Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.53555/5v613c62

FUNCTIONAL OUTCOME OF ABP OSTEOSYNTHESIS FOR HUMERUS MID-THIRD DIAPHYSEAL FRACTURES USING THE MIPPO TECHNIQUE: A HOSPITAL-BASED PROSPECTIVE FOLLOW-UP STUDY

Dr Prashant Kumar Sharma[1], Dr. Sai Kiran Juttiga[2*], Dr. Sanjay Dev[3], Dr. J. Jerin Tamil Valan[4], Dr. Rijin Plasis[5]

[1]Associate Professor, Department of Orthopedics, Rama University Faculty of Medical Sciences
[2*]Senior Resident, Department of Orthopedics, Rama University Faculty of Medical Sciences.
[3]Senior Resident, Department of Orthopedics, Rama University Faculty of Medical Sciences.
[4]Post Graduate Resident, Department of Orthopedics, Rama University Faculty of Medical Sciences.
[5]Assistant Professor, Department of Orthopedics, Rama University Faculty of Medical Sciences.

***Corresponding Author:** Dr. Sai Kiran Juttiga
*Senior Resident, Department of Orthopedics, Rama University Faculty Of Medical Sciences,
Email Id: saikiran.2809@gmail.com

ABSTRACT

Background: The anterior approach in minimally invasive percutaneous plate osteosynthesis (MIPPO) has gained recognition for its efficacy in managing humeral shaft fractures. This study evaluates the clinical and functional outcomes of anterior bridge plating (ABP) using the MIPPO technique.

Materials and Methods: A total of 48 patients with closed comminuted or non-comminuted mid-shaft humeral fractures were treated using a 4.5 mm locking compression plate (LCP) via the MIPPO approach. Outcomes were assessed using the University of California, Los Angeles (UCLA) shoulder score and the Mayo Elbow Performance Score (MEPS).

Results: Four patients were lost to follow-up, and 44 patients completed the study. The mean time to fracture union was 13.63 weeks. Two patients experienced superficial infections, which resolved with intravenous antibiotics and local wound care. One patient developed a non-union. The mean UCLA score was 32.20 ± 2.77, and the mean Mayo elbow score was 87 ± 6.71.

Conclusion: Anterior bridge plating using the MIPPO technique provides favorable functional outcomes, with high union rates and minimal complications. The approach demonstrated excellent to good results in most patients, alongside satisfactory cosmetic outcomes.

Keywords: Anterior Bridge Plating, Minimally Invasive Percutaneous Plate Osteosynthesis (MIPPO), Humerus Shaft Fractures, Biological Fixation, Functional Outcome

INTRODUCTION

The humerus is the longest bone of the upper limb, articulating proximally with the glenoid to form the shoulder joint and distally with the radius and ulna to form the elbow joint[1]. Its vascular supply is predominantly from the anterior and posterior circumflex humeral arteries, the brachial artery, and the profunda brachii artery[2]. The shaft extends from the pectoralis major insertion to the distal metaphysis, and its shape transitions from cylindrical proximally to more triangular distally[3–4]. Humeral shaft fractures comprise approximately 5% of all fractures and often display a bimodal distribution: high-energy trauma in younger populations and low-energy falls in older individuals[5]. The mid-diaphyseal region is particularly prone to both transverse and spiral fractures. Transverse fractures often result from direct trauma, while spiral fractures are typically associated with falls on an outstretched arm[5]. The proximity of the radial nerve and profunda brachii artery in this region presents additional challenges, with primary radial nerve injury rates reported between 4% and 22% and iatrogenic injuries estimated around 3%[6]. Traditional methods focusing on absolute anatomical reduction often compromise soft tissue and vascular integrity. However, a shift toward biological fixation strategies has emerged, favouring techniques that preserve blood supply and reduce soft tissue disruption[7–8]. Various treatment modalities—including conservative management, external fixation, intramedullary nailing (IMN), and plating—offer differing benefits and drawbacks[9–12]. Operative management generally yields faster union times and lower non-union rates, although infection risks may be slightly elevated[13]. While IMN has lower infection and radial nerve injury rates, it is linked to increased risks of shoulder impingement and rotator cuff damage[14–15]. The MIPPO technique, particularly via the anterior approach, minimizes soft tissue injury and reduces the likelihood of radial nerve damage compared to traditional open techniques such as the posterior approach[14–15]. This study assesses the functional outcomes of ABP performed through MIPPO, over a minimum follow-up of six months.

