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ORIGINAL RESEARCH

Assessment of management of diaphyseal fracture non-union by the Masquelet technique using external or internal fixator

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ABSTRACT
Background: The surgical treatment of diaphyseal forearm fracture-non-unions remains a therapeutic challenge for orthopaedic trauma surgeons. Masquelet technique, which is the use of a temporary cement spacer followed by staged bone grafting, is a recent treatment strategy to manage a posttraumatic bone defect. Hence; the present study was conducted for assessing the outcome of management of fracture non-union by Masquelet technique using external or internal fixator. **Materials & methods:**A total of 20 cases of infected forearm non-unions where the defects post-debridement ranged from 4 to 7.5 cm were enrolled. Complete demographic and clinical details of all the patients was obtained. All the patients were treated withMasquelet technique and follow-up was carried at 6 weeks,3 months, 6 months and 1 year. Pre-treatment biochemical and hematological findings were evaluated. Pre-treatment preparation was done. The antibiotic was continued for 6 weeks. All the results were recorded in Microsoft excel sheet and were subjected to statistical analysis using SPSS software.**Results:**Mean age of the patients were 43.9 years with majority proportion of patients were males. Right side involvement occurred in 13 cases and left in 7 patients. Four of them received internal fixation and 16 received external fixation. At the final follow-up, there was an improvement in the range of motion in all instances, with the wrist flexion ranging from 40° to 60° and the wrist extension ranging from 45° to 60°. The pronation range varied between 50° and 85°, whereas the pronation itself ranged from 60° to 85°. Recurrent infection was seen in one patient and joint stiffness was seen in 2 patients. **Conclusion:**Fracture non-union cases can be effectively managed by Masquelet technique using using external or internal fixator for stabilizing the affected area.

Key words: Non-union, External Fixator, Masquelet

INTRODUCTION

The surgical treatment of diaphyseal forearm fracture-nonunions remains a therapeutic challenge for orthopaedic trauma surgeons. Key to success in the management of these demanding conditions is to develop a comprehensive treatment concept which considers the forearm and its adjacent joints, the elbow and wrist, as a complex functional unit.[1]Nonunions of the radius and ulna shaft cause a severe anatomic and functional impairment, related to disturbance of the interosseous membrane and dysfunction of the adjacent joints, elbow and wrist.[2, 3]
Typical rates reported for forearm non-unions in large cohort studies range between 2 and 10%. A diaphysealforearm non-union is disabling as it effects not only the forearm but also the elbow and wrist. Failure to reconstitute the exact relation between radius and ulna will affect the proximal and distal joints, limiting the ability to place the hand in space. Most often the non-union has a multifactorial cause combining fracture characteristics (e.g. low vs. high energy impact, comminution, location, soft tissue damage, open vs. closed), patient characteristics (age, co-morbidities) as well as surgeon-dependent causes (surgical technique and strategy).[4- 6]
Masquelet technique, which is the use of a temporary cement spacer followed by staged bone grafting, is a recent treatment strategy to manage a posttraumatic

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bone defect. The Masquelet technique has been accepted as a two-stage procedure to treat bone defects. The first stage is by filling up bone defects with polymethyl methacrylate (PMMA) cement. PMMA cement is used as a spacer to eliminate dead ends, a local antibiotic delivery system, and a bioreactor chamber to stimulate osteogenesis. The second stage is the osteosynthesis procedure allowing the mixture of autologous bone grafting and allograft. The secret to the success of the Masquelet technique is the radical debridement, as is highlighted in the treatment of infected nonunion.[7-10]Hence; the present study was conducted for comparing the outcome of management of fracture non-union by external fixator and Masquelet technique.

MATERIALS & METHODS

The present study was conducted for comparing the outcome of management of fracture non-union by external fixator and Masquelet technique. A total of 20 cases of infected forearm non-unions where the defects post-debridement ranged from 4 to 7.5 cm were enrolled. Complete demographic and clinical details of all the patients was obtained. The original implant was extracted and all patients underwent a two-stage Masquelet procedure involving thorough removal of infected tissue and the use of alternative methods for stabilizing the affected area. The complete resolution of inflammatory symptoms and reduction of infection markers (such as interleukin-6 (IL-6), C-reactive protein, and white blood cell count) to within normal levels were considered as successful removal of infected tissue. The choice of alternative stabilization methods depended on the condition of the surrounding soft tissues.

