International Journal of Research in Orthopaedics
Parmeshwar SS et al. Int J Res Orthop. 2026 May;12(3):701-706
http://www.ijoro.org

Original Research Article

DOI: https://dx.doi.org/10.18203/issn.2455-4510.IntJResOrthop20261219

Comparison of synovial fluid IL-6 levels in post arthroscopic reconstruction of anterior cruciate ligament using press fit technique with BPTB graft versus bio-screw fixation

Siddharath S. Parmeshwar[1]*, Putta Kempa Raju[2], Preetham Nagaraj[2], Sahana V. Kanakagiri[1], Purushotham V. Javaregowda[1]

[1]Department of Orthopaedics, ESIC Medical College and PGIMSR, Rajajinagar, Bangalore, Karnataka, India
[2]Department of Orthopaedics, Bangalore Medical College and Research Institute, Bangalore, Karnataka, India

Received: 28 January 2026
Revised: 11 March 2026
Accepted: 11 March 2026

***Correspondence:**
Dr. Siddharath S. Parmeshwar,
E-mail: siddharathsp@gmail.com

ABSTRACT

Background: Anterior cruciate ligament (ACL) injury causes an increase in synovial fluid concentrations of inflammatory cytokines and biomarkers of cartilage breakdown. ACL reconstruction reinitiates an "inflammatory hit" that leads to an increase in these markers and chondral degeneration, and is prolonged. A study aimed at comparing the IL-6 levels in patients undergoing ACL reconstruction with the press-fit technique and bio-screw fixation at different intervals.
Methods: A retrospective study of 60 subjects between 14 and 62 years with ACL tear were divided randomly into two groups, Group 1 and Group 2, undergoing arthroscopic ACL reconstruction using bio-screw fixation and press-fit technique (Implant-less), respectively. The synovial fluid levels of IL-6 were assessed in the affected knee at 3months, 6months and 12 months post-surgery. Tegner-Lysholm Knee Scores were also compared.
Results: It was found that at 6 months, IL-6 levels in Group 2 (average 47±0.2 pg/ml) were lower compared to Group 1 (average of 148±0.7 pg/ml). And at 12 months, Group 2 had an average of 41±0.5 pg/ml and Group 1 had an average of 84±0.3 pg/ml. Tegner-Lysholm scores in both groups were similar at the end of 12 months.
Conclusions: Press fit technique allows bone-to-bone healing and is devoid of problems associated with hardware fixation like biocompatibility, biodegradability, synovial reaction, chondral degeneration and tunnel enlargement, though clinical outcomes are similar.

Keywords: Anterior cruciate ligament, Press-fit technique, BPTB graft, Synovial fluid, IL-6

INTRODUCTION

The annual incidence of anterior cruciate ligament (ACL) tear being 68.6 per 100,000 person-years, it remains a common orthopaedic injury, with males being affected more than the females. Incidence peaked (241.0 per 100,000) between 19 and 25 years and (227.6 per 100,000) between 14 and 18 years in males and the females, respectively.[1,2] The anterior cruciate ligament (ACL), a crucial connective tissue in the knee joint (tibiofemoral joint) which is an important rotational stabiliser having two bundles, the anteromedial (AM) and the posterolateral (PL) bundle, separated by a connective tissue septum that ensures synergic movements of the bundles. Patients with a complete ACL tear present with pain, swelling secondary to hemarthrosis, and instability in the case of chronic tears.

The anterior drawer test and the Lachman test are the clinical tests used to diagnose an ACL tear. The ancient Greeks were the first to describe ACL injuries. Mayo Robson proved to be a pioneer in performing ACL repair surgery in the era of late 1800s, and by the end of the 19th century, he demonstrated the management of ACL tears by repairing femoral attachment sites. ACL repair with a re-rupture rate of >50% was gradually replaced by ACL reconstruction surgery.[3] Anteromedial bundle reconstruction using the middle third of the patellar ligament, which was the gold standard in the 1980s, was replaced by double bundle ACL reconstruction due to insufficient control of rotational laxity with the former. In partial tears, biological reconstruction with ACL remnant conservation is in vogue. Wires and extra-articular screws were initially used to fix the graft that was subsequently largely improved by the use of interference screws, and the most recent advent being bio-absorbable screws.[4] Press-fit fixation appears to be a good option for patients undergoing ACL reconstruction, where hardware-associated complications are eliminated.[5]

