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Comparison of Outcomes of Diaphyseal Humeral Shaft Fractures Treated With Anterior Bridge Plating Vs Open Reduction Internal Fixation by Posterior Approach

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Abstract
Humeral shaft fractures are common and account for approximately 3% of all orthopaedic injuries.The aim of this study is to analyse and compare the clinical, radiological and functional outcomes of humeral shaft fractures treated with minimally invasive anterior bridge plating (ABP) VS open reduction and internal fixation (ORIF) by posterior approach.A prospective randomised controlled trial study was carried out for a total of 40 cases of humeral shaft fractures.20 cases in minimally invasive ABP and 20 cases in posterior ORIF group. Study population washumeral shaft fractures in skeletally mature patients.All the cases were followed up for a minimum period of six months. Result was assessed usingDASH(The Disabilities of the Arm, Shoulder and Hand)Score. The average age of patients was 36.2 years with 29 males and 11 females.There were 12 excellent results in the anterior bridge plating group and 15 in the posterior ORIF with plating group. 6 good results in the anterior bridge plating group and 5 in the posterior ORIF. 2 poor results in the anterior bridge plating group and none in the posterior ORIF. On statistical analysis, the p-value was >0.05 and therefore statistically not significant. We thus conclude that for humeral shaft fractures, both the modalities of treatment i.e. minimally invasive anterior bridge plating and posterior ORIF with plating are good as far as union of the fracture is concerned, but considering the overall result, anterior bridge plating offers better result than posterior ORIF with plating with respect to minimal soft tissue dissection, fracture haematoma, periosteal blood supply, decreased risk of radial nerve injury, minimal operative site scar and shorter operative time.
Key Words*:Humeral shaft fracture;Anterior bridge plating; Open reduction and internal fixation.*

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I. Introduction

Fractures of the shaft of humerus are common and account for approximately 3% of all orthopaedic injuries, and result in a significant burden to society from lost productivity and wages[1]. With the advances in mechanization, increasing speed of life and increased life expectancy in the swarming population, fractures of the shaft of humerus are increasingly becoming common.[1]

Traditionally various methods were used to treat shaft of humerus fractures. Many of the fractures can be effectively treated conservatively, whereas, internal fixation has the advantage of early mobilization and reduced chances of malunion. These are chosen according to the fracture pattern, age, duration and other factors. Open reduction internal fixation with plating has the risk of devitalising the fragments due to excessive tissue dissection. Minimally invasive anterior bridge plating (ABP) holds promise as the fracture site is bypassed and there is only minimal insult to soft tissues and bones due to surgical dissection.[2] These two techniques hold promise for effective management of shaft of humerus fractures. This randomized controlled study is taken up with primary objective of comparing the outcome of these two techniques.

II. Material And Methods

This prospective randomised controlled trial study was carried out for a total of 40 cases of shaft of humerus fractures attending the OPD and Emergency department of Orthopaedics, Gauhati Medical College & Hospital, during the period fromApril 2018 to August 2019, who meet the inclusion and exclusion criteria outlined below. All the cases were followed up for a minimum period of six months. The patients were divided into two groups of 20 patients each according to randomization done using the plan generated from the website *www.randomization.com* to allocate the patient into one of the following two treatment methods: 1)Anterior Bridge Plating (ABP) and 2) ORIF with plating through posterior approach.

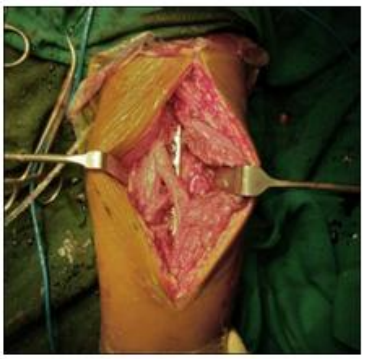
All closed humeral shaft fractures less than 2 weeks old in skeletally mature patients of either sex, without neuro-vascular deficit and associated fractures of the affected limb were included in the study, provided the patients met the medical standards for routine elective surgery.All patients were operated under general or regional anaesthesia. For Anterior bridge plating (ABP), the patients were placed in the supine position with the arm resting on a radiolucent side table, with the forearm in full supination. Patients undergoing ORIF through posterior approach were placed in the lateral decubitus position with the arm supported in an arm rest with elbow flexed at 90° and hanging at the end of the arm rest.