MATERIALS AND METHODS:

Study Design and Setting: This was a hospital-based prospective follow-up study conducted in the Department of Orthopaedics at a tertiary care centre located in central India. The study spanned three years, from January 2021 to December 2023.

Ethical Considerations: Approval for the study was obtained from the Institutional Ethics Committee prior to the initiation of patient recruitment. All participants provided informed written consent before inclusion.

Study Population: A total of 48 patients presenting with closed mid-shaft humeral fractures were initially enrolled. These fractures were classified according to the AO/OTA system as types 12A, 12B, and 12C. Over the course of the follow-up, four patients were lost, resulting in a final analytical sample of 44 patients.

Inclusion Criteria

- Skeletally mature individuals
- Radiologically confirmed closed mid-shaft humeral fractures (AO types 12A, 12B, 12C)
- Patients with good bone quality
- Willingness to undergo surgical treatment
- Ability and willingness to comply with a minimum of 6 months of follow-up

Exclusion Criteria

- Ipsilateral upper limb injuries (including neurovascular involvement)
- Polytrauma patients
- History of previous humeral fractures
- Systemic disorders adversely affecting bone health (e.g., severe osteoporosis, endocrine disorders)
- Primary bone diseases (e.g., osteogenesis imperfecta)
- Malignancies (either primary or metastatic)

- Open fractures

Sampling Technique: A purposive sampling method was employed, using a convenience-based approach for patient recruitment. Patients were enrolled consecutively based on the fulfilment of eligibility criteria and willingness to participate.

Surgical Technique: All procedures were performed with patients lying comfortably in the supine position. Anaesthesia was administered either via brachial plexus block or general anaesthesia, depending on patient and anaesthesiologist preference. The anterior bridge plating technique began with two small incisions—one near the shoulder and one near the elbow. The proximal incision, approximately 2–3 cm in length, was placed just medial to the deltoid and biceps, about 5 cm below the acromion. The distal incision was similarly sized and located lateral to the biceps, around 5 cm above the elbow crease. Through these mini-open windows, the biceps was gently retracted to identify and safeguard the musculocutaneous nerve. The brachialis muscle was carefully split longitudinally to reach the bone, with its lateral portion serving as a natural protector for the radial nerve. A sub-brachialis, extra-periosteal tunnel was then crafted to allow insertion of a 4.5-mm locking compression plate (LCP) along the anterior surface of the humeral shaft. Reduction was achieved using manual traction to restore proper length, alignment, and rotation, and temporarily held in place with K-wires. Although early cases posed some technical challenges in achieving alignment, experience led to smoother execution. The "cortical step sign," as described by Krettek[16], served as a useful intraoperative marker to detect rotational misalignment. Once proper positioning was confirmed, the plate was anchored with two or three screws on either side of the fracture. Special care was taken during anterior tunnelling to prevent iatrogenic injury to the radial nerve. Post-surgery, patients were supported with a sling initially for comfort. Gradual mobilization was encouraged as pain subsided, facilitating a smooth recovery process.

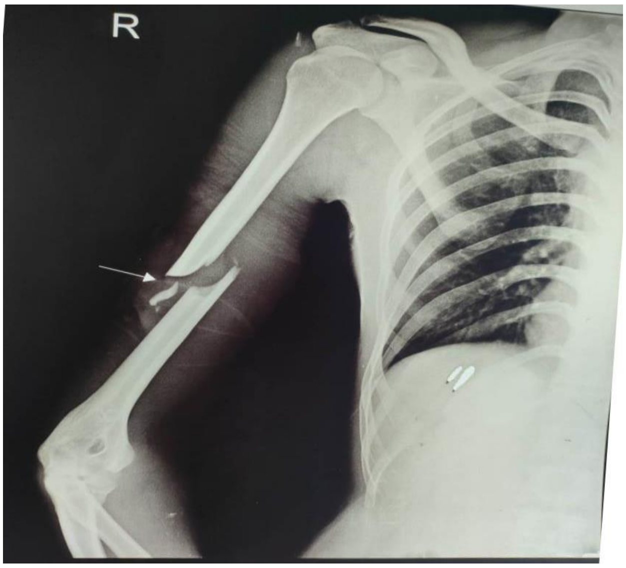

Figure 1: Pre-operative X-ray showing middle third shaft of humerus fracture

Figure 2: Intra-operative image showing the proximal and distal incision of arm

Fig.3: Sliding LCP plate through the sub muscular plane through distal entry site.

