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A comparative study between variable and fixed angle volar locking plates in management of unstable intra-articular distal radius fractures

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ABSTRACT

Background: The current study is conducted to assess and compare the radiological and functional outcomes between variable and fixed angle volar plating in unstable intra-articular distal radius fractures.
Methods: A prospective study was conducted from May 2018 to May 2020. A total of 156 patients were randomised into two groups A and B of 78 patients each. The plates were T or oblique fixed angle volar plate in group A and variable angle volar plate in group B. Patients were followed up for minimum 12 months. The functional outcome was measured by patient rated hand wrist evaluation score (PRHWE) and radiological outcome by radial height, volar tilt and radial inclination. The secondary objective was to correlate complications.
Results: In our study average PRHWE score was better in group B ($p<0.05$). Radial height, volar tilt, radial inclination was much closer to anatomical wrist radiology was seen in group B. The most common complication was finger and wrist stiffness in group A.
Conclusions: Patients treated with variable angle volar plate showed better results in functional and radiological outcomes at 12 months follow-up but limitations include short duration of follow up.

Keywords: Distal radius fractures, PRHWE score, Variable angle volar plate, Fixed angle volar plate

INTRODUCTION

Fractures of the distal end radius are the most common fracture of upper extremity fracture.[1] In 1814 Abraham Colle's described most common pattern of distal end radius fracture and is eventually named after him.[2] Colle's fracture is an extra-articular injury of cortico-cancellous junction (within 2-3 cm of articular surface) of distal radius. Barton's fracture is displaced intra-articular fracture in coronal plane. They have Bi-modal distribution intra-articular fractures of distal end radius are due to high-energy trauma occurring in young adults whereas extra-articular distal end radius fractures are common in geriatric patients caused by fall on outstretched hand (FOOSH).[3.] The closed reduction of unstable and comminuted intra-articular distal end radius fractures leads to permanent deformity, residual pain and loss of normal function due to loss of articular incongruity, palmar tilt, radial shortening.[4] There are various treatment options for intra-articular distal end radius fractures like external fixation, percutaneous pinning, open reduction and internal fixation by volar or dorsal approach. In unstable comminute fractures open reduction and internal fixation by volar plates have shown better results.[5.] External fixation also approved in treatment of intra- articular distal end radius fractures.[6]The external fixation has got high incidence of pin tract problems and difficulty in maintaining articular congruence.[7]

As per recent advances to maintain perfect articular congruity lead to development of first generation dorsal plates but resulted in complications like tendon rupture and

dysfunction, that prompted to development of volar fixed angle plates.[8] In bio-mechanical studies placement of distal screws is important in maintaining articular congruity.[9] Loss of hand function for most patients such as labourers, carpenters, musicians, surgeons and others implies loss of career.[10] And unstable fractures of the distal radius remain challenging problem for orthopaedic surgeons, there are increasing evidence of unsatisfactory results in maintaining radial length and radial inclination following reduction.[11] Variable angle volar plates can achieve better subchondral screw placement and provides better stability for the fracture fragments.[12] The main objective of this randomised prospective study was to compare functional outcome between fixed angle volar plate and variable angle volar plate in intra-articular distal end radius fractures by using PRHWE score and radiological outcomes between fixed angle volar plate and variable angle volar plate by radial height, volar tilt, and radial inclination.

METHODS

Included all 156 patients of both sexes admitted in all hospitals attached to Tertiary care centre between May 2018 to May 2020. Randomisation done by chit box method. The plates used were 3.5 mm T or oblique plates in group A and 2.7 mm variable angle volar locking in group B and a standard Henry approach was used in all patients. Study was started after approval from ethics committee. Indications for surgery included patients with unstable intra-articular distal end radius fractures AO type 23 B and AO type 23 C, patients of any sex in the age group of 18 to 65 years. Patients with pathological fractures were excluded. The study was conducted to analyse better outcomes with two groups. Collected data on wrist extension, palmar flexion, radial and ulnar deviation, forearm supination and pronation, grip strength. PRHWE score at 6 months and 12 months post-operatively. Radiographic assessment was made at 6 months and 12 months to assess consolidation or collapse at the fracture site. The fracture was considered united when clinically there was no tenderness, subjective complaint like pain, and radiologically when the fracture line was not visible in all orthogonal views. Arthritic changes were graded according to the system described by Knirk and Jupiter.

