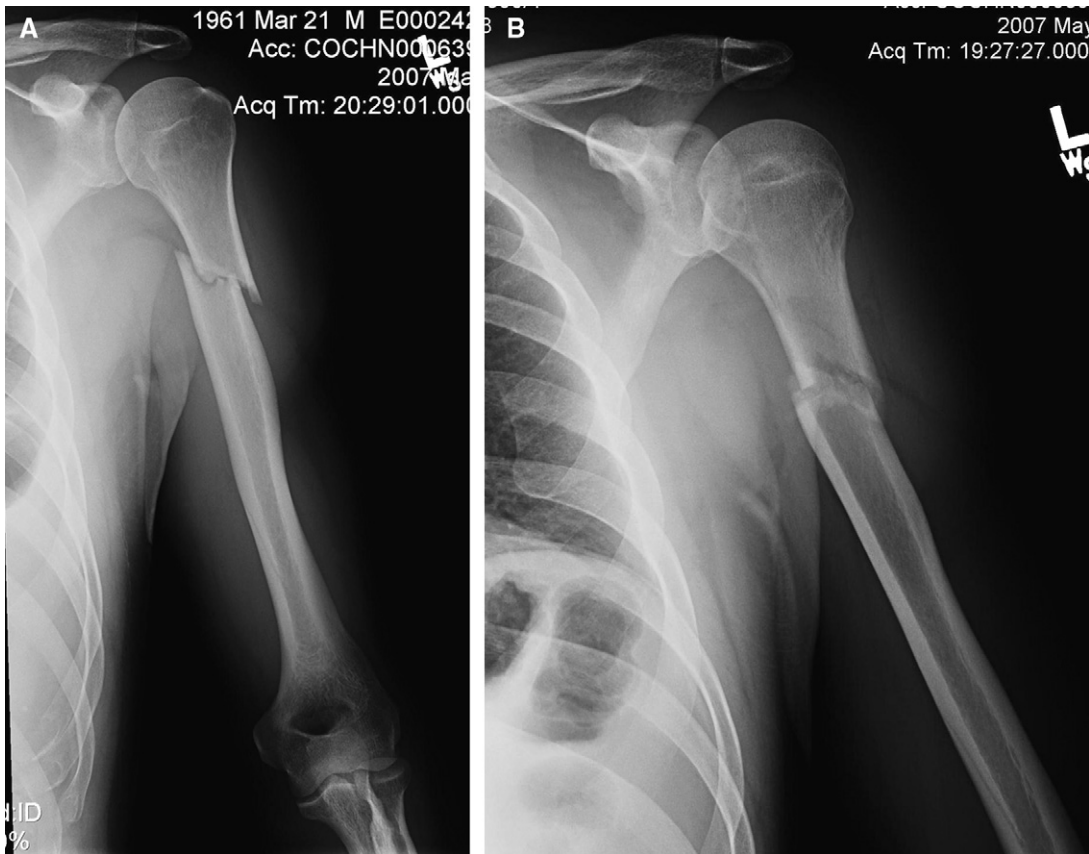


Figure 1 Patient 1: (A and B) proximal-third spiral humeral shaft fracture involving the cortical drill hole from the biceps tenodesis screw placed 6 months prior to fracture.

At 4 months following surgery, the patient reported picking up a bag and developed tremendous pain over the upper part of the arm. Radiographs taken at that time revealed a proximal-third short oblique humeral shaft fracture at the level of the previous biceps tenodesis screw placement (Fig. 3, A, B). The patient was initially placed in an immobilizer and underwent an open reduction with plate fixation shortly after injury (Fig. 4, A, B). At time of surgery, the fracture line appeared to originate, or at least include, the cortical drill hole used for screw placement. Postoperative protocol consisted of passive and active assisted range of motion for the first 6 weeks. The patient's postoperative course was uneventful and he returned to full duties as a physician.

Discussion

Biceps tenodesis with a subpectoral interference screw has become a popular surgical option for treating pathology of the biceps long head tendon as a result of technique simplicity, preservation of length-tension relationship, removal of tendon from the bicipital groove, and superior tendon pullout strength advantage.⁷ A number of studies have demonstrated excellent clinical outcomes following this procedure, including improved pain relief and arm function.^{8,9,11} Additionally, this procedure is generally regarded as fairly safe, as rates of complications following

surgery have been shown to be as low as 2.0%, consisting mostly of failure of fixation or biceps pain.¹⁴ Postoperative humeral fracture following keyhole tenodesis have been reported,^{3,4} but only a single case following tenodesis with interference screw technique exists in English-language journals.¹⁶ We present 2 cases of young, active patients who sustained postoperative humerus fracture following subpectoral biceps tenodesis with interference screw.

