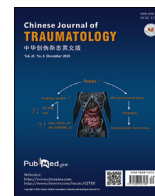




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## Original Article

## Plating the radial shaft on the lateral surface: An outcome study

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## ABSTRACT

**Purpose:** Plate fixation is the gold standard for the treatment of displaced forearm shaft fractures in adults. Conventionally radial shaft fractures will be plated either on the volar surface or on the dorsal surface depending on which approach has been chosen. The lateral surface of the radius provides an even and uniformly curved area for placing a plate. It has the advantage of restoring and easy assessing the radial bow after surgery. We designed a prospective study to observe the outcome of lateral plating of radius shaft fractures.

**Methods:** Nineteen patients were included in this study performed in Government Medical College, Jammu, India. Among them, 13 had fractures of both the forearm bones and 6 had isolated radial shaft fracture. Three patients had Galeazzi fracture dislocation. Fixation was done within 36 h of injury in all using 3.5 mm limited contact dynamic compression plate or locking compression plate applied to the lateral surface of the radius. Ulna was fixed in routine manner.

**Results:** Union was achieved in 18 out of 19 patients, after a mean time of 17.44 weeks. According to Anderson et al.'s criteria, 12 patients had excellent results, 5 had satisfactory and 1 had unsatisfactory result. There was one failure (nonunion).

**Conclusion:** The outcomes including rate of union were comparable to those in the existing literature. Plating the radial shaft on the lateral surface is a viable alternative to volar or dorsal plating of the radius. Larger studies with randomized data are needed to assess whether it has any superiority over other existing techniques.

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## Introduction

Forearm fractures are common orthopaedic injuries, accounting for about 1% of all fractures in adults.<sup>1,2</sup> In the presence of significant deforming muscle forces, it is very difficult to maintain an acceptable alignment in these fractures by non-operative methods.<sup>3,4</sup> All displaced, unstable fractures of the radius and ulna in adults are therefore, best treated with internal fixation preferably with plates.<sup>5–9</sup> Plating has traditionally been done on the radius either on the dorsal or on the volar surface, using dorsal (Thompson) or volar (Henry) approaches respectively.<sup>10–13</sup>

Forearm shaft fractures are considered articular injuries. Non-anatomic reductions affect the mechanics of the interosseus membrane (considered the third joint between the radius and

ulna), leading to forearm stiffness or instability. During rotational movements, the radius rotates around the relatively immobile ulna. For the rotational movement to proceed smoothly, the ulna has a relatively straight form, but the radius has a more pronounced curve.<sup>14</sup> In most part, the radius is curved laterally and slightly posteriorly. In 1959, Sage<sup>15</sup> pointed out the importance of maintaining the curves of the radius, particularly the lateral bow. The argument was later confirmed by Schemitsch and Richards,<sup>16</sup> who concluded that a good functional outcome after fixation of radius fractures was associated with restoration of the normal amount and location of the lateral bow.

Most authors have reported excellent results with dorsal or volar surface plating of the radius. It is an unmistakable observation that in the conventional method of plating on the volar or dorsal surface, some part of the plate has to remain off the bone in order to maintain the bow of the radius. This is a direct consequence of using a straight plate on a curved surface (Fig. 1A). Also, the dorsal and volar surfaces have significant muscle cover and are not completely uniform. We felt that the third (lateral) surface of the

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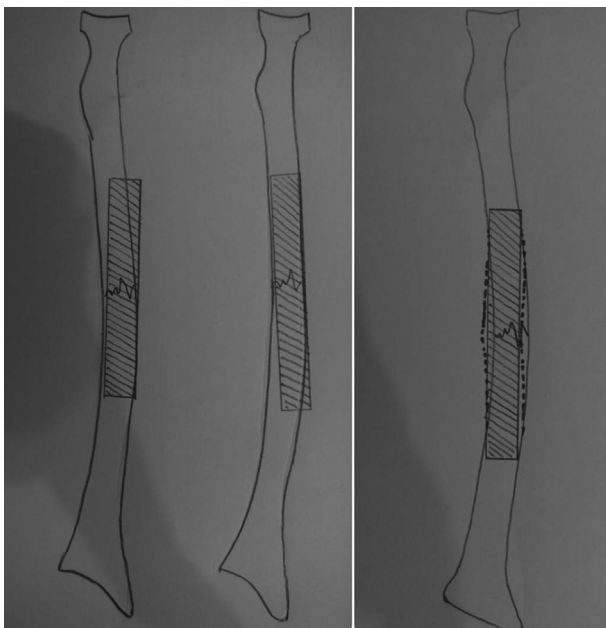
**Fig. 1.** An example shows seating a straight plate on the dorsal and lateral radius. A: Plate placed on dorsal aspect of radius will remain off the bone at one end because of the lateral bow. On the right is a plate placed on the volar surface, which again has a gentle dorsal curve, and the plate will remain off not only at one end, but also in the middle. B: The lateral surface is uniformly convex and the plate can easily be molded.

radius was underused, and could provide an alternate surface for plate fixation with its own advantages.