An unstable distal radius fracture was defined as possessing variables that, if present, would result in the fracture re-displacing into an unacceptable alignment even if a successful closed reduction were obtained. Variables of instability included any of the following criteria: dorsal comminution greater than 50% of the width of the dorsal cortex or any volar cortical comminution, initial dorsal angulation greater than 20, initial fracture displacement or translation greater than 1 cm, intra-articular disruption, and an associated ulnar neck or shaft fracture. Surgery was recommended to patients whose fractures could not be reduced successfully by closed means or whose fractures were displaced and had associated variables of instability.

Surgical procedure

All operations were performed under general anaesthesia in 31 cases and regional anaesthesia in 125 cases. All patients were placed supine on the operating table and pneumatic tourniquet was applied. All patients are given pre-operatively 1 gm of intravenous ceftriaxone. The volar radial approach which uses the interval between the flexor carpi radialis (FCR) and the radial artery was used (figure 1). An incision was made just radial to the FCR tendon and careful dissection protected the radial artery, which was retracted radially with brachioradialis. The pronator quadratus was elevated and cut from the radial surface of distal radius. Fracture fragments were reduced and locking volar plates of both groups applied (figure 2). Pronator quadratus muscle was used to close implant. The operational limb was supported with a below elbow POP slab with wrist in neutral position and the patient was encouraged to keep the hand elevated and initiate early finger motion. Patients were discharged on the 3rd post-operative day. At 2nd week sutures were removed, radiographs were taken and rehabilitation was initiated under the supervision of certified physiotherapist. From weeks 2 to 6 further range of motion exercises were continued with tendon gliding. After 6 weeks, the patient was re-evaluated and forwarded to progressive strengthening and resistance exercises. At 12 weeks post-operatively, the patient was re-evaluated and advanced to a work-hardening program depending on occupational needs. Further the range of wrist movements, any deformity and PRHWE score was assessed at 6th and 12th month follow up.

RESULTS

All 156 cases admitted reporting to emergency and outpatient department were considered for the study. Statistical analysis was performed with the SPSS, version 21 for Windows statistical software package (SPSS inc., Chicago, IL, USA). The categorical data was presented as numbers (%) and were compared among groups using Chi square test. The quantitative data was presented as mean and standard deviation and were compared by student's t-test. The mean age in fixed angle volar locking plate (group A) was 42 years and in variable angle locking plate (group B) was 40 years ($p>0.05$). Majority of patients in both the group were found in age group 19 to 30 years. In fixed angle volar locking plate 53 patients (67.95%) were male, 25 patients (32.05%) were females. In the variable angle volar locking plate 62 patients (79.49%) were male, 16 patients (20.51%) were females. Total male and female patients in our study were 115 and 41 respectively ($p>0.05$). In our study there were 32 cases (41.03%) of left sided involvement and 46 cases (58.97%) of right sided involvement in group A. In group B 22 cases (28.21%) of left sided involvement and 56 cases (71.79%) of right sided involvement were involved ($p>0.05$). Road traffic