Such an injury results in sustained increase in inflammatory cytokines and cartilage breakdown biomarkers concentration in the synovial fluid of the affected joint which is considered as the "first hit".[6] IL-6, one of the inflammatory cytokines that significantly increases after ACL injury, in the joint environment is known to inhibit the production of collagen II that is the structural protein of articular cartilage and increases the production of matrix metalloproteinase enzyme (MMP) that degrades non-collagen matrix components of the joints hence playing significant role in development of osteoarthritis. Additionally, IL-6 also promotes the production of IL-8 from chondrocytes, which is also an inflammatory chemokine in the development of osteoarthritis. IL-6 has been found to have both pro and anti-inflammatory properties.[7] These inflammatory mediators also trigger the production of free radicals, which are involved in cartilage catabolism. Post Traumatic Osteoarthritis (PTOA) is a common sequela in ACL injury seen in affected individuals with 50-60% developing radiographic changes of osteoarthritis within 5years and clinical symptoms by 10years.[7,8] Reconstruction of the anterior cruciate ligament leads to initiating the inflammatory reaction, which is a 'second inflammatory hit', hence recurrence events leading to chondral breakdown.[7-9] The concentration of cytokines follows a "V-shaped" trend. IL-8 promotes production of matrix metalloproteinase-13 (MMP-13), neutrophil accumulation and activation and leukocyte homing to the synovium. IL-8 also induces chondrocyte hypertrophy and differentiation.[10]

This study aimed to compare the synovial fluid levels of inflammatory mediators in patients undergoing ACL reconstruction using the interference screw versus the press-fit technique. It is hypothesised that cytokines are significantly higher in techniques using interference screws. Bone-to-bone healing noted in press fit techniques eliminates complications associated with hardware fixation, such as graft laceration, biocompatibility, biodegradability, and local reactions leading to tunnel enlargement.

METHODS

A Retrospective study was conducted at a tertiary care centre included sixty patients aged between 18 and 60 years presenting with ACL injury confirmed clinically and radiologically were included in this study. The study was conducted between June 2021 to September 2022. All patients were divided into two groups. Institutional ethical clearance was taken (IRB no.532/11/12). The patients were 42 males and 18 females with a mean age of 20 (14-62) years. The patients who did not have any previous history of injury to the knee were included. The mean period of injury was 21 days (6-106). The patients who had multi-ligamentous injury, inflammatory arthritis and those who had previous surgery or intra-articular injection on the same knee were excluded. The patients were divided into two groups, namely ACL reconstruction with bio-screw fixation and the other group with Press-fit fixation (No implants).

Preoperatively, before surgery and at subsequent follow-up months, synovial fluid was collected from the suprapatellar pouch using a wide-bore needle. IL-6 level was measured by ELISA (Enzyme-Linked Immunosorbent Assay) kits.

Surgical technique

(Group 2) Press-fit fixation was performed using the bone patellar tendon. On both sides of the femur and tibia, the graft was fixed with press-fit bone plugs into the tunnels. In this technique, the tibial tunnel was made at the anatomical footprint, and the femoral tunnel was created through a transtibial technique. In contrast, the other group (Group 1) was operated on using hamstring tendons, fixed with bio-screws (interference screws) on the tibial side, and with an endo-button on the femoral side. In group 1, both tibial and femoral tunnels were created at their respective anatomic footprints.

Press-fit fixation (Group 2) is a natural, implant-free technique used in ACL reconstruction, most commonly using a bone–patellar tendon (BPTB) graft. Instead of relying on metal or bioabsorbable screws, this method uses the patient's own bone for fixation. The small bone blocks at each end of the graft are carefully shaped and tightly fitted into the prepared bone tunnels in the femur and tibia.