The operative procedure forAnterior bridge plating (ABP):

The fracture site of thehumerus is confirmed with the image intensifier and the incision locations are determined and marked.A 3cm proximal incision is made approximately 6 cm distal to the anterior part of acromion process between lateral border of proximal part of biceps brachialis muscle, and the medial border of deltoid muscle. Deltopectoral approach used for the proximal incision and the dissection is carried down to the bone.Distally, a 3 cm incision is made along lateral border of biceps muscle approximately 5 cm proximal to flexion crease of elbow.The interval between biceps brachii muscle and brachialis muscle is identified; the biceps is retracted medially to expose the musculocutaneous nerve lying on the anterior surface of brachialis.The brachialis is then split longitudinally along its midline to reach the periosteum of anterior cortex of the distal humerus.The musculocutaneous nerve is retracted together with medial half of split brachialis, while the lateral half serves as a cushion to protect radial nerve. A sub-brachialis extraperiosteal tunnel is then created by blunt dissection by passing a periosteum elevator, used as a tunneling instrument, from the distal to proximal window.Through this tunnel a long narrow 4.5 mm LCP or DCP is inserted from proximal incision, passing over fracture site and down to distal incision.The plate and reduction is visualized on image intensifier. Manual traction is applied to restore length and correct varus/valgus angulation and rotation.The plate is temporarily fixed to the bone with 2mm K- wires.After ensuring that the position of plate in the distal fragment is central, it is fixed with a cortical/locking screwand, similarly, the proximal fragment is also fixed.After confirming the reduction alignment, the fixation is completed with a minimum of two cortical screws in both the fragments and K- wires removed.

Incisions for ABP

Insertion of plate



ORIF through post. approach

The procedure for ORIF through posterior approach was done in the usual manner by identifying the gap between the lateral and long heads of triceps, radial nerve identified, fracture reduced and fixation done using 4.5mm LCP/DCP.

Statistical analysis:

The statistical analysis of data was performed usingthe computer program, Statistical Package for Social Sciences (SPSS for Windows, version 20.0. Chicago, SPSS Inc.) and Microsoft Excel 2010. Results on continuous measurements are presented as mean ± standard deviation are compared using student t test. Discrete data are expressed as number (%) and are analysed using Chi square test and Fischer's exact test (where the cell counts were <5 or 0). Pearson's correlation coefficient (r) was used to measure the associations among continuous variables. For all analyses, the statistical significance was fixed at 5% level (p value <0.05).

III. Results

40 skeletally mature patients with shaft of humerus fractures were chosen for the study and randomly allocated into two of the following treatment groups according to the randomization table.

1. Fixation of the fracture by Anterior Bridge Plating (ABP) (n= 20)
2. Fixation of the fracture by Open Reduction and Internal Fixation by posterior approach (ORIF) (n= 20)

All patients were followed up for a minimum period of six months. Follow up was carried out at 2,4, 6, 12, 24 weeks and then at 3 monthly intervals. Full assessment was done at the end of 6 months from the date of operation in all cases.

The fractures were classified as per the AO classification. There were 4 type A1; 15 type A2 and 13 type A3; 4 type of B3; 3 type of C2 and 1 type of C3 fractures in our study. Most of the fractures were A2 having simple oblique fracture in the diaphysis (Tables 1,2; Fig. 1).

Most of the cases (60.0%) were operated within 3-7 days following injury. The mean time intervalbetween surgery and trauma was 5.3 days.In the ABP group the mean interval was 4.6 days and in posterior ORIF group, it was 4.8 days. On statistical analysis p value was found to be 0.7470, which is statistically insignificant (Table: 3, Fig:2).In our study, 28 cases were done under regional anaesthesia and rest of the cases were done under general anaesthesia.

