Clinical Research

Comparison of biomechanical stability between double posterior plate, parallel plate, and perpendicular (90˚) plate fixation in supracondylar humerus fracture

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ABSTRACT

Introduction: Distal humerus fracture is still a problem in orthopaedics due to the limitation of the implant installation area and the difficulty of surgical procedures caused by the neurovascular structure present in the distal portion of the humerus so that the complication rate of this fracture is quite high. Current gold standard for distal humerus fracture is ORIF with double plating, but until now there is still controversy mentioning superiority of one technique compare to the others.

Methods: This study is an in vitro experimental study on 27 cadaveric humerusbones, which is divided into 3 groups of treatment consisting of parallel plating; perpendicular plating; and double posterior plating fixation.Biomechanical tests were performed to determine the stability ofthese groups based on the displacement of the fracture fragments after repeated loading of 200 N of 10x, 20x, 50x, and 100x.

Results: The result of pull test with 200 N force showedthat double posterior plate hadthe lowest displacement fracture fragment comparedtoparallel plate and perpendicular plate, with mean of displacement of 0.20 mm (p = 0.400) after 10x repeated loading, 0.57 mm (p = 0.394) after 20x repeated loading, 0.82 mm (p = 0.107) after 50x repeated loading, and 1.58mm (p = 0.145) after 100x repeated loading.

Conclusion: The biomechanics of double posterior plate is more stable than parallel plate and perpendicullar plate but not significantly different.Double posterior plate on the distal humerus fracture couldbecome one of the alternative fixations with an easier and safer approach.

ABSTRAK

Pendahuluan: *Fraktur humerus distal masih merupakan masalah di bidang ortopedi karena keterbatasan area pemasangan* implant *dan kesulitan prosedur operasi akibat struktur neurovaskuler yang ada di bagian distal tulang humerus sehingga tingkat komplikasi penanganan fraktur ini cukup tinggi. Saat ini* gold standart *dalam penanganan fraktur humerus distal adalah ORIF dengan* double plating *namun hingga saat ini masih terdapat kontroversi yang menyebutkan superioritas teknik yang satu dibandingkan dengan lainnya.*

Metode: *Penelitian ini merupakan studi eksperimental* in vitro *pada 27 tulang humerus cadaver yang dibagi menjadi 3 kelompok perlakuan yaitu fiksasi* parallel plating*;* perpendicular plating *dan* double posterior plating*. Uji biomekanik dilakukan untuk mengetahui stabilitas dari ketiga kelompok teknik* plating *berdasarkan pergeseran fragmen fraktur setelah pemberian beban sebesar 200 N yang diulang berkala, sebesar 10x, 20x, 50x, dan 100x.*

Hasil: *Hasil uji tarik dengan gaya 200 N menunjukkan bahwa* double posterior plate *memiliki nilai pergeseran fragmen fraktur yang paling rendah dibandingkan* parallel plate *dan* perpendicular plate *dengan rerata pegeseran 0.20 mm (p = 0.400) pada uji tarik sebanyak 10x, 0.57 mm (p = 0.394) pada uji tarik sebanyak 20x, 0.82 mm (p = 0.107) pada uji tarik sebanyak 50x, dan 1.58 mm (p = 0.145) pada uji tarik sebanyak 100x*

Kesimpulan: *Secara biomekanik* double posterior plate *lebih stabil dibandingkan* parallel plate *dan* perpendicullar plate *namun tidak berbeda secara bermakna.* Double posterior plate *pada fraktur humerus distal dapat menjadi salah satu alternatif fiksasi dengan* approach *yang lebih mudah dan aman.*

Keywords: Supracondylar humerus fracture, distal humerus fracture, double posterior plating

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INTRODUCTION

Distal humerus fracture is one type of fracture that is still a problem in orthopaedics. The unique shape of the distal humerus bone surface joint limits the space for implantinstallation, mainly due to the neurovascular structure present in the distal portion of the humerus bone which is increasing the difficulty during the surgical procedure.The incidence of distal humerus fracture as a whole reaches 5.7 cases per 100,000 population annually with a similar ratio between male and female and constitutes 2% of overall fractures in adults.[1,2]

The main purpose of handling fractures on the distal humerus is torestore theelbow joint function without pain. To achieve this, anatomical reconstruction of the joint surface, restitution of the entire geometry of the distal humerus bone, and stable fixation of the fracture fragments to enable early rehabilitation and mobilization shall be done.[3] Although thesegoalsarenecessary to regain the elbow joint functions, stable fracture fixation requires difficult techniques, especially in comminutive fractures or in the presence of osteoporosis.[2]