Postoperative rehabilitation

In group 1, patients who underwent surgery with implants were allowed to bear weight as tolerated using walkers and a long knee brace immediately after surgery. Knee bending was started immediately after surgery and gradually

increased: 0-30° in the first week, 30-60° in the second week, and 60-90° in the 3rd to 4th weeks, depending on the status of meniscus repair. After one month, patients were allowed to bear full weight without a walker and a long knee brace. Stationary cycling was initiated for all patients at the one-month follow-up. In Group 2, consisting of patients operated without implants, knee bending and weight-bearing were initiated after one week. Full weight-bearing was started at 4 to 6 weeks, without a walker and a long knee brace. Knee bending was gradually increased and reached 90° by the 4th week of follow-up, similar to group 1.

Follow-up visit

All patients were analysed using the Tegner-Lysholm score at regular intervals: 1st month, 3rd month, 6th month, and 12th month.

Statistical method

The obtained data were compiled systematically in Microsoft Excel. A master table was prepared, and the total data were subdivided and distributed meaningfully and presented as individual tables along with graphs. Data collected were analysed using the SPSS software, IBM, Armonk, New York, USA. Descriptive and inferential statistical analyses were carried out in the present study. Results on continuous measurements were presented as mean ± SD, and results on categorical measurements were presented as numbers (%). The level of significance was fixed at p= 0.05, and any value ≤0.05 was considered statistically significant.

Chi-square analysis was used to find the significance of study parameters on a categorical scale. A two-tailed, independent Student's t-test was used to find the significance of study parameters on a continuous scale between two groups (intergroup analysis) on metric parameters. If required, any other suitable statistical methods were used at the time of data analysis.

RESULTS

A total of 60 patients were included in the study, with 30 patients in each group, namely the Bio-screw group (Group 1) and the Press-fit group (Group 2). The median time from injury to surgery was comparable between the two groups (26 days in Group 1 vs. 38 days in Group 2; p = 0.75). The median age of the cohort was 21 years (range 14-62), with no significant difference between groups (p= 0.67). The male-to-female ratio was 42:18 overall (Group 1:22:8; Group 2:20:10; p=0.54). At 12 months follow-up, the mean Tegner-Lysholm score was comparable between groups (74±0.9 in Group 1 vs. 71±0.8 in Group 2; p=0.75). Associated meniscal injury was present in 40% of patients overall (33.3% in Group 1 vs. 46.6% in Group 2). (Table 1).

Table 1: Demographic table.

	Total	Group 1 (bio-screw)	Group 2 (press-fit)	p-value
Number of patients	60	30	30	
Time from injury to surgery (days)(median (range))	21 (6-106)	26 (7-87)	38 (6-106)	0.75
Age (year)(median (range))	21(14-62)	19(14-62)	18(14-60)	0.67
Gender (M:F)	42:18	22:08	20:10	0.54
Tegner-Lysholm score (average at 12th month follow-up)	72±0.4	74±0.9	71±0.8	0.75
Meniscus injury	24(40%)	10 (33.3%)	14(46.6%)	