Table1:Fracture Types (AO/ASIF)

AO CLASSIFICATION	NO OF FRACTURES	PERCENTAGE
TYPE 12A1	4	10
TYPE 12A2	15	37.5
TYPE 12A3	13	32.5
TYPE 12B3	4	10
TYPE 12C2	3	7.5
TYPE 12C3	1	2.5
TOTAL	40	100

Fig 1: AO/ASIF Classification

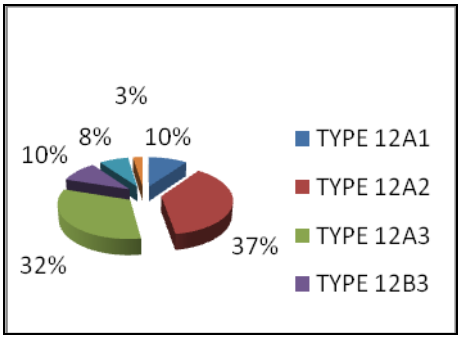


Table 2: Fracture distribution in the 2 groups

FRACTURE SUBCLASS	ABP	ORIF	TOTAL
TYPE 12A1	2	2	4
TYPE 12A2	8	7	15
TYPE 12A3	7	6	13
TYPE 12B3	1	3	4
TYPE 12C2	1	2	3
TYPE 12C3	1	0	1
TOTAL	20	20	40

χ^2 = 2.477, P value = 0.780 (NS)

Fig 2: Graph showing fracturedistribution in the 2 groups

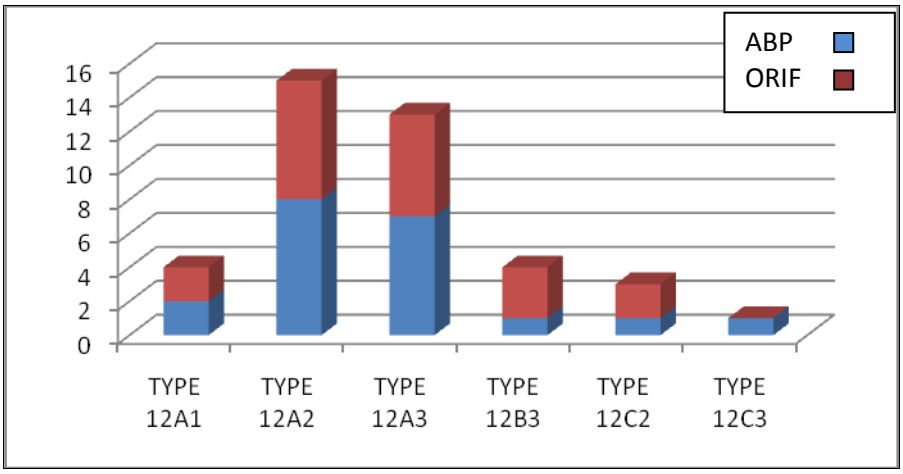
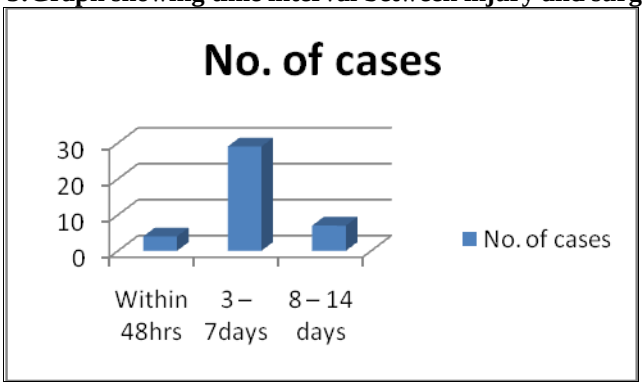


Table 3: Time interval between injury and surgery

Time interval	No. of cases	Percentage
Within 48hrs	4	10.0
3 – 7days	29	72.5
8 – 14 days	7	17.5
Total	40	100

Fig 3:Graph showing time interval between injury and surgery



The criteria of Anderson et al (1975) were taken into account to assess the union of the fracture. A fracture was defined as healed when there was obliteration of fracture line and evidence of bridging trabeculae. Accordingly, all of the fracturesin both the study groups united without the need for a second procedure before 6 months. Thus the union rate was 100% in both the groups.The average time taken for union in ABP group was 12.85 weeks and that for posterior ORIF group was 13.30 weeks.