With this technique, tenodesis of the biceps tendon requires creation of a drill hole in the diaphysis of the proximal humerus for placement of the tendon and interference screw. The cortex is drilled using an 8-mm acorn drill to a depth of 24 mm. A 7- or 8- x 20-mm bioabsorbable screw with the biceps tendon is then placed into the drill hole to complete the tenodesis. Bioabsorbable tenodesis interference screws are comprised of PLLA (poly-L-lactic acid), which are designed to degrade in vivo following surgery. Although the resorption of PLLA screws has been reported to last up to 5 years, the exact time to resorption in humans is unknown⁶ and has been shown to not necessarily follow the gradual and controlled pattern demonstrated in the ovine model.¹⁸ Additionally, an in vitro study has shown a loss of 50% of compression strength in PLLA screws due to hydrolytic degradation between 2 and 5 months.¹⁷ Ultimately, as screw degradation occurs,

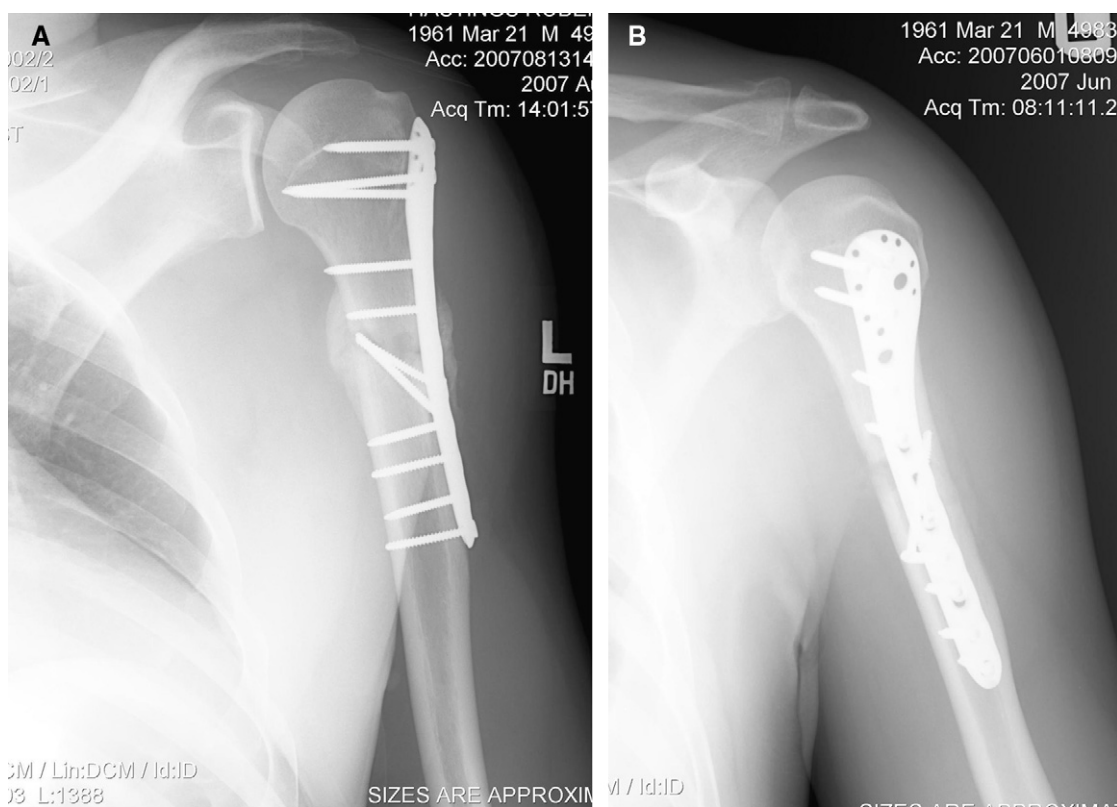


Figure 2 Patient 1: (A and B) following open reduction internal fixation with complete humeral fracture healing.

a period of time exists where a cortical defect forms at the location of the drill hole.