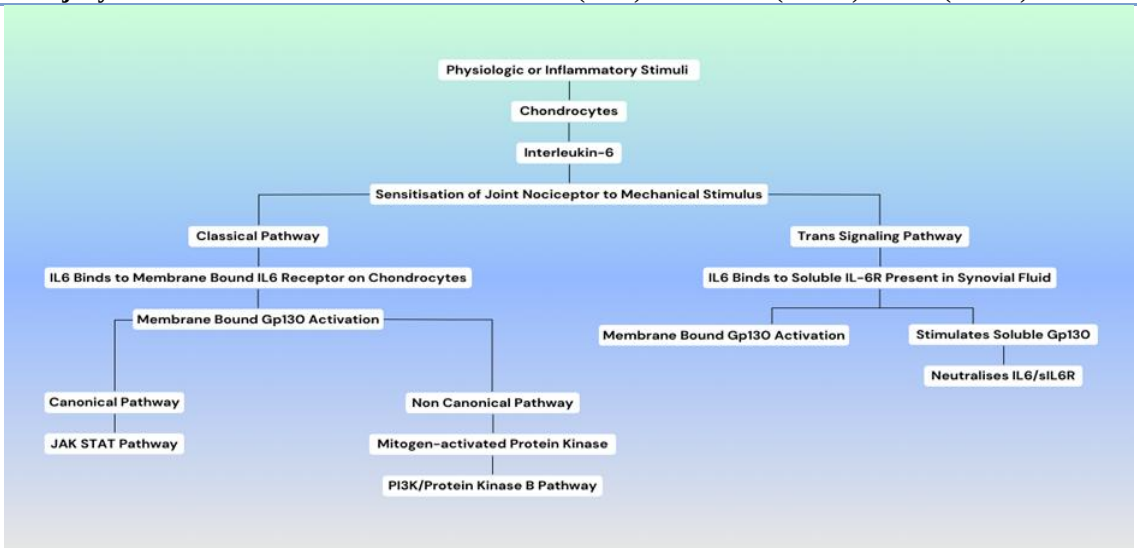

Figure 1: Flowchart of the inflammatory pathway in knee joint.

Arthroscopic evaluation of cartilage changes, based on the outer bridge classification, revealed that most patients in both groups had Grade II or III cartilage changes, with no significant difference in distribution (Table 2).

Table 2: Arthroscopic findings for cartilage defects (outer bridge classification).

Outer bridge classification	Group 1	Group 2
Grade 1	07	05
Grade 2	13	12
Grade 3	06	11
Grade 4	04	02

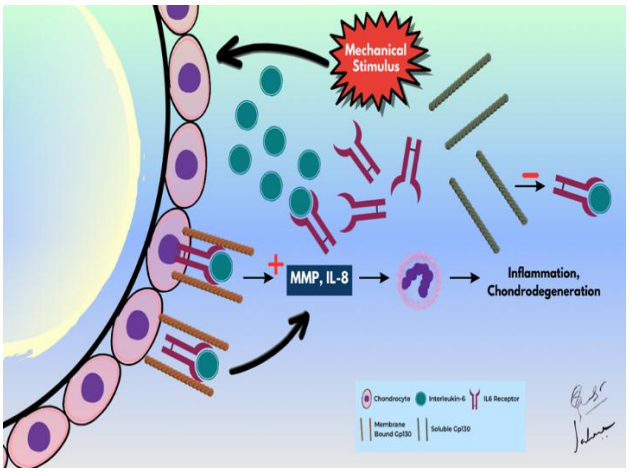

Figure 2: Schematic diagram of the pathogenesis of PTOA in the knee joint following a mechanical stimulus.

The mean synovial fluid IL-6 concentrations showed a marked postoperative rise in both groups, but were significantly higher in the bio-screw group at all postoperative intervals. Preoperative: 34.5±0.4 pg/ml (Press-fit) vs. 40.8±0.6 pg/ml (Bio-screw), p=0.7, Day 1 Postoperative: 65±0.3 pg/ml vs. 189±0.5 pg/ml, p < 0.001, 6th Month Postoperative: 47±0.2 pg/ml vs. 148±0.7 pg/ml, p<0.001, 12th Month Postoperative: 41±0.5 pg/ml vs. 84 ±0.3 pg/ml, p<0.001 (Table 3).

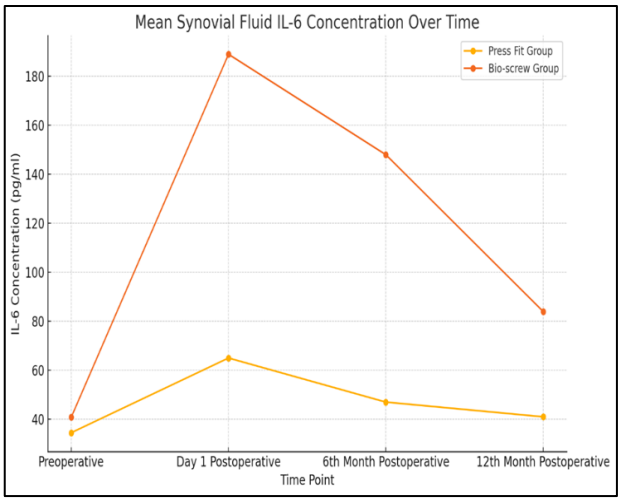

Figure 3: Graphical representation of synovial fluid IL6 level in the group 2 (press-fit/implant-less) and group 1 (bio-screw group).