Masquelet technique

Surgical Procedure

Step 1: Debridement and Hardware Removal

The affected region was uncovered, and the hardware was extracted. Necrotic and non-viable bone was surgically removed until healthy bone with little bleeding points was discovered, a phenomenon known as the Paprika sign.

Step 2: Bone End Preparation

The bone ends were oriented in a transverse direction.

Step 3: Soft Tissue Debridement

Diseased soft tissue was excised along with sinus tracts.

Step 4: Stabilization

The deformity was immobilized using a plate and screws. Standard dynamic compression plates were used for stabilization in most cases, while locking plates were utilized in a few cases.

Step 5: Infection Eradication Confirmation

If there was any uncertainty over the eradication of the infection, further Gram staining was performed throughout the process to confirm effective removal of infected tissue.

Step 6: Antimicrobial Cement Insertion

The antimicrobial cement, shaped to match the defect, was inserted into the breach, partially covering the cleaned bone ends.

Step 7: Wound Closure

The wound was meticulously sutured to cover the cement and the plate.

Second-Stage Surgery

Step 1: Cement Spacer Removal

After a period of six weeks following the initial procedure, the cement spacer was removed.

Step 2: Bone End Preparation

The ends of the bone were cleaned and stripped of any dead tissue.

Step 3: Graft Insertion

The graft extracted from the iliac crest was fragmented into small pieces and inserted into the space.

Step 4: Soft Tissue Closure

The soft tissue was meticulously sutured to cover the graft and the biological membrane, resulting in the formation of a sealed biological chamber. (Figure 1)

Postoperative Management

Antibiotic Administration

Antibiotics were administered to all patients according to the culture report, and the medications were adjusted accordingly if the intraoperative material sent for culture revealed a different type of bacteria. The administration of antibiotics was maintained for a duration of 6 weeks.

Immobilization

The patient was immobilized in a splint for a duration of 6 weeks, followed by a gradual introduction of controlled movement after 2 weeks.

Radiological Monitoring

Regular radiological monitoring was conducted every two months for a period of six months, and thereafter continued on a monthly basis. (Figure 2)

Statistical analysis

All the results were recorded in Microsoft excel sheet and were subjected to statistical analysis using SPSS software.

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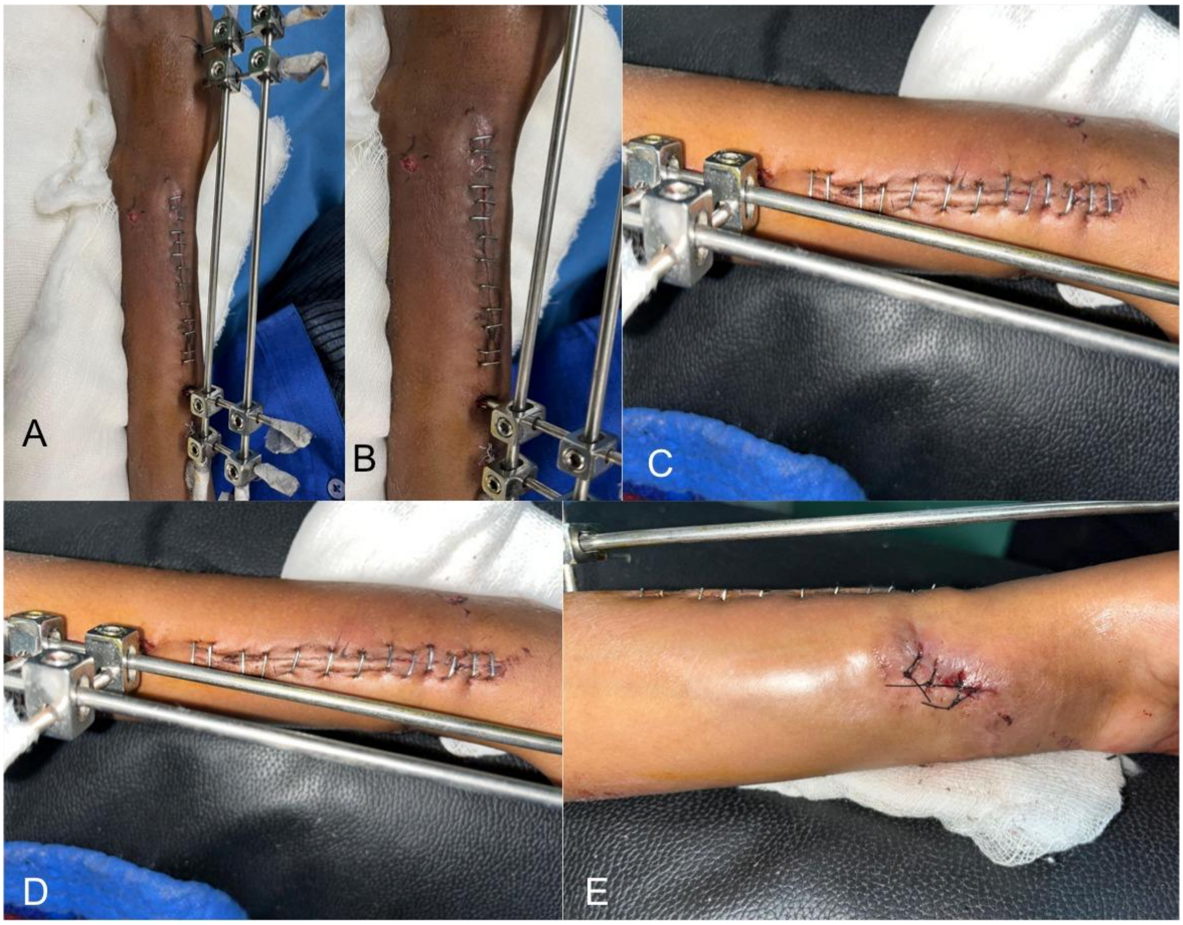