The lateral surface is uniformly convex, unlike the variable contour of the volar and dorsal surfaces in addition to their curvature in the coronal plane (Fig. 1B). As mentioned previously, placing a straight plate on this curved anterior or posterior surface leads to the plate being off the bone partly. This is especially true for smaller radii, as seen in the average Asian population. We also observed that in the enthusiasm to seat the plate on the bone all along, some malreduction and consequently distortion of the radial bow is possible (Fig. 2). We think that such subtle distortions may escape intraoperative detection, being concealed by the plate, and then

again on postoperative anteroposterior (AP) radiographs due to superimposition of the plate on the fracture site.

There is also evidence that injury to the nutrient artery, which enters the radius anteriorly, leads to delay or failure of fracture healing.<sup>17</sup> Hence there may be some merit to avoid the volar surface for plate application. Furthermore, several texts and published manuscripts described volar and dorsal plating of the radius, but illustrative examples showed that the plate was placed on the lateral surface. Thus, lateral surface plating seems to be done every once in a while but is not reported. The idea for this study was thus conceived. We considered it worthwhile to assess the clinical and radiologic outcome of plating radial shaft fractures on the lateral surface in adults.<sup>18–21</sup>



**Fig. 2.** Seating the plate on the dorsal or volar surface can leave the plate off proximally or distally, especially in smaller radii. In an effort to bring both fragments under the plate, sometimes the anatomy is distorted as marked in the figure on the right.

## Methods

The study was a prospective case series conducted between September 2014 and March 2016, in the orthopaedic department of a regional teaching hospital. Prior approval was obtained from the

**Table 1**  
General data of patients.

Variables	
Male/Female	15/4
Age (years)	36.23 (18–61)
Injury	
Fractures of both the forearm bones	13
Isolated radial shaft fracture	6
Fracture type	
Closed	17
Open	2 (a grade I and a grade II)
Mode of trauma	
Motor vehicle accident	8
Fall on the hand	8
Assault	2
Torsional injury <sup>a</sup>	1
Affected level of radial shaft	
Upper third	2
Middle third	17

Note: Two of the patients with isolated radius fracture and one with both bone fracture had distal radio-ulnar joint disruption (Galeazzi fracture dislocation).

<sup>a</sup> This injury is due to loss of control over heavy drilling equipment.

**Table 2**  
Anderson et al.<sup>6</sup> criteria for assessment of functional outcome.

Result	Union	Flexion/extension at wrist	Supination/pronation
Excellent	Present	<10° loss	<25% loss
Satisfactory	Present	<20° loss	<50% loss
Unsatisfactory	Present	<30° loss	>50% loss
Failure	Nonunion with or without loss of motion		

Institutional Ethics Committee. Subjects were chosen from adult patients with forearm fractures attending the emergency department, after consenting them for the procedure. Patients below 18 years of age, open grade 3 fractures, and fractures with preoperative neurovascular deficits, compartment syndrome or other major ipsilateral upper limb injuries were excluded. Nineteen patients fulfilled the inclusion criteria, of whom 15 were males and 4 females. The mean age of the patients was 36.23 years (18–62 years). Detailed data of patients are shown in Table 1.

All the patients were operated upon within 36 h of injury. The radius was approached first in most cases. In the first 3 cases, radius was approached from the volar side (Henry, 1 case) or dorsally (Thompson, 2 cases). Thereafter, we developed a direct lateral approach to the radius, using the interval between the brachioradialis and the extensor carpi radialis longus; this was subsequently used in all the remaining cases. In proximal fractures, care was exercised to protect the posterior interosseus nerve by elevating the supinator. Fixation was done using a 3.5 mm limited contact dynamic compression plate (LC-DCP) or locking compression plate (LCP), depending on the mode of plating. After reduction of the radius, a template was used to assess the lateral bow, and the plate was contoured accordingly before being placed on the lateral surface. Thereafter fixation was done in routine manner with 3 bicortical screws on both sides of the fracture. The distal radioulnar joint (DRUJ) was assessed in Galeazzi type injuries and addressed accordingly. In patients with comminuted radius, the ulna was fixed first. Closure was done in routine manner.