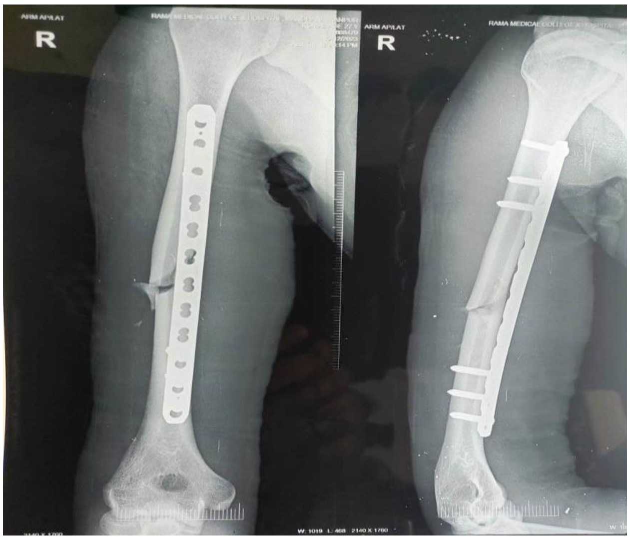

Fig.4: Immediate Post-Operative X-Ray showing LCP with MIPO technique.

POST OP FOLLOW UP AND REHABILITATION:

After surgery, patients were discharged within 1 week after course of antibiotics stopped and converting the rest injectable medications to tablet form with the affected arm immobilized in a simple sling. Pendulum and range of motion (ROM) exercises for the elbow, wrist, and hand began as soon as possible after the surgery, based on patient tolerance. At 2 weeks post-surgery, under the guidance, passive and active-assisted shoulder ROM exercises were started. Active abduction beyond 90° and rotational movements were allowed between 3 and 4 weeks post-surgery. Patients gradually resumed their preoperative activities, incorporating muscle strengthening, and returned to full activity by 9 to 12 weeks. The patient who did not show signs of radiographic or clinical union after 6 months was further evaluated and treated for non-union.

Fig.5: Follow-up image showing Extension movement at the elbow.

Fig.6: Follow-up image showing Flexion movement at the elbow.

Fig.7: Follow-up image showing Supination movement of forearm.

Fig.8: Follow-up image showing Pronation movement of forearm.

Fig.9: Follow-up image showing External rotation movement at the shoulder. .

Fig.10: Follow-up image showing Internal rotation movement at the shoulder.

Fig.11: Follow-up X-Ray image in Lateral view showing union through callus formation.

Fig.12: Follow-up X-Ray image in AP view showing union through callus formation.

RESULTS

Out of the 48 patients initially enrolled in the study, 4 were lost to follow-up. Therefore, the final analysis was conducted on data obtained from 44 patients (Table 1).

Demographics and Injury Characteristics: Of the 44 patients, 32 (72.72%) were male and 12 (27.27%) were female. The mean age was 34.20 years, with a range of 19 to 51 years. The dominant limb was involved in the majority of cases (31 patients; 70.45%). The most common mechanism of injury was road traffic accidents (RTA), accounting for 26 cases (59.09%), followed by falls on an outstretched hand in 12 patients (27.27%), and direct trauma in 6 patients (13.63%). All fractures were closed and classified under the AO/OTA system as types 12A, 12B, or 12C. Each case was managed using the minimally invasive percutaneous plate osteosynthesis (MIPO) technique with a 4.5 mm locking compression plate (LCP).

Fracture Union and Complications: Fracture union was achieved in 43 patients. One patient showed signs of non-union at 10 weeks, which was managed successfully with bone marrow aspirate grafting, leading to union by 19 weeks. The average time to radiological union across the cohort was 13.63 weeks (range: 10–19 weeks). No patient exhibited coronal or sagittal malalignment exceeding 15 degrees, and none had limb shortening greater than 1 cm. Two patients developed superficial surgical site infections—on postoperative days 7 and 30, respectively. These were effectively managed with thorough irrigation, local debridement, and a course of intravenous antibiotics, resulting in complete resolution.

Functional Outcomes: Functional evaluation was performed using the University of California, Los Angeles (UCLA) shoulder score and the Mayo Elbow Performance Score (MEPS):

The **mean UCLA shoulder score** was 32.20 ± 2.77 (Table 2), with outcomes rated as: Excellent: 28 patients**,** Good: 14 patient and Fair: 2 patients.