Figure 1: Postop clinical images (A& B) Incisional scar for bone graft (C & D) Open fracture site (E)

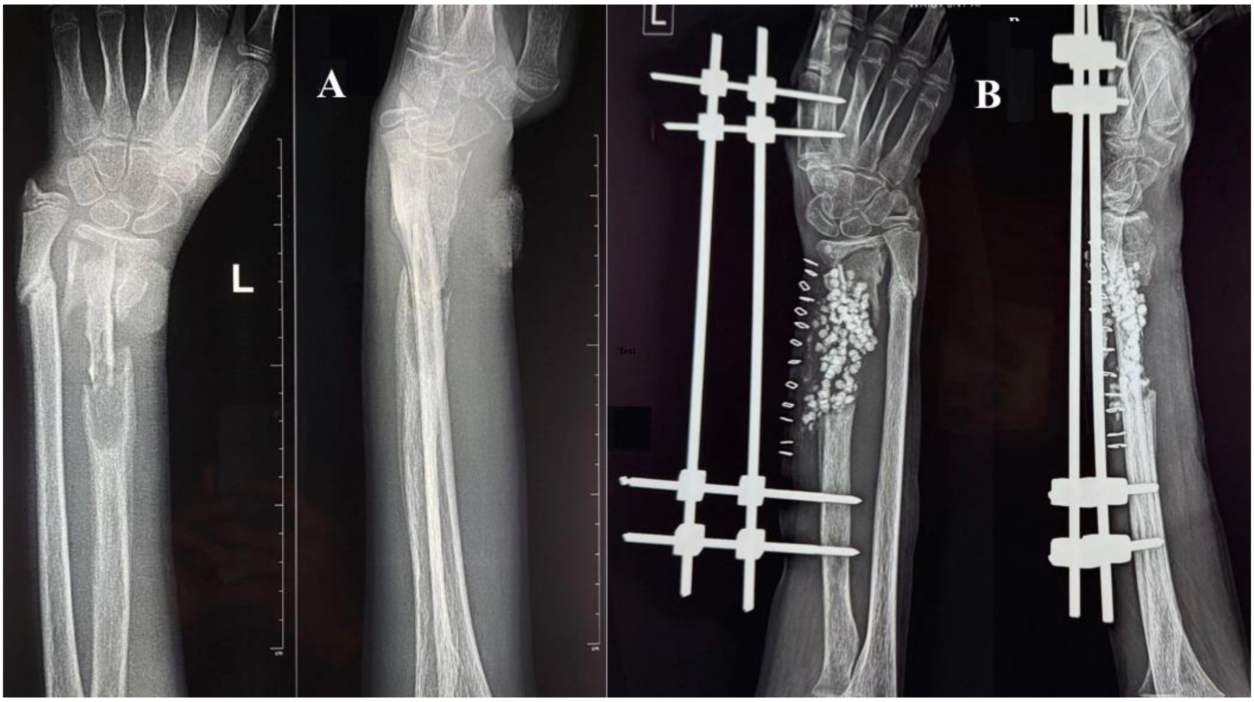

Figure 2: Preop and Post op x-ray

RESULTS

Mean age of the patients were 43.9 years with majority proportion of patients were males. Right side involvement occurred in 13 cases and left in 7 patients(table 1). Culture report showed 11 cases were infected with Staphylococcus aureus, 6 cases of Escherichia coli, 1 case with Klebsiella and 2 cases with mixed infections.Four of them received internal

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fixation and 16 received external fixation (table 2). Range of motion is shown in table 3 and 4. At the final follow-up, there was an improvement in the range of motion in all instances, with the wrist flexion ranging from 40° to 60° and the wrist extension ranging from 45° to 60°.

The pronation range varied between 50° and 85°, whereas the pronation itself ranged from 60° to 85°.Recurrent infection was seen in one patient andjoint stiffness was seen in 2 patients. All of the cases were followed for at least 1 year.

Table 1: Demographic data

Variable	number of patients=20
Mean age (years)	43.9years
Males (n)	15
Females (n)	5
Right side involved (n)	13
Left side involved (n)	7

Table 2: Culture analysis, type of fixation and union

Parameters	Results	
Culture	Staphylococcus aureus	11
	Escherichia coli	6
	Klebsiella	1
	Mixed infections	2
Fixation	Internal fixation	4
	External fixation	16