Postoperatively, a long arm plaster splint was used in patients with DRUJ disruption for six weeks. In those without DRUJ injury, no postoperative immobilization was used; and active hand, wrist and elbow exercises were encouraged from the first postoperative

day. Antibiotics were given for three days, and only one dressing change done on the third day. Stitches were removed at 2 weeks in the clinic. Activity was gradually increased depending on patient comfort, and the patients were followed up clinicoradiologically at 4 week intervals for the first three months and at 6 week intervals thereafter till union. Final follow-up was done at an averaged 6 months following surgery and the scoring done at this time.

Union was assessed by gradual disappearance of the fracture line and/or development of bridging callus at the fracture site. Functional outcome was determined using Anderson et al.'s<sup>6</sup> criteria (Table 2, Figs. 3–5).

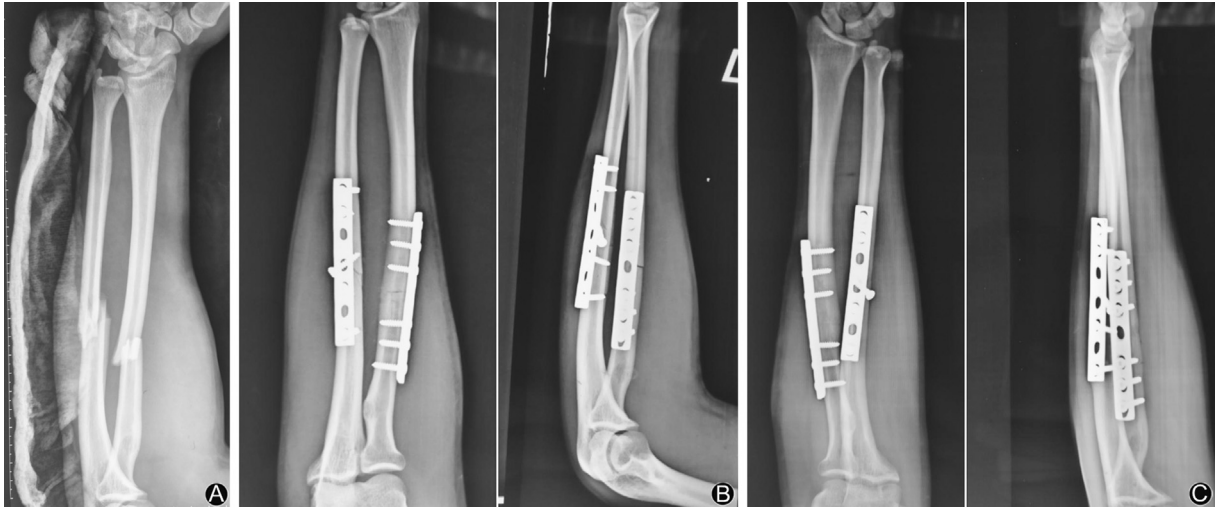
## Results

Fixation was done within 36 h of injury in all the cases. LC-DCP (3.5 mm) was used for compression/neutralization plating of the radius in 16 cases, and 3.5 mm LCP used for bridge plating in 3 radii. Primary bone grafting was done in 1 patient with severe comminution of the radius, while delayed bone grafting was done at 18 weeks in another patient with delayed union of the radius. There was one case of nonunion of the radius who was asymptomatic, and despite repeated counseling the patient refused revision surgery. At one year follow-up, he had intact implant and excellent function, but was classified as a failure according to Anderson et al.'s<sup>6</sup> criteria.

There was no case of ulnar nonunion. The mean time to union of both bones was 17.44 weeks (10–28 weeks). The mean arc of elbow flexion was 136.7° (127°–142°), and that of the wrist was 140.1° (130°–145°). The mean arc of rotation of the forearm was 129.6° (64°–152°). There were no nerve or vessel injuries, and no infections in this series.



**Fig. 3.** A case of an 18 years old male. A: Preoperative radiograph, and immediate postoperative AP and oblique radiographs. The radius was approached dorsally, and the plate placed laterally after a lag screw. B: Follow-up AP, lateral and oblique radiographs at 4 months showing healed fractures.