The **mean Mayo elbow score** was 87 ± 6.71 (Table 3), distributed as follows: Excellent: 15 patients**,** Good: 26 patients **and** Fair: 3 patients.

	Frequency
AGE (YEARS)	
< 25	9 (20.45%)
25–34	14 (31.81%)
35–44	12 (27.27%)
45–54	9 (20.45%)
SEX	
Male	32 (72.72%)
Female	12 (27.27%)
SIDE	
Dominant	31 (70.45 %)
Non- Dominant	13(29.54%)
MODE OF INJURY	
Road traffic accident	26 (59.09%)
Fall on out stretched hand	12 (27.27%)
Direct trauma	6 (13.63%)

Table 1: Patient demographics.

UCLA SCORE	NO. OF PATIENTS (PERCENTAGE)
Excellent	28 (63.63%)
Good	14 (31.81%)
Fair	2 (4.54%)
Poor	0

Table 2: UCLA shoulder score.

MAYO SCORE	NO. OF PATIENTS (PERCENTAGE)
Excellent	15 (34.09%)
Good	26 (59.09%)
Fair	3 (6.81%)
Poor	0

Table 3: MAYO elbow score.

DISCUSSION

Minimally Invasive Plate Osteosynthesis (MIPO) was initially introduced by Tscherne and Krettek in 1996.[17] Over the past few decades, it has garnered increasing attention as a viable and effective surgical technique for managing humeral shaft fractures. This technique has been adopted widely due to its ability to preserve the biological environment around the fracture site. By minimizing soft tissue disruption and preserving periosteal blood supply, MIPO facilitates biological healing, potentially resulting in faster recovery and lower rates of infection and non-union.[18]

Although technically demanding, MIPO is recognized for its reproducibility and versatility. The approach enables surgeons to stabilize a wide range of fracture patterns while adhering to the principles of minimally invasive surgery. Its application in the humerus, particularly in diaphyseal fractures, offers distinct biomechanical and clinical advantages. The use of a long plate for fracture fixation helps to distribute mechanical stresses more uniformly along the humeral shaft. This strategic distribution reduces localized stress concentrations, which are commonly responsible for hardware-related complications such as screw loosening or plate breakage. Consequently, construct stability is enhanced, which may translate into better clinical and functional outcomes.[18]

Anterior Bridge Plating (ABP), a specific application of the MIPO technique, is particularly advantageous for patients involved in occupations or activities requiring frequent overhead arm movements. In such individuals, ABP offers a robust fixation modality that respects the native anatomy and provides sufficient stability to allow early mobilization. This is especially pertinent for athletes and manual laborers, where restoration of full functional capacity is paramount.[19] By maintaining alignment and avoiding extensive soft tissue stripping, ABP helps to preserve muscle and tendon function, thereby supporting quicker and more complete return to pre-injury activity levels.

Compared to traditional posterior plating techniques, MIPO with ABP offers several benefits that align with the current goals of orthopedic surgery—namely, reduced invasiveness, improved healing conditions, and superior cosmetic results. The anterior approach enables the use of smaller incisions, which leads to less soft tissue trauma and improved aesthetic outcomes.[19] Additionally, this method avoids detachment or injury to the rotator cuff, a complication commonly associated with intramedullary nailing. Preserving the integrity of the rotator cuff minimizes postoperative shoulder dysfunction, a crucial advantage for patients requiring full upper limb mobility.[20]

Despite these advantages, the MIPO technique is not without limitations. One of the most significant challenges is its steep learning curve. The technique requires advanced surgical skills, thorough knowledge of humeral anatomy, and a high degree of intraoperative precision.[17] Inexperience or deviation from surgical principles may increase the risk of complications, such as malalignment or iatrogenic nerve injury. Therefore, MIPO should ideally be performed by surgeons who are adequately trained and operate under guided supervision during the initial stages of their learning curve.

Another notable limitation of MIPO is its reliance on intraoperative fluoroscopy. Compared to open posterior plating, MIPO often necessitates prolonged fluoroscopic guidance to ensure accurate reduction and correct implant placement. This not only increases the duration of surgery but also exposes the surgical team to higher levels of ionizing radiation.[18] Thus, appropriate radiation safety protocols must be strictly followed, and fluoroscopy time should be minimized through experience and proper planning.