The IL-6 trend demonstrated an early postoperative surge, followed by a gradual decline over time, in both groups; however, the bio-screw group maintained persistently elevated levels, suggesting a prolonged inflammatory response compared to the Press-fit group. (Figures 1, 2 and 3). Two patients in group 1 and one patient in group 2, who were affected with superficial wound infection, were successfully treated with antibiotics. Four patients experienced anterior knee pain in the press-fit group, whereas only one patient in the bio screw group reported anterior knee pain.

Table 3: Comparison of the mean value of synovial fluid IL6 concentration at different intervals.

Mean value of synovial fluid IL6 concentration at various time	Group 2 Press fit group (in pg/ml)	Group 1 Bio-screw group (in pg/ml)	p-value
Preoperative	34.5±0.4	40.8±0.6	0.7
Day 1 post operative	65±0.3	189±0.5	<0.001
6th month post operative	47±0.2	148±0.7	<0.001
12th month Post operative	41±0.5	84±0.3	<0.001

DISCUSSION

The present study compared postoperative synovial fluid interleukin-6 (IL-6) levels between patients who underwent ACL reconstruction using the press-fit fixation technique and those treated with bio-screw fixation. In a study conducted by Akoto R et al, ACL reconstruction with quadriceps tendon graft and press-fit fixation versus quadruple hamstring graft and interference screw fixation – a matched pair analysis after one year follow-up, it was noted that press-fit fixation for QT grafts could be an alternative to conventional fixation techniques and advantageous as it both saves fixation material, resulting in lower cost, and involves less bone tunnel enlargement, which could aid revision surgery. In our study, we used the bone patellar tendon graft in all group 2 patients, but it gave a similar functional outcome.[11] In a study conducted by Biazzo et al, there was no difference in efficacy found between femoral press-fit fixation and screw fixation. Thus, the press-fit technique ensured better clinical results

and knee stability, avoiding all disadvantages of hardware. The donor site morbidity appears to be a major concern of all BPTB graft techniques, including complications such as damaging the knee extensor apparatus, the potential for subsequent patello-femoral joint pain or crepitation, patella fracture, patella tendon rupture, infra-patellar contraction, numbness caused by damage of the infra-patellar branch of the saphenous nerve and possible loss of quadriceps strength.[12]

In a study conducted by Bigoni M et al, IL-6, IL-8, and IL-10 levels were found to be significantly higher in the acute ACL tear and post ACL reconstruction group with respect to the chronic ACL tear group. Thus, surgical trauma for ACL reconstruction clearly stimulated a recurrence of the inflammatory picture, causing IL-6, IL-8, and IL-10 concentrations to follow a "V-shaped" trend (i.e., high-low-high values).[13] The physical activity recovery was affected by the severity of joint inflammation in the acute phase after surgery, which in turn was significantly higher if the timing of index ACL reconstruction surgery was delayed, as concluded in a study conducted by Inoue M et al.[6]

In a study done by Zysk SP et al, it was found that a direct relationship existed between tibial bone tunnel enlargement and elevated synovial fluid concentrations of IL-6, TNF-α, and NO 7 days after ACL surgery, thus likely involvement of these biological mediators in the pathogenesis of bone tunnel enlargement.[14] In a study conducted by Gupta et al, elevated levels of IL-6 were found to be associated with cartilage damage in the knee.[15]