Mean duration of union	Mean: 7.10 months (range 6-12 months)	

Table 3: Range of supination/pronation after treatment and at follow up

Cases	Post-op	6 weeks	3 months	6 months	1 year
1.	15-0-30	30-0-45	45-0-55	45-0-70	45–0–80
2.	10-0-10	30-0-30	30-0-45	45-0-45	60–0–50
3.	15-0-35	20-0-30	45-0-50	55-0-60	80–0–80
4.	15-0-30	30-0-35	45-0-55	60-0-65	80–0–70
5.	10-0-15	30-0-30	45-0-65	55-0-65	55–0–70
6.	15-0-30	30-0-45	45-0-55	55-0-60	70–0–65
7.	10-0-10	30-0-30	30-0-45	45-0-45	70–0–65
8.	15-0-35	20-0-30	45-0-50	55-0-60	70–0–65
9.	15-0-30	30-0-35	45-0-55	60-0-50	60–0–50
10.	15-0-31	30-0-15	45-0-55	55-0-60	80–0–70
11.	10-0-11	30-0-0	30-0-45	45-0-5	80–0–70
12.	15-0-25	20-0-31	45-0-60	55-0-61	75–0–70
13.	15-0-20	30-0-36	45-0-65	60-0-66	75–0–70
14.	15-0-32	30-0-15	45-0-55	45-0-30	75–0–70
15.	10-0-12	30-0-30	30-0-45	45-0-55	75–0–80
16.	15-0-15	20-0-32	45-0-70	55-0-62	80–0–80
17.	15-0-10	30-0-37	45-0-75	60-0-57	60–0–60
18.	15-0-33	30-0-45	45-0-55	45-0-70	75–0–75
19.	10-0-15	30-0-60	30-0-45	45-0-45	60–0–50
20.	15-0-15	20-0-33	45-0-70	55-0-75	80–0–85

Table 4: Range of motion flexion /extension [wrist]after treatment and at follow up

Cases	Post-op	6 weeks	3 months	6 months	1 year
1.	15-0-10	30-0-30	35-0-45	40-0-45	45–0–50
2.	15-0-10	30-0-37	45-0-50	55-0-50	60–0–60
3.	15-0-33	30-0-45	45-0-55	45-0-55	60–0–60
4.	10-0-15	30-0-40	30-0-45	45-0-45	60–0–60
5.	15-0-20	30-0-35	45-0-40	45-0-40	50–0–45
6.	10-0-15	30-0-25	30-0-45	45-0-50	50–0–55
7.	15-0-20	20-0-35	45-0-45	45-0-50	50–0–55