Anatomically, anterior plating introduces a specific concern regarding the risk of radial nerve injury. This is particularly critical at the distal third of the humerus, where the radial nerve passes through the lateral intermuscular septum and becomes vulnerable during plate application.[10,21] Although MIPO aims to minimize soft tissue dissection, inadvertent manipulation or retraction at this site may place the nerve at risk. To mitigate this, meticulous surgical technique, along with preoperative and intraoperative knowledge of nerve anatomy, is essential. Some authors advocate limited open approaches or nerve monitoring in high-risk zones to prevent such complications.[9,21]

In addition to the surgical approach and technique, implant selection plays a crucial role in the overall success of MIPO. The choice between locking and non-locking cortical screws can significantly influence construct stability. Locking screws, by creating a fixed-angle construct, are particularly useful in osteoporotic bone and comminuted fractures where conventional screw purchase may be inadequate. Non-locking screws, on the other hand, allow for micro-motion at the fracture site, potentially enhancing secondary bone healing.[22] The selection must therefore be individualized, based on bone quality, fracture morphology, and the mechanical demands expected of the construct.

In conclusion, MIPO using the anterior bridge plating approach represents a significant advancement in the management of humeral shaft fractures. It merges the principles of minimally invasive surgery with biomechanical stability and favorable functional outcomes. While it offers several advantages over traditional open plating and intramedullary fixation, it demands considerable surgical expertise and careful intraoperative planning. Surgeons must be mindful of the potential complications, including nerve injury and increased fluoroscopy exposure. Future studies with larger cohorts and long-term follow-up could help further refine the technique and broaden its applicability in varied clinical settings.

CONCLUSION

Our study demonstrates that anterior bridge plating for mid-shaft humerus fractures significantly enhances functional recovery. Most patients attained excellent to good outcomes, with minimal complications and a high union rate. The technique is associated with favourable cosmetic results and is consistently reproducible. Despite its technical demands, the benefits of anterior MIPO plating make it a viable and effective treatment option. However, to develop standardized protocols and further validate its efficacy, larger multicentric studies with control groups are recommended.

REFERENCES

1. Capo JT, Criner KT, Shamian B. Exposures of the humerus for fracture fixation. Hand Clin. 2014 Nov;30(4):401-14, v. doi: 10.1016/j.hcl.2014.07.001. Epub 2014 Oct 23. PMID: 25440069.
2. Attum B, Thompson JH. Humerus Fractures Overview. 2023 Jul 4. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024 Jan–. PMID: 29489190.
3. Walker M, Palumbo B, Badman B, Brooks J, Van Gelderen J, Mighell M. Humeral shaft fractures: a review. J Shoulder Elbow Surg. 2011 Jul;20(5):833-44. doi: 10.1016/j.jse.2010.11.030. Epub 2011 Mar 9. PMID: 21393016
4. Lambert SM. Shoulder girdle and arm. Gray’s anatomy: the anatomical basis of clinical practice. 2016:797-836.
5. Gallusser N, Barimani B, Vauclair F. Humeral shaft fractures. EFORT Open Rev. 2021 Jan 4;6(1):24-34. doi: 10.1302/2058-5241.6.200033. PMID: 33532084; PMCID: PMC7845564.
6. Updegrove GF, Mourad W, Abboud JA. Humeral shaft fractures. J Shoulder Elbow Surg. 2018 Apr;27(4):e87-e97. doi: 10.1016/j.jse.2017.10.028. Epub 2017 Dec 29. PMID: 29292035.
7. Frigg R, Wagner M. AO Manual of fracture management. Chapters 1.2: Concepts of fracture fixation, 2006
8. Baumgaertel F, Buhl M, Rahn BA. Fracture healing in biological plate osteosynthesis. Injury. 1998;29 Suppl 3:C3-6. doi: 10.1016/s0020-1383(98)95002-1. PMID: 10341891.
9. Apivatthakakul T, Arpornchayanon O, Bavornratanavech S. Minimally invasive plate osteosynthesis (MIPO) of the humeral shaft fracture. Is it possible? A cadaveric study and preliminary report. Injury. 2005 Apr;36(4):530-8. doi: 10.1016/j.injury.2004.05.036. PMID: 15755436.