accident (RTA) was the leading cause of fractures in 56 patients (71.79%) and 45 patients (57.69%) in group A and group B respectively. The second most common mode seen was FOOSH in 16 patients (20.51%) and 30 patients (38.46%) in group A and group B respectively. Other causative factors were fall from height and assault (Table 1). All fractures are distributed according to AO classification. Group A had 6 type B1, 12 type B2, 18 type B3, 15 type C1, 17 type C2, 10 type C3. Group B had 5 type B1, 4 type B2, 18 type B3, 15 type C1, 22 type C2, 14 type C3 (Figure 3). All patients were operated in the range 1 to 9 days from injury to surgery. In group A, 5 cases were lost to follow up before completing 12 months whereas in group B, 7 cases were lost to follow up, which is statistically not significant ($p>0.05$). In this study mean palmar flexion, dorsiflexion, radial deviation, ulnar deviation, supination, pronation, and grip strength at 12 months was 72.11-degree, 55.92-degree, 15.36-degree, 29.68-degree, 75.16-degree, 72.44-degree, 27.15 kg respectively in group A (figure 4). In group B mean palmar flexion, dorsiflexion, radial deviation, ulnar deviation, supination, pronation, and grip strength at 12 months was 74.77-degree, 70.04-degree, 18.30-degree, 38.62-degree, 84.55-degree, 83.11 degree and 28.39 kg respectively which are statistically significant ($p<0.05$) except grip strength. This implies that variable angle locking plate has better results in terms of range of motion at 12 months follow up. In our study radiological outcome was found by calculating mean radial height, volar tilt and radial inclination were 8.65 mm, 7.68 degree and 16.34 degree respectively at 12 months for group A (figure 5). The mean radial height, volar tilt, radial inclination was 10.14 mm, 10.31 degree and 19.77 degree respectively at 12 months for group B, which are statistically highly significant ($p<0.05$). It implies that radiological outcomes are much close to natural wrist radiology in variable angle volar locking plate group. At 6 months mean PRHWE score was 6.95 (SD±2.77) in group A and 3.52 (SD±1.89) in group B which is statistically highly significant ($p<0.05$). At 12 months mean PRHWE score was 4.28 (SD±2.43) in group A and 1.73 (SD±1.17) in group B which is statistically highly significant ($p<0.05$). This shows that variable angle locking plate group has overall better outcomes compared with fixed angle volar locking plate group because of proper follow up and post-operative rehabilitation. Patient's movements were highly improved at 12 months as compared at 6 months in both groups except two variables in group A which are palmar flexion and Dorsiflexion. The most common complication was finger and wrist stiffness which was in 4 cases and 1 case in group A and group B respectively. Wound infection was in 1 case of group A, which was superficial infection successfully treated with antibiotics. No deep infections were noted in our study. Residual pain was seen in 3 cases of group A and 2 cases of group B. In group A 3 cases had arthritic changes (figure 6).

This showed hardware related complications were less with variable angle volar locking plate group and patients had good compliance due to better sub-chondral screw placements.

Table 1: Demographic table.

Patient demographics	Group A (78)			Group B (78)			
	N	%	Mean	N	%	Mean	P value
Age (years)			42			40	0.059
Male	53	67.95		62	79.49		0.10
Female	25	32.05		16	20.51		
Right side	46	58.97		56	71.79		0.092
Left side	32	41.03		22	28.21		
RTA	56	71.79		45	57.69		0.07
FOOSH	16	20.51		30	38.46		
Fall from height	5	6.41		3	3.85		
Assault	1	1.28					

Figure 1: Intra-operative picture of volar radial approach reducing fracture by K wire.

Figure 2: Application of variable angle volar locking plate.

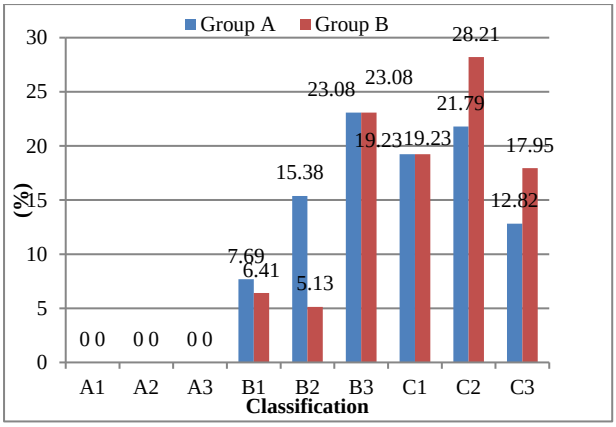

Figure 3: Distribution of cases according to AO classification.

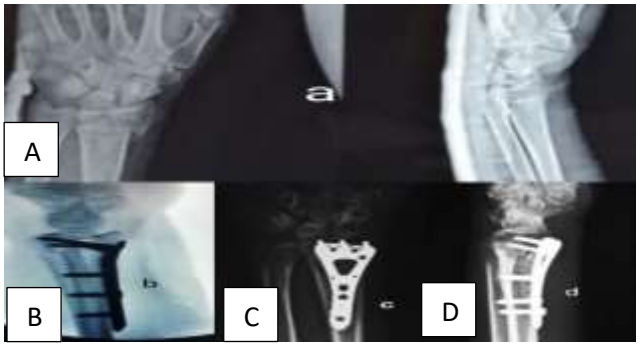

Figure 4: X-ray pictures of patient operated with variable angle volar locking plate.
(A): Pre-operative X-ray of wrist in anteroposterior and lateral views of AO type C. (B): Immediate post-operative X-ray in lateral view. (C and D): Follow-up X-ray of anteroposterior and lateral view at 3 months.