Several investigational models have demonstrated that the diameter and depth of cortical defects or drill hole, as well as the bone diameter and cortical width, determine the stress riser effect of a hole in bone. In a rabbit model, Alford et al reported a 50% decrease in torsional peak load to failure in screw holes encompassing only 20% of the diameter of the diaphyseal cortex.¹ Using a finite element analysis model, Hipp et al found that small transcortical holes reduced torsional strength by 40%, while a hole with a diameter of 50% of the outer bone diameter reduced torsional strength by up to 60%.⁵ McBroom et al investigated defects in canine diaphyseal bone, demonstrating at a ratio of drill hole diameter to bone diameter of 0.2, long bones retain only 62% of their cortical strength.¹⁰ The average humeral diameter has been shown to be between 18-21 mm;¹² therefore, these models indicate that a cortical defect of 8 mm would likely substantially diminish bone strength.

In addition, these models are based on an assumption that the drill hole is placed into the correct position and to the appropriate depth. With the subpectoral technique, the width of the humerus is very close to the depth of the recommended drill hole and may be prone to bicortical disruption from over drilling by only several millimeters. Additionally, bone flanking the bicipital groove is more

dense than the groove itself. Off-center drilling may substantially decrease the ultimate strength of the humerus even further. Lastly, tunnel widening has been seen with intraosseous soft tissue grafts and may lead to a larger drill hole than the one originally drilled.¹³ Thus, although a cortical defect in itself may create a significant stress riser, this effect has the potential to be substantially increased by variation in location and depth of the drill hole.

Conclusion

This case report presents 2 young, active patients with postoperative humerus fracture following biceps tenodesis with an interference screw. In these patients, review of postfracture imaging and intraoperative observation demonstrated that the cortical defect from the drill hole for screw placement appeared to create a stress riser effect, thus the observation that this technique can result in fracture of the humerus in active patients.

In a recent case report by Rieff et al presenting a single incidence of fracture following subpectoral tenodesis, the authors recommended placement of a nonabsorbable screw into the cortical drill hole to limit strength reduction by the cortical defect.¹⁶ Analysis of