Table 4: Fracture union in the two groups(weeks)

Sl no.	ABP	Posterior ORIF
1	11	12
2	9	16
3	11	12
4	14	13
5	15	13
6	10	15
7	12	15
8	16	16
9	13	11
10	14	15
11	12	14
12	11	16
13	13	12

14	13	11
15	16	13
16	15	12
17	12	14
18	13	13
19	24	13
20	23	10

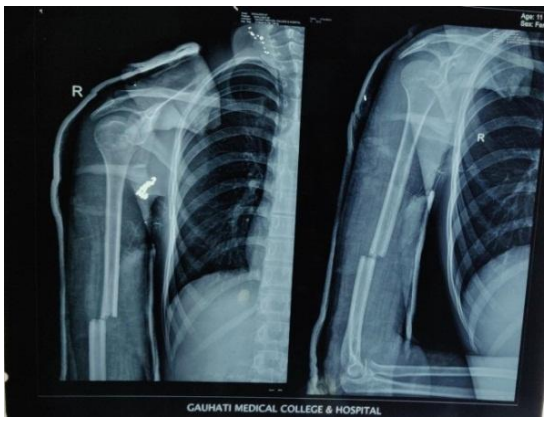
χ^2 = 14.02, P value = 0.7825 (NS)

The functional results were evaluated according to the DASH scoring system. The DASH questionnaire has thirty questions, the answers of which are graded from one to five points.The functional score is calculated by the formula:

DASH DISABILITY / SYMPTOM SCORE = {(sum of n responses)-1} X25N

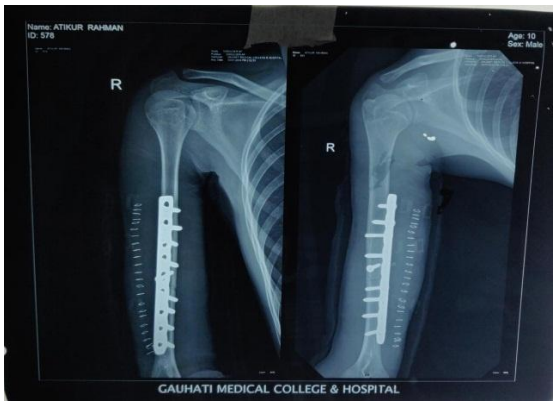
Where'N'is the number of responses. The best possible score is '0' and the worst possible score is '100'. The functional outcome decreases as the score increases.

Pre-operative x-ray(ABP)



Pre-operative x-ray (ORIF)

Immediate post-operative x-ray (ABP)



Immediate post-operative x-ray (ORIF)

8 weeks followup (ABP)

16 weeks follow up(ORIF)

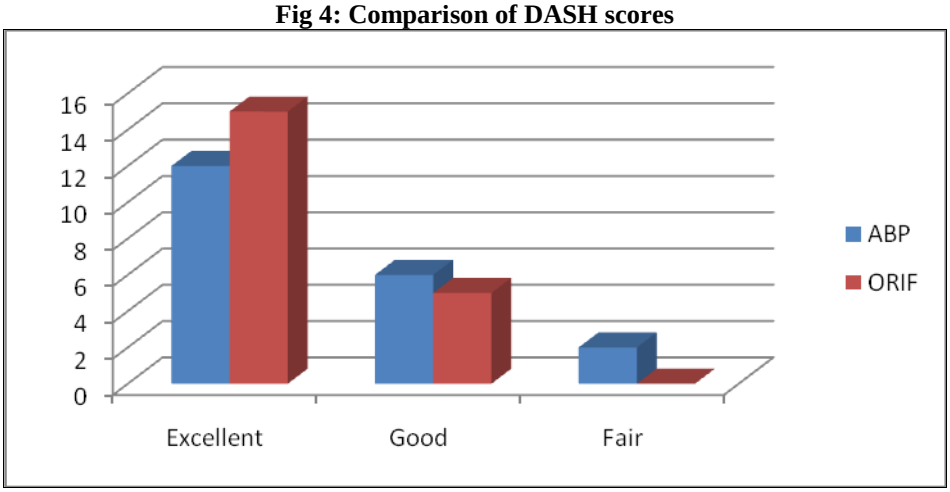
The results were then graded as excellent, good, fair and poor as follows:
Excellent – 0 to 20 points.
Good – 21 to 40 points.
Fair – 41 to 60 points.
Poor – Greater than 60 points

Table 5: Comparison of DASH scores

Results	Group		Total
	ABP	Posterior ORIF	
Excellent	12	15	27
Good	6	5	11
Fair	2	0	2
Total	20	20	40

χ^2 =0.456, p=>0.05, not significant

Fig 4: Comparison of DASH scores



DASH scores of 0 to 20 was taken as excellent, 21 to 40 good, 41 to 60 was taken as fair and above 61 was taken as poor. The average DASH score of the whole series was 34.1 (Lower the DASH score better the function). The average DASH score in the anterior bridge plating group was 26.10 and in the posterior group it was 19.85. The results were statistically not significant with p value of 0.4082.Among the 40 patients 27 had excellent results, 11 had good and 2 had fair results.