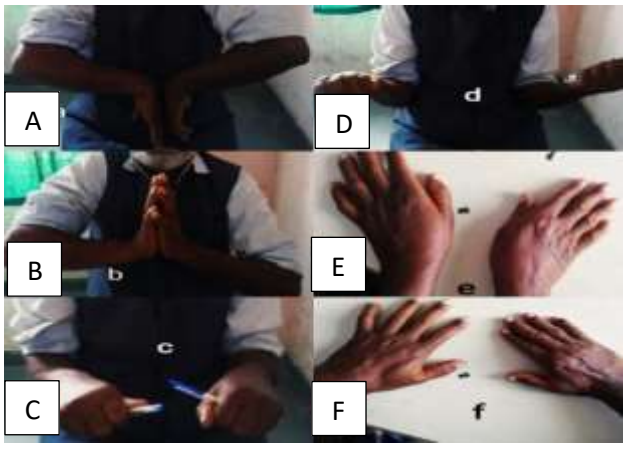

Figure 5: At 12 months patient operated with variable angle volar locking plate returned to work with almost symmetric range of motion.
(A) Flexion, (B) Extension, (C) Pronation, (D) Supination, (E) Ulnar deviation, (F) Radial deviation.

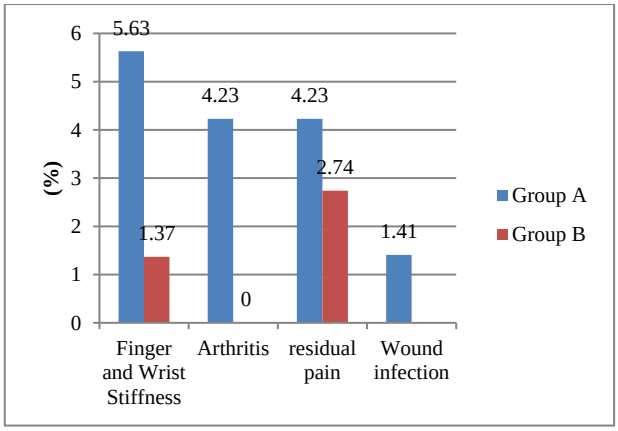

Figure 6: Distribution of cases according to complications.

DISCUSSION

Fractures of the distal end radius particularly requiring anatomical reduction of radio-carpal and radio-ulnar joint congruency must be treated with open reduction and internal fixation for better radiological and functional outcomes.[13] The return of better hand and finger functions has been attributed with early wrist movements.[14]

The work of Knirk and Jupiter showed intra-articular fractures with displacement of more than 2 mm in the radio-carpal joint results in osteoarthritis and functional disability.[15] The study by Seitz WH Jr showed external fixation is preferred than plaster reduction for comminuted intra-articular distal end radius fractures.[16] Comminuted intra-articular fractures are also treated by external fixation but a meta-analysis of randomised controlled trials by Qiang et al supports the use volar plating.[17] Bridging external fixation in unstable distal end radius works by principle of ligamentotaxis. However, it has limitations intra-articular fractures like due to viscoelastic behaviour of ligaments, there is a gradual loss of the initial distraction force applied to the fracture site through stress relaxation. Also it does not restore the volar tilt of the articular surface, nor does it reduce depressed lunate fragments.[18] For this study we didn't opt dorsal plating systems due to major complications like tendon irritation and ruptures, formation of adhesions due to decreased space between extensor tendons and dorsal surface of radius, to overcome this problems lead to development of low-profile dorsal plates or dual plating systems to decrease tendon ruptures.[13,19,20] In this study in both groups we used volar plating to improve pull out strength in osteoporotic bone and volar surgical approach that avoids extensive dorsal dissection. Patients tolerate volar area scars better then dorsal area scars. And complications like flexor tendon rupture were unlikely with volar plating as volar surface of radius provides more space and implant is isolated from flexor tendons by the pronator quadratus.[21] The study by Kapoor et al showed many published clinical trials comparing treatment regimens of closed reduction, external fixation and percutaneous pinning with open