Despite the fact that surgical techniques for the treatment of distal humerus fractures have advanced substantially over the last 20 years and are quite sophisticated, the complication rate for handling these fractures remains high. The anatomical structure of this area, combined with smooth cancellous bone structure, continues to cause major problems for orthopaedic surgeons.[2,3]Current gold standardin treating distal humerus fracture is open reduction and internal fixation (ORIF) with double plating. Other popular platingtechniques used in distal humerus fractures are parallel plating (with medial and lateral plate positions) and perpendicular plating (with a plate position 90° in medial and posterolateral).Both techniques are able to provide stable fixation in fracture fragments, but to date there is still controversy about the superiority of one technique compared to the other. The AO (Association for the Study of Internal Fixation) recommends the use of perpendicular plating, while O'Driscoll et al. suggested the use of parallel platingin the distal humerus fracture.[4 – 6]

Placement of the platein the medial and lateral areas has difficulty due to the presence of muscles and ligaments in the lateral column of the distal humerus and the position of the ulnar nerve in the medial column so that the placement of the platein the posterior side is thought to be an alternative installation for preservation of common extensor tendons and collateral ligament complexinthe lateral column and ulnar nerve in the medial column.[6]In addition, the placement of the platein the lateral section is technically more difficult due tosoft tissue stripping with the risk of damage to the posterior blood vessel of humerus condyle resulting in delayed ornon-union. Whereas placement of platein the medial part requires preservation of the ulnar nerve to prevent injury to the ulnar nerve or post-operative ulnar neuritis.[7]

Most of the previous studies demonstrated the superiority of parallel plating compared toperpendicular plating. However, this comparison is basically not possible because of differences in implant type, fracture pattern, mechanical tests, and type and the number of screw used in thestudies.In studies showing the superiority of parallel plating, 3.5-mm non-locking plate was the type of plate used for posterolateral platingandperpendicular plating used as a comparison.To obtain adequate fixation in the distal fragments with this type of plate is difficult due to the limited number of screwthat can be mounted in the distal fragments.Given the new type of precontoured locking plate, there is a possibility for the fixation of distal fragments with four 2.7-mm locking screws.[5,6]Based on this, we consider the use of double posterior plates with placement in theposteromedial and posterolateral portions of the distal humerus to obtain adequate fixation with an easier and safer approach.

METHODS

This study is an in vitro experimental study on cadaveric humerus bone.The research design used Randomized Control Post Test-Only Group Design.This design is chosen with the assumption that the specific population of each unit is homogeneous, where the characteristics of each population are the same.

The sample was 27 cadaveric humerus bones divided into 3 groups: treatment group (P1) received parallel plating fixation; treatment group (P2) obtainedfixation of perpendicular plating; and treatment group (P3) obtained double fixation posterior plating.

We used Shimadzu AG-10 TE autograft machine, pliers, Kirschner wire 1.0, and digital thrust term. Biomechanical tests wereperformed by measuring fracture or displacement fragments,whiletensile tests wereperformed using an autograft machine.Humerus bone fixed by using dual plating wasplaced on the autograft machine.The flexion-extension movement of the elbow joint wasreplaced by anterior-posterior bending on the distal humerus.In both fragments, each fracture wasmarked with a point andKirschner wire 1.0 was then installed perpendicularly as a marker.Prior to the tensile strength testing, the distance between the

two point markers wasmeasured byusing the digital thrustterm. The autograft was given an engine pulling force of 200 N, and repeated constantly.At 10x, 20x, 50x, and 100x repetitions, the engine pull was stopped and the distance was measured betweenboth markers.

The collected data analyzed statistically using SPSS 23 program. In this research the data was obtained in quantitativeform. Normality test was performed using Kolmogorov – Smirnov test.The parametric test was done tonormally distributed data. Anova test was performed to see whether there were differences between the three groups.

RESULTS

The results showed that the use of double posterior platehadthe strongest biomechanical strength characterized by lower fracture shift distance compared to the other plate configurations after the biomechanical test for 10x, 20x, 50x, and 100x tensiletest, respectively.

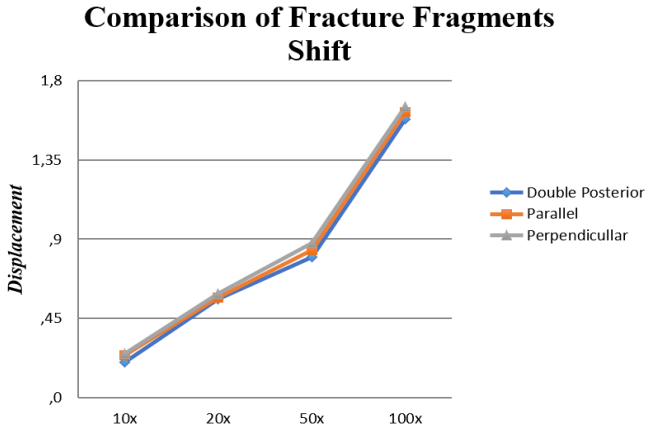

Figure 1. Comparison of fracture fragments shift indouble posterior platefixationwithparallel plateandperpendicularplate.