All the patients were followed up at regular intervals and checked for early and late complications. Following were the complications noted at the end of six month follow up. Within this study period we found 2

cases of implant loosening in the ABP group which lead to implant failure later on. Both these cases were operated with DCP. There was loosening of the screws in the distal fragment and partial failure of the plate in both these fractures. There were 5 cases of radial nerve palsies (12.5%) seen in our study sample. 4 recovered during follow up and 1 radial nerve palsy not yet recovered and under follow up. One case of the posterior ORIF with plating group was found to have gross restriction of shoulder movement.Therefore a total 8 complications were seen in our series of 40 shaft of humerus fractures.

CLINICAL PHOTOS OF ANTERIOR BRIDGE PLATING

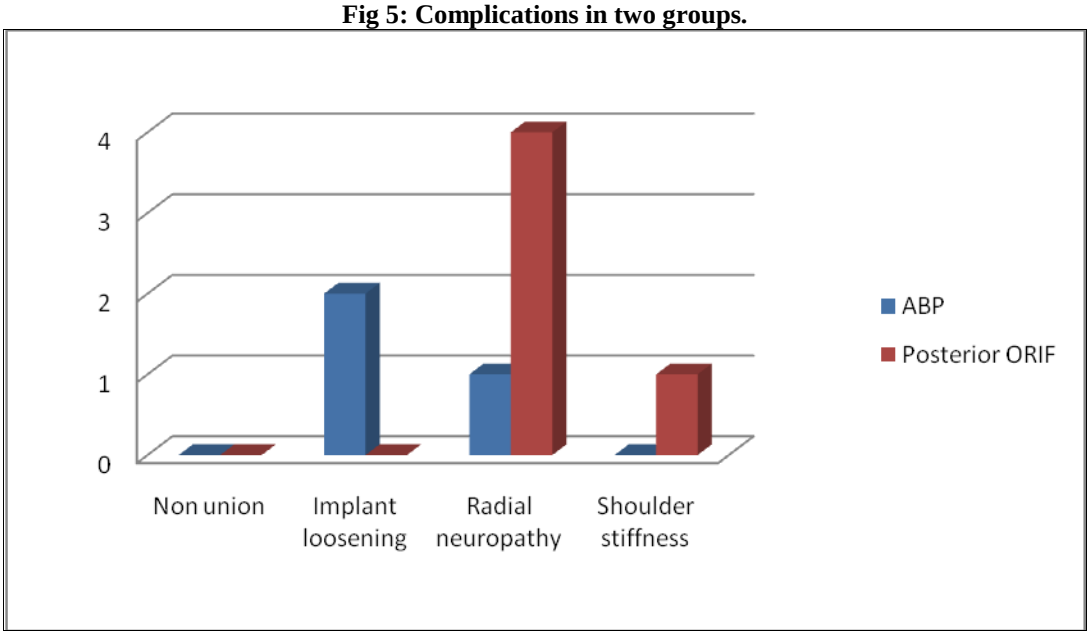
CLINICAL PHOTOS OF ORIF BY POSTERIOR APPROACH

Table 6: Complications in the two groups.

COMPLICATIONS	ABP	Posterior ORIF	TOTAL (%)
Nonunion	0	0	0
Implant Loosening	2	0	2(5%)
Radial neuropathy (Nerve palsies)	1	4	5(12.5%)
Shoulder stiffness	0	1	1(2.5%)
TOTAL	3	5	8(20%)

P value= 0.1778 (Not significant)

Fig 5: Complications in two groups.



IV. Discussion

In the present study, forty cases of diaphyseal fractures of humerus were selected and surgically managed by DCP/LCP osteosynthesis. The purpose of the study was to evaluate the outcome of the management of diaphyseal fractures of humerus by ABP or posterior ORIF.Using a prescribed format, the data was collected, assessed, analyzed and compared with other series and the following observations were made.