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8.	10-0-15	30-0-30	30-0-45	45-0-56	50–0–55
9.	15-0-15	20-0-33	45-0-45	45-0-60	60–0–60
10.	15-0-10	30-0-37	45-0-55	55-0-55	60–0–60
11.	15-0-30	30-0-45	45-0-55	45-0-55	60–0–60
12.	10-0-15	30-0-45	33-0-45	45-0-50	50–0–55
13.	15-0-15	30-0-35	45-0-50	45-0-50	50–0–55
14.	10-0-12	30-0-35	30-0-45	45-0-53	50–0–55
15.	10-0-13	30-0-30	30-0-45	45-0-50	50–0–55
16.	15-0-15	20-0-33	45-0-50	55-0-55	40–0–60
17.	15-0-10	30-0-37	35-0-40	40-0-45	45–0–45
18.	15-0-33	30-0-45	45-0-50	45-0-50	55–0–55
19.	10-0-13	30-0-30	30-0-45	45-0-56	60–0–60
20.	15-0-15	20-0-33	45-0-50	55-0-53	60–0–60

Table 5: Complications

Complications	N=20
Recurrent infection	1
Joint stiffness	2

DISCUSSION

Non unions are a major complication of diaphyseal fractures of the forearm, with eventual variable dysfunction of the upper limb and hand. Non-union is defined as absence of radiological and clinical signs of unions after an average period of six months. The use of dynamic compression plate has totally changed the prognosis of surgical treatment of diaphyseal fractures of the radius and ulna. Although large series in the literature have shown that this technique is simple with a low complication rate, the incidence of aseptic nonunion of the forearm fractures remains significant between 2% and 10% in various publications. The management of these non-unions remains difficult due to the poor bone mass, the existence of previous implant material and joint stiffness that is associated with long-term immobilization. The goal of surgery is to achieve complete union of the fractures and restore the functional anatomy between the radius and the ulna, so as to obtain a normal hand function.[11-13]

The Masquelet (or Induced Membrane) technique, invented in the 1980s, consists of 2 stages: During the first stage, thorough debridement of the bone and soft tissue is carried out, and a cement spacer (with or without antibiotics) is put in place to fill the resultant cavity, with the construct being stabilized either temporarily or permanently. A subsequent period of 6 to 8 weeks is enough for the cement to induce around it an inflammatory, richly vascularized “foreign body” membrane containing important molecular mediators. A closed cavity then forms which during the second stage is opened and after the removal of the cement spacer is filled in with bone graft and enhanced with adjuncts, for example bone marrow aspirate concentrate (BMAC) or bone-morphogenetic protein-2 (BMP-2). The affected extremity is then stabilized definitively as indicated with the appropriate selection of suitable implants.[14-16]Hence; the present study was conducted for evaluating the outcome of management of fracture non-union by external or internal fixatoralong withMasquelet technique.

Majority proportion of patients of both the study groups were males. Right side involvement occurred in majority of the patients. Mean duration of union was 7.10 months (range 6-12 months)Four of them received internal fixation and 16 received external fixation. At the final follow-up, there was an improvement in the range of motion in all instances, with the wrist flexion ranging from 40° to 60° and the wrist extension ranging from 45° to 60°.

The pronation range varied between 50° and 85°, whereas the pronation itself ranged from 60° to 85°.

Our results are comparable with similar studies. In their study, Ma et al[17] examined the efficacy of the induced membrane approach in treating infected forearm nonunion. They observed 32 patients who did not experience any recurring infection or loosening of internal fixation, and concluded that this technique is an effective remedy. Walker M et al[18] successfully applied this technique to treat forearm nonunion cases with deformities of up to 5.4 cm. Pachera et al[19]documented a case of a 53-year-old patient who had a deformity in their left forearm caused by a weakened union of the ulna and a misaligned union of the radius. The patient's condition was effectively treated using the Masquelet technique in combination with a corrective osteotomy of the radius, aided by a 3D model. Possible complications associated with the Masquelet procedure encompass implant loosening, infection, graft fracture, and bone resorption. Another study by Liu X et al, a retrospective study of 23 patients showed that 21 cases were successfully reconstructed without infection recurrence, 20 patients had satisfactory functional outcomes, while 3 cases had discrepancies in leg length and joint stiffness. The study suggests that this technique can achieve high success rates in resolving infections and promoting bone healing, with careful selection of alternative fixation methods based on local soft tissue conditions.