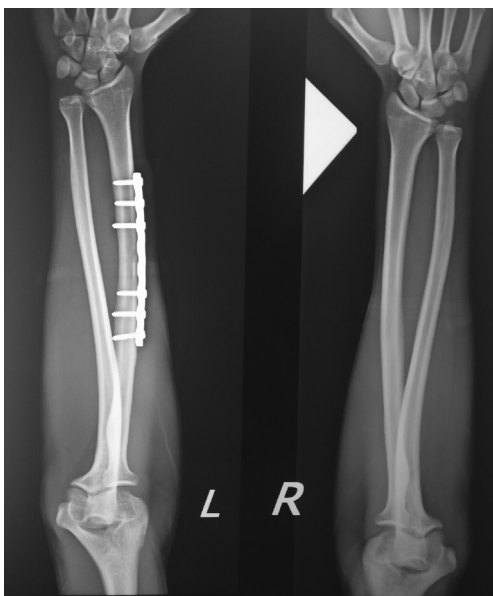


**Fig. 4.** Another case. A: Preoperative radiograph showing radial shaft fracture in the proximal third. B: Immediate post operative AP and lateral radiographs after compression plating of the radius on the lateral surface. The approach used here was a direct lateral. C: Follow up radiographs showing union by primary fracture healing (no callus).

According to Anderson et al.<sup>6</sup> criteria, 12 patients had excellent results, 5 had satisfactory and 1 unsatisfactory result. There was one failure (nonunion). The profile and outcome of all patients is summarized in Table 3.

## Discussion

The surface to plate the radius is almost always decided by the choice of surgical approach. Thus surgeons favoring the dorsal approach carry out plate fixation on the dorsal surface, and those favoring the volar approach on the volar surface of the radius. By far, the debate has always been over the preferred approach<sup>22–24</sup> and the choice of surface been deemed obvious (dorsal or volar). It was felt that there is an equally accessible third surface which is unexplored and not routinely plated on.



**Fig. 5.** Comparative AP radiographs of both forearms of a man with laterally plated radius on one side. Note the beautifully healed fracture with identical radial bow on both sides.

The volar surface of the radius is convex in the proximal part, with an average apex anterior curvature of  $13.1^\circ$  and concave in the distal part with curvature of  $6.4^\circ$ .<sup>15</sup> This corresponds to similar opposite curvatures of the dorsal surface. When the natural radial bow of the radius is added to this, we are faced with the situation of having to address two plane curvatures with a single straight plate (Fig. 1A), which creates potential for error and malreduction. Furthermore the assessment of the radial bow is frequently obscured by the plate in the post-operative anteroposterior radiographs.

As against this, the lateral surface is uniformly curved (representing the lateral bow), and relatively more even than the dorsal and volar surfaces. It thus becomes easier to recreate the radial bow when plating on the lateral surface. The cross section of the radius is triangular in most of its length, except in the proximal-most part. Screws placed through a lateral plate get far cortex purchase in the interosseus border which is thick and strong. This screw orientation also avoids potential irritation of tendons from dorsally protruding screw tips.

There are also concerns about biceps tendons impingement from a high volar plate and Mekhail et al.<sup>25</sup> suggested lateral plating through a volar approach. Another point of interest is the potential injury to the nutrient artery of the radius while plating on the volar surface. The nutrient vessel enters the radius in the second proximal quarter of the diaphysis from anterior to medial.<sup>26</sup> It has been argued by several authors that although the periosteal and metaphyseal vessels maintain blood flow to the bone after injury to the nutrient artery, it is not enough to avoid disturbances in fracture healing.<sup>27–29</sup> According to Giebel et al.,<sup>17</sup> the dorsolateral surface of the radius is always free of the nutrient foramen, and thus plating here is advantageous. They stated that lesions of the supplying vessels of the bone are not recognized for weeks or months after surgery and when fracture healing fails, other circumstances are often blamed.

The idea of lateral plating may not necessarily be new. As mentioned before, there have been illustrative examples in the form of radiographs present in the literature. However, to the best of our knowledge, the results of lateral surface plating are hitherto unreported. Our series was an attempt to fill this void. We compared our results with the existing literature on dorsal and volar plating and found that they were largely comparable. The average rate of union in our series was 94.73% (18 out of 19 cases).