reduction and internal fixation are lacking. And their data are difficult to compare as most studies are retrospective in nature and use of inconsistent outcome tools specially in regard to comminuted intra-articular fractures.[22] In this study used PRHWE score which is a self-administered, patient specific questionnaire. In 2004 it was modified from the original PRWE score. PRWE was designed to measure wrist pain and disability in activities of daily living, and consists 15 items with two sub scales pain and function. The pain sub scale includes five items where 0 is no pain and 10 is worst pain ever experienced, while function sub scale includes six specific activities and four usual activities where 0 is no difficulty experienced and 10 is unable to do mentioned activities. The total score of PRWE is the sum of the both scores of sub scales. A score of 100 represents the worst functional score, whereas 0 represents no disability. PRHWE consists of same items as PRWE with minor changes like wrist was replaced by wrist/hand, also two items which are not part of scoring system were added.[23,24] In this study there are no cases of bone grafting due to zero incidence of bone loss, several authors recommend a bone grafting either local or from the iliac crest in patients with bony impaction after fracture reduction.[25] One of the drawbacks of our study is wrist arthroscopy. Wrist arthroscopy is an important companion in the management of intra-articular distal radius fractures in detection of partial or complete ligament tears. As even in anatomically healed fractures some patients continued to be painful. In this study one of major complications were residual pain in both groups.[26] A retrospective comparative study between fixed angle volar locking plate and variable angle volar locking plate by Seung-do Cha et al showed no difference in which is contrary to our study results.[27] A bio mechanical study by Stanbury et al expressed superiority of a variable angle volar locking plate for capturing a distal radial styloid fragment compared to fixed angle plate.[28] Rogachefsky et al used open reduction with combination of external fixation for AO type C fractures and found that this provides satisfactory function and can restore radiological parameters. Open reduction and internal fixation with volar plate is a practiced surgical procedure for volar angulated distal radius fractures. While its application in fractures with dorsal displacement has been considered biomechanically unfavourable. Thus, development of new fixed and variable angle plate systems has created an increasing interest in this technique and the first sequences have been published.[29] No nerve injury or reflex sympathetic dystrophy, flexor or extensor tendon irritation or rupture, wound dehiscence due to infection, fracture collapse or reduction loss were seen in our study. This may be due to adherence to basic surgical principles and better post-operative rehabilitation. This study supports the hypothesis of early fixation of these fractures to persist good results and early return of the activity. To conclude patients with intra-articular distal radius fractures (AO type B and C) treated with variable angle volar locking plate shows better functional and radiological outcomes.

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Ethical approval: The study was approved by the institutional ethics committee

REFERENCES

1. Court-Brown CM, Caesar B. Epidemiology of adult fractures: a review. Injury. 2006;37(8):691-7.
2. Solomon L, Warwick D, Nayagam S. 9th ed. Florida: CRC press. Apley's System of Orthopaedics and Fractures. 2001;615-8.
3. Meena S, Sharma P, Sambharia AK, Dawar A. Fractures of distal radius: an overview. J Family Med Prim Care. 2014;3(4):325-32.
4. Howard PW, Stewart HD, Hind RE, Burke FD. External fixation of plaster for severely displaced comminuted Colles' fractures: A prospective study of anatomical and functional results. J Bone Joint Surg Br. 1989;71:68-73.
5. Axelrod TS, McMurtry RY. Open reduction and internal fixation of comminuted intra-articular fractures of the distal radius. J Hand Surg Am. 1990;15:1-11.
6. Cooney WP. External fixation of distal radial fractures. Clin Orthop Relat Res. 1983:44-9.
7. Szabo RM, Weber SC. Comminuted intra-articular fractures of the distal radius. Clin Orthop Relat Res. 1988:39-48.
8. Soong M, van Leerdam R, Guitton TG, Got C, Katarincic J, Ring D. Fracture of the distal radius: Risk factors for complications after locked volar plate fixation. J Hand Surg Am. 2011;36:3-9.
9. Drobetz H, Bryant AL, Pokorny T, Spitaler R, Leixnering M, Jupiter JB. Volar fixed-angle plating of distal radius extension fractures: influence of plate position on secondary loss of reduction-a biomechanic study in a cadaveric model. J Hand Surg Am. 2006;31:615-22.
10. Crenshaw Andrew H Jr. Fractures of Shoulder, Arm, and Forearm. Chapter 54 in Campbell's operative Orthopaedics, Philadelphia: Mosby, Inc. 10th Ed. part xv: 2003;3:3058-3066.
11. Abe Y, Doi K, Kuwata N, Yamamoto H, Sunago K, Kawai S. Surgical Options for distal radius fractures: indications and limitation. Arch Orthop Trauma Surg. 1998;117:188-92.
12. Al-Mouazzen, Louay Chou, Daud Kyriakopoulos, Georgios Hambidge, John. Polyaxial versus Uniaxial Volar Locking Plate for Distal Radial Fractures. Journal of orthopaedic surgery (Hong Kong). 2014;22:9-12.
13. Daniel R, Pietro R. Fractures of the distal end of the radius treated by internal fixation and early function. A preliminary report of 20 cases. J bone joint surg. 1196;78:588-92.
14. Diego F.Should anatomic reduction be pursued in distal radial fractures? J Hand Surg Br. 2001;25:523-7.