10. Livani B, Belangero W, Andrade K, Zuiani G, Pratali R. Is MIPO in humeral shaft fractures really safe? Postoperative ultrasonographic evaluation. Int Orthop. 2009 Dec;33(6):1719-23. doi: 10.1007/s00264-008-0616-x. Epub 2008 Aug 13. PMID: 18704415; PMCID: PMC2899185.
11. Ziran BH, Belangero W, Livani B, Pesantez R. Percutaneous plating of the humerus with locked plating: technique and case report. J Trauma. 2007 Jul;63(1):205-10. doi: 10.1097/01.ta.0000231870.11908.3e. PMID: 17622893
12. Zhiquan A, Bingfang Z, Yeming W, Chi Z, Peiyan H. Minimally invasive plating osteosynthesis (MIPO) of middle and distal third humeral shaft fractures. J Orthop Trauma. 2007 Oct;21(9):628-33. doi: 10.1097/BOT.0b013e31815928c2. PMID: 17921838.
13. Westrick E, Hamilton B, Toogood P, Henley B, Firoozabadi R. Humeral shaft fractures: results of operative and non-operative treatment. Int Orthop. 2017 Feb;41(2):385-395. doi: 10.1007/s00264-016-3210-7. Epub 2016 May 6. PMID: 27150488.
14. Zhao JG, Wang J, Meng XH, Zeng XT, Kan SL. Surgical interventions to treat humerus shaft fractures: A network meta-analysis of randomized controlled trials. PLoS One. 2017 Mar 23;12(3):e0173634. doi: 10.1371/journal.pone.0173634. PMID: 28333947; PMCID: PMC5363833.
15. Beeres FJP, van Veelen N, Houwert RM, Link BC, Heng M, Knobe M, Groenwold RHH, Babst R, van de Wall BJM. Open plate fixation versus nailing for humeral shaft fractures: a meta-analysis and systematic review of randomised clinical trials and observational studies. Eur J Trauma Emerg Surg. 2022 Aug;48(4):2667-2682. doi: 10.1007/s00068-021-01728-7. Epub 2021 Jul 5. PMID: 34219193.
16. Krettek C, Miclau T, Grün O, Schandelmaier P, Tscherne H. Intraoperative control of axes, rotation and length in femoral and tibial fractures. Technical note. Injury. 1998;29 Suppl 3:C29-39. doi: 10.1016/s0020-1383(98)95006-9. PMID: 10341895.
17. Krettek C, Schandelmaier P, Tscherne H. Distale Femurfrakturen. Transartikuläre Rekonstruktion, perkutane Plattenosteosynthese und retrograde Nagelung [Distal femoral fractures. Transarticular reconstruction, percutaneous plate osteosynthesis and retrograde nailing]. Unfallchirurg. 1996 Jan;99(1):2-10. German. PMID: 8850073.
18. Mishra P, Verma M, Verma R. Anterior Bridge Plate Osteosynthesis in Comminuted Fracture Shaft of Humerus in Manual Workers- is it Optimum Choice? Arch Bone Jt Surg. 2021 Nov;9(6):702-707. doi: 10.22038/abjs.2021.52287.2579. PMID: 35106336; PMCID: PMC8765204.
19. Mahajan AS, Kim YG, Kim JH, D'sa P, Lakhani A, Ok HS. Is Anterior Bridge Plating for Mid-Shaft Humeral Fractures a Suitable Option for Patients Predominantly Involved in Overhead Activities? A Functional Outcome Study in Athletes and Manual Laborers. Clin Orthop Surg. 2016 Dec;8(4):358-366. doi: 10.4055/cios.2016.8.4.358. Epub 2016 Nov 4. PMID: 27904716; PMCID: PMC5114246.
20. Singisetti K, Ambedkar M. Nailing versus plating in humerus shaft fractures: a prospective comparative study. Int Orthop. 2010 Apr;34(4):571-6. doi: 10.1007/s00264-009-0813-2. Epub 2009 Jun 9. PMID: 19506868; PMCID: PMC2903148.
21. Shin SJ, Sohn HS, Do NH. Minimally invasive plate osteosynthesis of humeral shaft fractures: a technique to aid fracture reduction and minimize complications. J Orthop Trauma. 2012 Oct;26(10):585-9. doi: 10.1097/BOT.0b013e318254895f. PMID: 22534690.
22. O'Toole RV, Andersen RC, Vesnovsky O, Alexander M, Topoleski LD, Nascone JW, Sciadini MF, Turen C, Eglseder WA Jr. Are locking screws advantageous with plate fixation of humeral shaft fractures? A biomechanical analysis of synthetic and cadaveric bone. J Orthop Trauma. 2008 Nov-Dec;22(10):709-15. doi: 10.1097/BOT.0b013e31818df8cb. PMID: 18978547.