In our study 20(50%) patients were approached anteriorly and 20 (50%) posteriorly.

Table 7: Approaches used for surgery

Studies	Anterior MIPO	Posterior ORIF
An et al. (2010)[3]	51.5%	48.4%
Oh et al. (2012)[4]	49.1%	50.8%
Wang et al. (2015)[5]	47.9%	52.0%
Esmailiejah et al. (2015)[6]	49.2%	50.7%
Kim et al. (2015)[7]	52.9%	47.05%
Lian et al. (2013)[8]	51.06%	48.93%
Present study	**50%**	**50%**

Out of 40 cases, 38(95%) fractures united and 2 cases went for delayed union due to implant failure. The results in the present study are comparable to those obtained by various other studies. On statistical analysis, the p-value was found to be 0.782, which is statistically not significant.The functional results were evaluated according to DASH scoring system. The scoring system has 150 maximum possible scores. 95% of the patients had good or excellent outcomes which correlates to the other mentioned studies.

Table 8: Fracture union rate obtained in various studies

Studies	Total number of patients	Delayed union	Non- union	Overall union
Bell MJ et al. (1985)[8]	34	-	1 (3%)	33 (97%)
Griend RV, Tomasin J, Ward EF et al. (1986)[10]	36	5(14.6%)	1 (3%)	35 (97%)

Heim D et al. (1993)[11]	127	-	2 (1.5%)	125 (98.5%)
Rodriguez-Merchan EC (1995)[12]	20	1 (5%)	-	20 (100%)
Tingstad EM et al. (2000)[13]	83	-	5 (6%)	78 (94%)
McCormack RG et al. (2000)[14]	21	-	3 (12%)	41 (88%)
Gongol and Mracek D (2002)[15]	32	-	1 (3.1%)	31 (96.9%)
Changulani M et al (2007)[16]	24		3 (12%)	20 (85.7%)
Kulkarni et al. (2017)[17]	33	-	-	33(100%)
Longxiang Shen et al. (2012)[18]	43	-	4	39(90.6%)
Present study	**40**	**2(5%)**	**-**	**40 (100%)**

There were 5 cases of radial nerve palsies (12.5%) seen in our study sample out of which 4 recovered during follow up within 3 months and 1 radial nerve palsy yet to recover and under follow up. Seddon in 1975 stated that 70% of radial nerve injuries associated with humeral shaft fractures will recover, the recovery rate in our study was 80%.

Table 9: Results obtained in various studies

Studies	Total number of patients	Good / Excellent outcome
Bell MJ et al. (1985)[9]	34	91.2%
Heim D et al. (1993)[11]	127	87.3%
Rodriguez-Merchan EC (1995)[12]	20	95%
Dayez J (1999)[19]	36	89%
Tingstad EM et al. (2000)[13]	83	94%
McCormack RG et al. (2000)[14]	44	95.7%
Changulani M et al. (2007)[16]	24	87.5%
Jayant Sharma et al. (2015)[20]	11	81.8%
Sang Jin Shin et al. (2012)[21]	21	85.7%
Present study	**40**	**95%**

The results of various studies showed that the overall result varied from 85% to 100% good to excellent outcome. In the present study, the final result was 95% good or excellent outcome, according to DASH scores which was comparable with the other studies conductedpreviously

The causes of poor results were two non-union and one radial nerve palsy. These were preventable and could be avoided by following proper surgical principles, attention to asepsis, patient education and good postoperativerehabilitation.

V. Conclusion

Fractures of the shaft humerus are one of the common fractures affecting present generation and treatment modality has to be decided carefully.We are of the opinion that the operative treatment of the humerus fractures should be done in patients with polytrauma and in patients with failed conservative treatment. Both the modalities of treatment i.e. minimally invasive anterior bridge plating and posterior ORIF with plating are good as far as union of the fracture is concerned. Considering the overall results, we are of the opinion that anterior bridge plating is a better option than posterior ORIF with plating, in terms of minimal soft tissue dissection, preservation of fracture haematoma, no periosteal stripping, minimal operative site scar, earlier union rate and less complications of radial neuropathy. We therefore conclude anterior bridge plating would be a preferable mode of fixation compared to ORIF with plating by the posterior approach in diaphyseal fractures of the humerus.

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