15. Knirk JL, Jupiter JB. Intra-articular fractures of the distal end of the radius in young adults. J Bone Joint Surg Am. 1986;68(5):647-59.
16. Seitz WH. External fixation of distal radius fractures. Indications and technical principles. Orthop Clin North Am. 1993;24:255-64.
17. Fu Q, Zhu L, Yang P, Chen A. Volar Locking Plate versus External Fixation for Distal Radius Fractures: A Meta-analysis of Randomized Controlled Trials. Indian J Orthopaedics. 2018;52(6):602-10.
18. David J, Osterman SA. Fractures and Injuries of the Distal Radius and Carpus. Saunders. 2008;592.
19. Jakob M, Rikli DA, Regazzoni P. Fractures of the distal radius treated by internal fixation and early function: a prospective study of 73 consecutive patients. J Bone Joint Surg. 2000;82B:340-44.
20. Leiv H, Nilsen P, Ove F, Hans O, Eirik S, Anders M. (1997). Open reduction and internal fixation of displaced intraarticular fractures of the distal radius - 31 patients followed for 3-7 years. Acta orthopaedica Scandinavica.1997:68:59-63.
21. Jupiter JB, Fernandez DL, Toh CL, Fellman T, Ring D. Operative treatment of volar intra-articular fractures of the distal end of the radius. J Bone Joint surg. 1996;78(12):1817-28.
22. Kapoor H, Agarwal A, Dhaon BK. Displaced intra-articular fractures of distal radius: A comparative evaluation of results following closed reduction, external fixation and open reduction with internal fixation. Injury. 2000;31(2):75-9.
23. MacDermid JC, Turgeon T, Richards RS, Beadle M, Roth JH. Patient rating of wrist pain and disability: a reliable and valid measurement tool. J Orthop Trauma. 1998;12:577-86.
24. MacDermid JC. Development of a scale for patient rating of wrist pain and disability. J Hand Ther. 1996;9:178-83.
25. Saffar P. Current trends in treatment and classification of distal radial fractures. In: Fractures of the distal radius (Eds. Saffar P, Cooney WP). Martin Dunitz Ltd. London. 1995;12-8.
26. Shkolnikova J, Harvey J. Wrist arthroscopy in the management of distal radius fractures. Ann of Joint. 2018;3:77.
27. Seung C, Jai P, Hyung-Soo K, Soo-Tae C, Jeong-Hyun Y, Joo-Hak K et al. Comparative Analysis of the Results of Fixed-angle versus Variable-angle Volar Locking Plate for Distal Radius Fracture Fixation. J Korean Fracture Society. 2012;25:197.
28. Stanbury SJ, Salo A, Elfar JC, Biomechanical analysis of a volar variable angle locking plate: the effect of capturing a distal radial styloid fragment. J Hand Surg Am. 2012;37:2488-94.
29. Rogachefsky APA, Richard A, Scott LR, Brooks A, Anne OE, Arnold SM et al. Treatment of Severely Comminuted Intra-Articular Fractures of the Distal End of the Radius by Open Reduction and Combined Internal and External Fixation. J Bone Joint Surg. 2001;83(4):509.

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