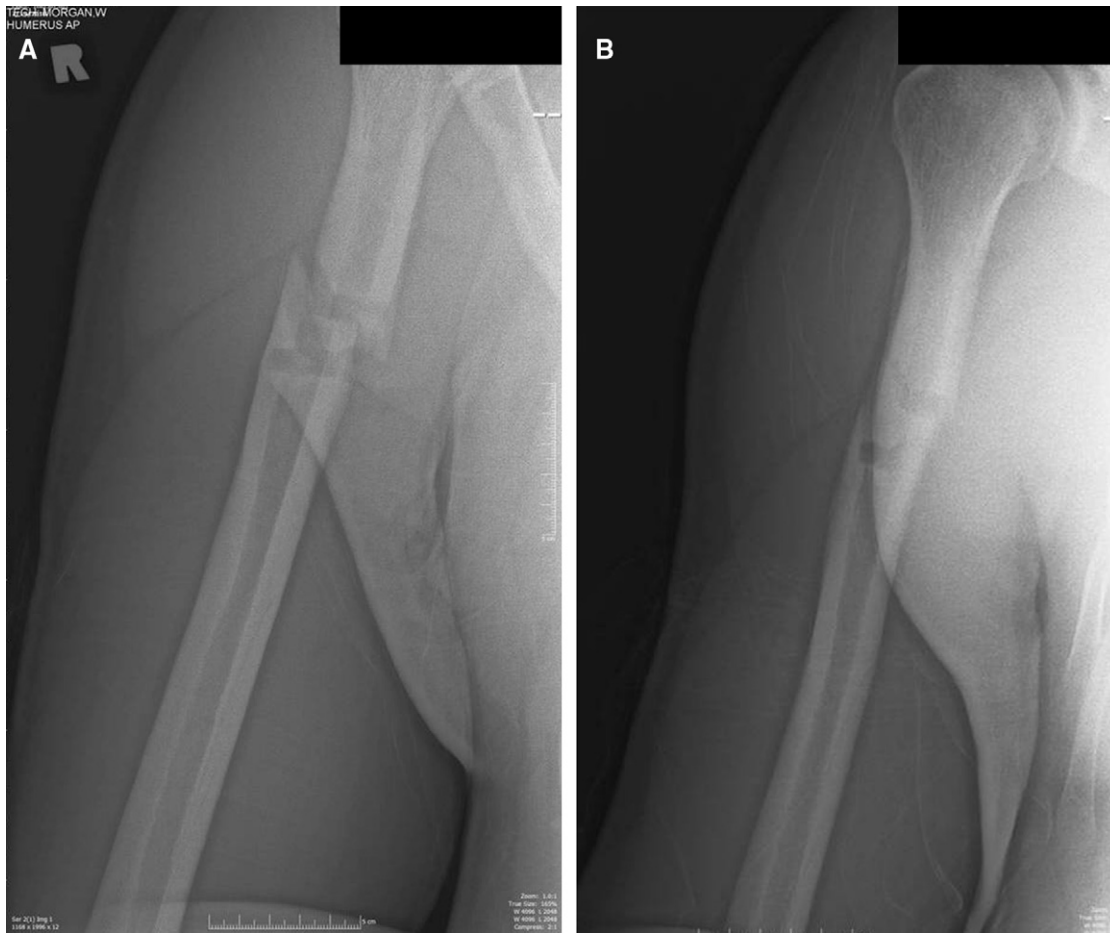


Figure 3 Patient 2: (A and B) proximal-third short oblique humeral shaft fracture at level of previous biceps tenodesis screw placement 4 months after surgery.

these cases would support this recommendation in effort to mitigate the stress riser effect, especially in the first 6-8 months following surgery when resorption of bio-absorbable screws likely occurs. Ultimately, “filling the hole” with a nonbioabsorbable screw would encourage postsurgical biomechanics to remain in a relatively native state; although, we have found no current studies that have evaluated humeral torsional strength following placement of an interference screw.

Another approach to reduce the potential stress riser effect may be to limit the size of the defect created in the humeral cortex. A subpectoral biceps tenodesis technique using a cortical button fixation has been described that requires a much smaller cortical hole (2.8 mm) than the interference screw method, thereby theoretically reducing biomechanical changes to the humerus.² Although fixation strength has been shown to vary among methods of repair,¹⁵ utilization of techniques that reduce collateral damage and limit stress riser formation maybe as important as tendon to bone strength of fixation.

Finally, it may also be advisable to limit activities during the postoperative period that increase stress levels across the cortical defect, such as lifting weights or contact sports. Ultimately, these considerations may be especially important in active patients who are involved in activities that may subject the humerus to excessive postoperative stresses prior to filling in of the cortical defect with bone.

Disclaimer

E.W.E. owns stock in Tornier, has received research funding from DePuy and Tornier and is a paid consultant for Tornier all with regard to arthroplasty. No financial remuneration with regard to biceps tenodesis. C.L.G. is a paid speaker for Mitek in relation to arthroscopy. No financial remuneration with regard to biceps tenodesis. No outside funding or grants received assisted in this study.

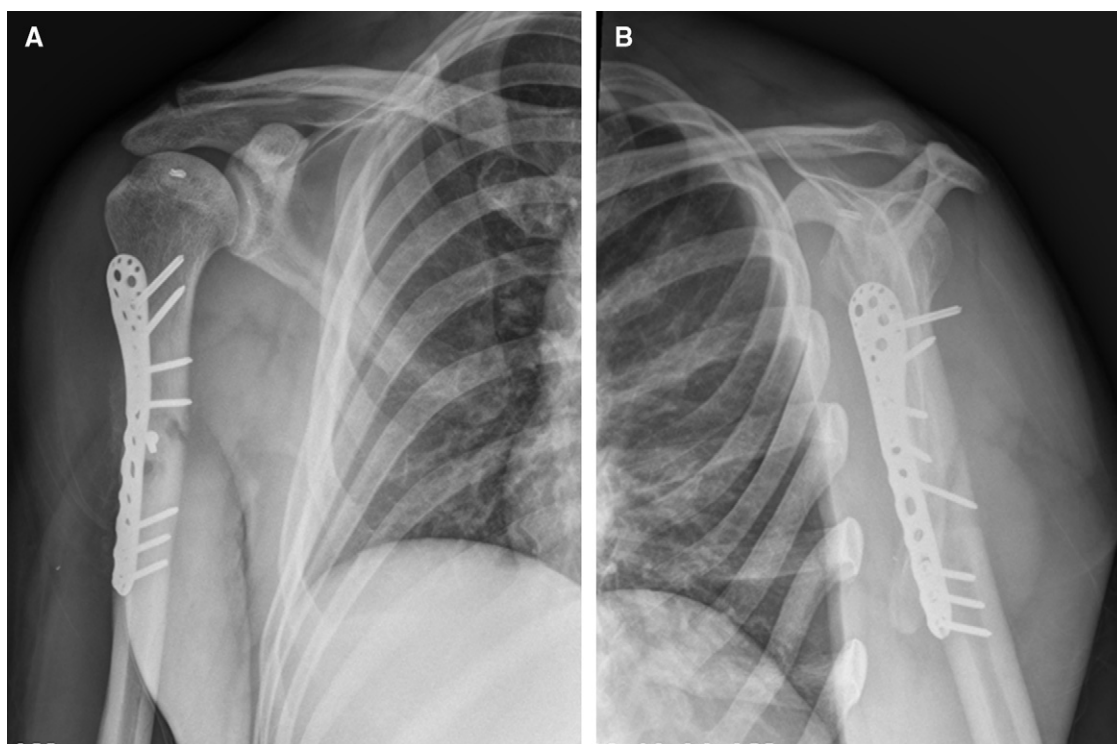


Figure 4 Patient 2: (A and B) immediate postoperative radiograph following open reduction internal fixation with complete humeral fracture healing.