**Table 3**  
Patient distribution and outcomes.

Patient No.	Age/sex	Injury	Mode of injury	Time to union (weeks)	Elbow arc (°)	Wrist arc (°)	Rotations (°)	Outcome (Anderson et al.)
1	33/M	Both bones fracture with DRUJ disruption	MVA	18	141	130	64	Unsatisfactory
2	60/M	Fracture radius	Fall	14	140	143	150	Excellent
3	28/M	Fracture radius	MVA	10	137	145	145	Excellent
4	22/M	Open fracture Bone bones	MVA	22	135	137	116	Satisfactory
5	42/M	Both bones fracture	Fall	16	138	140	136	Excellent
6	27/M	Both bones fracture	MVA	14	135	141	146	Excellent
7	30/M	Both bones fracture	Fall	18	140	142	113	Satisfactory
8	55/F	Both bones fracture	Fall	20	132	138	117	Satisfactory
9	62/F	Fracture radius	Assault	16	130	141	114	Satisfactory
10	45/M	Both bones fracture	Torsional injury	20	137	143	152	Excellent
11	46/M	Fracture radius	Fall	14	140	140	142	Excellent
12	36/M	Both bones fracture	MVA	28 (18 + 10)	127	133	111	Satisfactory
13	37/F	Galeazzi fracture dislocation	Fall	18	135	140	134	Excellent
14	43/M	Galeazzi fracture dislocation	Fall	16	140	143	137	Excellent
15	18/M	Both bones fracture	MVA	18	142	142	141	Excellent
16	23/M	Both bones fracture	MVA	14	140	145	134	Excellent
17	25/M	Both bones fracture	MVA	20	135	143	148	Excellent
18	22/M	Both bones fracture	Fall	18	137	141	143	Excellent
19	35/M	Both bones fracture	Assault	Non union	138	136	120	Failure
Mean				17.44	136.7	140.1	129.6	

Chapman et al.<sup>30</sup> reported a union rate of 90% in their series; Anderson et al.<sup>6</sup> reported 98% and Hadden et al.<sup>31</sup> 97%. The mean time for union in our patients was 17.44 weeks, while Leung and Chow<sup>8</sup> stated 20 weeks and Saikia et al.<sup>18</sup> 16.2 weeks. The elbow and wrist arcs of flexion/extension were 136.7° and 140.1° respectively; the average arc of forearm rotation was 129.6°. These figures compare favorably with those of Goldfarb et al.<sup>32</sup> whose wrist arc 140.1° and rotation 150°. The seemingly less rotation in our patients can be explained by the fact that the range of rotation in the contralateral normal forearm in our patients was 150°–160°, whereas Goldfarb et al.<sup>32</sup> in their series has documented a pronation of 85° and supination of 95° (total arc 180°) as normal. Overall we had 88.4% (17 of 19) excellent and satisfactory results, whereas others reported 86%, 92% and 80% excellent and satisfactory results in their respective series.<sup>6,30,31</sup> Thus our overall patient outcome is comparable to that reported in the literature. We faced one case of nonunion in 19 patients; though the patient was counseled for a second procedure he refused, and at the last follow-up (14 months) the patient had a pain-free full range of motion. We did not encounter any case of nerve injury or infection in our series. Chapman et al.<sup>30</sup> reported nonunion in 2% and infection in 2.3% of his patients. Hadden et al.<sup>31</sup> reported nonunion in 3%, infection in 5.4%, and nerve injury in 6.3% of his 111 operated forearms.

In our search through the literature, we did come across a paper describing lateral surface plating by Eglseder et al.<sup>33</sup> Theirs was however, an ex-vivo biomechanical study, and they concluded that a significant biomechanical difference did not exist between anterior and lateral plating of the distal radial shaft. And although they expressed their preference for volar plates because of “ease of application”, we are of the opinion that lateral plating is as much or even more convenient as volar plating, particularly when using the lateral approach that we have described.

Despite the utility of this technique, our study has some weaknesses. The possible effect of lateral plating on the subtle posterior curve of the radius has not been studied. Our follow-up period is short, and we did not operate on any patient for removal of the plate, thus the course after removal of a lateral plate is not known. In a few patients the radial plate was felt palpable in its distal part; however none of the patients complained of symptoms. The theoretical possibility of late hardware symptoms exists. Our sample size is also small and therefore, the clinical utility of this technique needs to be further established by larger and preferably

randomized studies. Ours can be considered as an initial report on the results of plating the radial shaft laterally.

To summarize, lateral plating of the radius is a viable alternative to the conventional techniques. Further long term studies with larger patient numbers and parameters of study are needed to confirm our results, and establish its proposed advantages.

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