Bioabsorbable screws have also been shown to have increased bacterial adherence than metallic screws, which may contribute to the inflammatory response in some cases.[16] Vuolteenaho et al (2017) emphasised the key role of interleukin-6 (IL-6) in connecting inflammation to cartilage damage in osteoarthritis (OA). Their study showed that patients with higher levels of IL-6 in synovial fluid also had increased levels of matrix metalloproteinases (MMP-1 and MMP-3) and more severe joint damage seen on X-rays. These results suggest that IL-6 plays an active part in driving the breakdown of cartilage and overall joint deterioration in OA.[17]

In the Chingford study, Livshits et al (2009) found that higher levels of interleukin-6 (IL-6) in the blood were a strong and independent predictor of knee OA on X-rays, even after accounting for age and body mass index. This finding underscores the importance of systemic inflammation in the development and worsening of OA. IL-6 appears to play a key role by promoting cartilage breakdown and changes in the underlying bone through inflammatory and catabolic processes. Overall, the study supports viewing IL-6 not only as a marker of disease severity but also as a promising target for future osteoarthritis treatment.[18] The persistent elevation of IL-6 in the bio-screw group, however, may have long-term implications for post-traumatic osteoarthritis (PTOA) development. Chronic low-grade inflammation following ACL reconstruction has been linked to early cartilage matrix breakdown, and in the Press-fit method, may offer an advantage in reducing intra-articular inflammatory burden.

The lower IL-6 levels observed in the press-fit fixation group could be attributed to the implant-free nature of the technique, minimising foreign-body reaction and associated inflammatory response. In contrast, bioabsorbable or metallic screws, though effective, may induce localised tissue irritation or inflammatory cell recruitment during degradation or mechanical stress. Additionally, the press-fit method promotes direct bone-to-bone contact, potentially facilitating early osteointegration and reducing cytokine release. Overall, this study supports the hypothesis that implant-free fixation leads to a milder biological response in the knee joint while achieving comparable functional recovery. Further longitudinal studies with larger cohorts and additional biomarkers are warranted to elucidate the long-term chondral health and clinical implications of these findings. In summary, the comparative analysis of synovial IL-6 levels suggests that fixation technique influences the intra-articular inflammatory milieu following ACL reconstruction. The press-fit method, by avoiding implant-related responses, may represent a biologically favourable alternative for graft fixation

CONCLUSION

This study suggests that the fixation method influences the early intra-articular inflammatory response following ACL reconstruction. Patients treated with the press-fit technique demonstrated comparatively lower synovial IL-6 levels than those with bio-screw fixation, indicating a potentially reduced inflammatory reaction and better biocompatibility. These findings support the press-fit method as a biologically favourable alternative for bone–patellar tendon-bone graft fixation.

ACKNOWLEDGEMENTS

The authors' sincere thanks are extended to all patients who participated in this study. Appreciation is also expressed to the clinical and administrative staff of the institution for their invaluable support during data collection and follow-up. Valuable input provided by colleagues during the preparation of this manuscript is also gratefully acknowledged.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: Institutional ethical clearance was taken (IRB no.532/11/12)