References

- Alford JW, Bradley MP, Fadale PD, Crisco JJ, Moore DC, Ehrlich MG. Resorbable fillers reduce stress risers from empty screw holes. *J Trauma* 2007;63:647-54. doi:10.1097/01.ta.0000221042.09862.ae
- Bosley J, Schnaerer E, Shishani Y, Goodfellow DB, Gobezie R. In situ subpectoral biceps tenodesis with a biceps button. *Tech Shoulder Elbow Surg* 2009;10:91-3.
- Friedel R, Markgraf E, Schmidt I, Dönicke T. Proximal humerus shaft fracture as a complication after keyhole-plasty. A case report [in German]. *Unfallchirurgie* 1995;21:198-201.
- Gyulai M. Humeral fracture after keyhole tenodesis [in Hungarian]. *MagyTraumatol Orthop Helyreallito Seb* 1990;33:234-6.
- 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.
- Martinek V, Seil R, Lattermann C, Watkins SC, Fu FH. The fate of the poly-L-lactic acid interference screw after anterior cruciate ligament reconstruction. *Arthroscopy* 2001;17:73-6.
- Mazzocca AD, Bicos J, Santangelo S, Romeo AA, Arciero RA. The biomechanical evaluation of four fixation techniques for proximal biceps tenodesis. *Arthroscopy* 2005;21:1296-306. doi:10.1016/j.arthro.2005.08.008
- Mazzocca AD, Cote MP, Arciero CL, Romeo AA, Arciero RA. Clinical outcomes after subpectoral biceps tenodesis with an interference screw. *Am J Sports Med* 2008;36:1922-9. doi:10.1177/0363546508318192
- Mazzocca AD, Rios CG, Romeo AA, Arciero RA. Subpectoral biceps tenodesis with interference screw fixation. *Arthroscopy* 2005;21:896. doi:10.1016/j.arthro.2005.04.002
- McBroom RJ, Cheal EJ, Hayes WC. Strength reductions from metastatic cortical defects in long bones. *J Orthop Res* 1988;6:369-78.
- Millett PJ, Sanders B, Gobezie R, Braun S, Warner JJ. Interference screw vs. suture anchor fixation for open subpectoral biceps tenodesis: does it matter? *BMC Musculoskelet Disord* 2008;9:121. doi:10.1186/1471-2474-9-121
- Murdoch AH, Mathias KJ, Smith FW. Measurement of the bony anatomy of the humerus using magnetic resonance imaging. *Proc Inst Mech Eng H* 2002;216:31-5.
- Neddermann A, Willbold E, Witte F, Hurschler C, Hankemeier S, Stübiger T, et al. Tunnel widening after anterior cruciate ligament reconstruction: an experimental study in sheep. *Am J Sports Med* 2009;37:1609-17. doi:10.1177/0363546509332251
- Nho SJ, Reiff SN, Verma NN, Slabaugh MA, Mazzocca AD, Romeo AA. Complications associated with subpectoral biceps tenodesis: Low rates of incidence following surgery. *J Shoulder Elbow Surg* 2010;19:764-8. doi:10.1016/j.jse.2010.01.024
- Ozalay M, Akpinar S, Karaeminogullari O, Balcik C, Tasci A, Tandogan RN, et al. Mechanical strength of four different biceps tenodesis techniques. *Arthroscopy* 2005;21:992-8.
- Reiff SN, Nho SJ, Romeo AA. Proximal humerus fracture after keyhole biceps tenodesis. *Am J Orthop (Belle Mead NJ)* 2010;39:E61-3.
- Schwach G, Vert M. In vitro and in vivo degradation of lactic acid-based interference screws used in cruciate ligament reconstruction. *Int J Biol Macromol* 1999;25:283-91.
- Sujith K, Sami HF. The unpredictable material properties of bio-absorbable PLC interference screws and their adverse effects in ACL reconstruction surgery. *Knee Surg Sports Trauma Arthro* 2009;17:293-7.