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The Masquelet technique with radical debridement and alternative fixation is effective in managing infected bone non-union.

CONCLUSION

Fracture non-union cases can be effectively managed by both external fixator and Masquelet technique.

REFERENCES

1. Rochard MJ, Ruch DS, Aldridge JM., 3rd Malunions and nonunions of the forearm. Hand Clin. 2007;23:235–243.
2. Richards RR. Chronic disorders of the forearm. J Bone Joint Surg (Am) 1996;78:916–930.
3. Schemitsch EH, Richards RR. The effects of malunion on functional outcome after plate fixation of fractures of both bones of the forearm in adults. J Bone Joint Surg (Am) 1992;74:1068–1078.
4. Orzechowski W, Morasiewicz L, Dragan S, Krawczyk A, Kulej M, Mazur T. Treatment of non-union of the forearm using distraction-compression osteogenesis. OrtopTraumatolRehabil . 2007;9:357–365.
5. Ling HT, Kwan MK, Chua YP, Deepak AS, Ahmad TS. Locking compression plate: a treatment option for diaphyseal nonunion of radius or ulna. Med J Malaysia. 2006;61:8–12.
6. Krzykawski R, Król R, Kamiński A. The results of locked intramedullary nailing for non-union of forearm bones. OrtopTraumatolRehabil . 2008;10:35–43.
7. Bezstarosti H, Van Lieshout EMM, Voskamp LW, Kortram K, Obremskey W, McNally MA, et al. Insights into treatment and outcome of fracture-related infection: a systematic literature review. Arch Orthop Trauma Surg. (2019) 139(1):61–72.
8. Metsemakers WJ, Kuehl R, Moriarty TF, Richards RG, Verhofstad MHJ, Borens O, et al. Infection after fracture fixation: current surgical and microbiological concepts. Injury. (2018) 49(3):511–22.
9. Depypere M, Morgenstern M, Kuehl R, Senneville E, Moriarty TF, Obremskey WT, et al. Pathogenesis and management of fracture-related infection. ClinMicrobiol Infect. (2020) 26(5):572–8.
10. Anderson LD, Sisk D, Tooms RE, Park WI. Compression- plate fixation in acute diaphyseal fractures of the radius and ulna. J Bone Joint Surg. (3rd) 1975;3-A:7–287.
11. Stern PJ, Drury WJ. Complications of plate fixation of forearm fractures. ClinOrthopRelat Res. 1983;175:25–9.
12. Ross ER, Gourevitch D, Hastings GW, Wynn-Jones CE, Ali S. Retrospective analysis of plate fixation of diaphyseal fractures of the forearm bones. Injury. 1989;4:211–4.
13. Wei SY, Born CT, Abene A, Ong A, Hayda R, De Long WG.,JrDiaphyseal forearm fractures treated with and without bone graft. J Trauma. 1999;6:1045–8.
14. Ma CH et al. Masquelet technique with external locking plate for recalcitrant distal tibial nonunion. Injury. 2017; 48(12): 2847- 2852.
15. George C, Nikolaos K, Paul H, Peter G. Induced membrane technique for acute bone loss and nonunion management of the tibia. OTA International. 2022; 5(2S): e170.
16. Khaled A, El-Gebaly O, El-Rosasy M. Masquelet–Ilizarov technique for the management of bone loss post debridement of infected tibial nonunion. International Orthopaedics. 2022; 46: 1937–1944.
17. Ma XY, Liu B, Yu HL, Zhang X, Xiang LB, Zhou DP. Induced membrane technique for the treatment of infected forearm nonunion: A retrospective study. The Journal of Hand Surgery. 2022 Jun 1;47(6):583-e1.
18. Walker M, Sharareh B, Mitchell SA. Masquelet reconstruction for posttraumatic segmental bone defects in the forearm. The Journal of Hand Surgery. 2019 Apr 1;44(4):342-e1.
19. Pachera G, Santolini E, Galuppi A, Dapelo E, Demontis G, Formica M, Santolini F, Briano S. Forearm segmental bone defect: Successful management using the Masquelet Technique with the aid of 3D printing technology. Trauma case reports. 2021 Dec 1;36:100549.
20. Liu X, Min HS, Chai Y, Yu X, Wen G. Masquelet technique with radical debridement and alternative fixation in treatment of infected bone nonunion. Frontiers in Surgery. 2022 Oct 6;9:1000340.