REFERENCES

1. Sanders TL, Maradit Kremers H, Bryan AJ, Larson DR, Dahm DL, Levy BA, et al. Incidence of anterior

cruciate ligament tears and reconstruction: A 21-year population-based study: A 21-year population-based study. Am J Sports Med. 2016;44(6):1502-7.
2. Hunt ER, Jacobs CA, Conley CE-W, Ireland ML, Johnson DL, Lattermann C. Anterior cruciate ligament reconstruction reinitiates an inflammatory and chondrodegenerative process in the knee joint. J Orthop Res. 2021;39(6):1281-8.
3. Shom P, Varma AR, Prasad R. The anterior cruciate ligament: Principles of treatment. Cureus. 2023;15(6):e40269.
4. Chambat P, Guier C, Sonnery-Cottet B, Fayard J-M, Thaunat M. The evolution of ACL reconstruction over the last fifty years. Int Orthop. 2013;37(2):181-6.
5. Shanmugaraj A, Mahendralingam M, Gohal C, Horner N, Simunovic N, Musahl V, et al. Press-fit fixation in anterior cruciate ligament reconstruction yields low graft failure and revision rates: a systematic review and meta-analysis. Knee Surg Sports Traumatol Arthrosc. 2021;29(6):1750-9.
6. Inoue M, Muneta T, Ojima M, Nakamura K, Koga H, Sekiya I, et al. Inflammatory cytokine levels in synovial fluid 3, 4 days postoperatively and its correlation with early-phase functional recovery after anterior cruciate ligament reconstruction: a cohort study. J Exp Orthop. 2016;3(1):30.
7. Tseng TH, Chen CL, Chang CH, Wang JH, Young TH. IL-6 induces periostin production in human ACL remnants: a possible mechanism causing post-traumatic osteoarthritis. J Orthop Surg Res. 2023;18(1):824.
8. Cameron ML, Buchgraber A, Passler HH, Vogt M, Thonar EJ-MA, Fu FH. "The natural history of the anterior cruciate ligament-deficient knee. Changes in synovial fluid cytokine and keratan sulfate concentrations," Am J Sports Med. 1997;25(6):751-4.
9. Higuchi H, Shirakura K, Kimura M, Terauchi M, Shinozaki T, Watanabe H, et al. Changes in biochemical parameters after anterior cruciate ligament injury. Int orthop. 2006;30(1):43-7.
10. Takahashi A, de Andres MC, Hashimoto K, Itoi E, Oreffo RO. Epigenetic regulation of interleukin-8, an inflammatory chemokine, in osteoarthritis. Osteoarthritis Cartilage. 2015;23:A191-2.
11. Akoto R, Albers M, Balke M, Bouillon B, Höher J. ACL reconstruction with quadriceps tendon graft and press-fit fixation versus quadruple hamstring graft and interference screw fixation - a matched pair analysis after one year follow up. BMC Musculoskelet Disord. 2019;20(1):109.
12. Biazzo A, Manzotti A, Motavalli K, Confalonieri N. Femoral press-fit fixation versus interference screw fixation in anterior cruciate ligament reconstruction with bone-patellar tendon-bone autograft: 20-year follow-up. J Clin Orthop Trauma. 2018;9(2):116-20.
13. Bigoni M, Turati M, Gandolla M, Sacerdote P, Piatti M, Castelnuovo A, et al. Effects of ACL reconstructive surgery on temporal variations of cytokine levels in synovial fluid. Mediators Inflamm. 2016;2016:8243601.
14. Zysk SP, Fraunberger P, Veihelmann A, Dörger M, Kalteis T, Maier M, et al. Tunnel enlargement and changes in synovial fluid cytokine profile following anterior cruciate ligament reconstruction with patellar tendon and hamstring tendon autografts. Knee Surg Sports Traumatol Arthrosc. 2004;12(2):98-103.
15. Gupta R, Kapoor A, Khatri S, Sandal D, Masih GD. There is an Association of Synovial Interleukin-6 Levels With Chondral Damage in Anterior Cruciate Ligament-Deficient Knees. HSS J. 2021;17(2):145-9.
16. Milam RJ, Drayer NJ, Wallace CS, Kang DG, Masini BD. Late tibial interference screw extrusion following anterior cruciate ligament reconstruction: A case report. Orthop Rev (Pavia). 2022;14(3):37078.
17. Vuolteenaho K, Koskinen-Kolasa A, Laavola M, Nieminen R, Moilanen T, Moilanen E. High synovial fluid interleukin-6 levels are associated with increased matrix metalloproteinase levels and severe radiographic changes in osteoarthritis patients. Osteoarthritis Cartilage. 2017;25(1):S92-3.
18. Livshits G, Zhai G, Hart DJ, Kato BS, Wang H, Williams FMK, et al. Interleukin-6 is a significant predictor of radiographic knee osteoarthritis: the Chingford study. Arthritis Rheum. 2009;60(7):2037-45.

Cite this article as: Parmeshwar SS, Raju PK, Nagaraj P, Kanakagiri SK, Javaregowda PV. Comparison of synovial fluid IL-6 levels in post arthroscopic reconstruction of anterior cruciate ligament using press fit technique with BPTB graft versus bio-screw fixation. Int J Res Orthop 2026;12:701-6.