We used Shapiro-Wilk test for normality test, and the p value from the double posterior plate, parallel plate, and perpendicularplategroupswere > 0.05.This indicates that the data represent the population and parametric test may be conducted. Furthermore, the statistical calculation using Anova test for tensile test with a force of 200 N showed that there was no significant difference for 10x (p = 0.400), 20x (p = 0.394), 50x (p = 0.107), and 100x (p = 0.145). These results suggest that double posterior plate is biomechanicallystronger but not significantly different from the parallel plate and the perpendicularplate, which isin conformity with the initial hypothesis proposed in this study.

Tensile Test 200 N	Type of Implant	Average (mm)	p
10x	Double Posterior	0.20 ± 0.074	0.400
	Parallel	0.22 ± 0.081	
	Perpendicullar	0.25 ± 0.084	
20x	Double Posterior	0.57 ± 0.049	0.394
	Parallel	0.59 ± 0.070	
	Perpendicullar	0.62 ± 0.076	
50x	Double Posterior	0.82 ± 0.041	0.107
	Parallel	0.84 ± 0.048	
	Perpendicullar	0.86 ± 0.049	
100x	Double Posterior	1,58 ± 0.103	0.145
	Parallel	1.63 ± 0.074	
	Perpendicullar	1.66 ± 0.043	

Table 1. Parametric Test to Biomechanical Results of Double Posterior Plate, Parallel Plate, and Perpendicular Plate.

DISCUSSION

In the last few years, two-column anatomical concept of the distal humerus has been widely applied, where the distal side of the humerus is regarded as a triangular structure consisting of coronoid fossa and olecranon fossa in the middle area with medial and lateral condylus as the two sturdy columns.Currently, the gold standard in the definitive treatment of distal humerus fractures is open reduction and internal fixation (ORIF) using a plate or screw.The two most popular plate mounting techniques for distal humerus fractures are parallel plating and perpendicullar plating.

Arnander's findings suggest that the parallel plating configuration is stronger and significantly rigid than the perpendicullar plating configuration when exposed to the sagittal bending force.[32]Penzkofer et al. concluded that the parallel plate configuration at 180° is the most stable fixation construction to withstand the in vivo load.However, the biomechanical study by Sabalic et al. regarding the stability generated by the installation of a parallel,perpendicullar,ordouble posterior plate in distal humerus fracture cases proved that shifting fragments (displacement) only occured to be very low.[4.32]

In this study, we foundlower occurence ofdisplacement fragments in double posterior plating compared to parallel plating and perpendicular plating after tensile test on the sagittal area. This is consistent with thestudy conducted by Sabalic et al. that reported theplacement of parallel configuration plates provided the highest stiffness in axial compression loads, but the double posterior plating

configuration gave higher rigidity in sagittal bending and varus forces.[32]Despite the result of lower fragment shifts in the double posterior plating, there was no significant difference in the tensile test with the 200 N force of 10x (p = 0.400), 20x (p = 0.394), 50x p = 0.107), and 100x (p = 0.145).These results also correspond to the biomechanical study by Sabalic et al regarding the stability of the double plating configuration, where the displacementwasreported to be minimal and within the range that permits union.[32]

The results of comparison of the three plate configurations that did not produce significant difference made the researchers interested inexploring the insertion of double posterior platingin the distal humerus fracture.Gupta et al.concluded that the placement of both platesin the posterior surface of the humerus after the corresponding contour causedless injury of the ulnar nerve, compared tothe platesthat placed both in the lateral and medial sides of the humerus (parallel configuration).In addition, the absence of fixation loss indicated that the placement of double posterior platingproducedfixation stability identical to that of parallel plating.[32]

The placement of both platesin the posterior surface of the distal humerus via the posterior approach does not require extensive surgery, and transposition of the ulnar nerve is significant, thus reducing the incidence of neuropraxia.In addition, lower incidence of infection may be explained by decreased operating time due to soft tissue dissection and minimal periosteal stripping.[32]

Another study by Lee et al. suggests that distal humerus fixation with a double posterior plating configuration results in stable fixation of bicortical screw, without disturbing the installation of compression screw (lag screw).The present study concludes that placing the plate with a double posterior configuration can be an easy and stable fixation method with good clinical outcomes.[34]Based on this, it can be said that mounting the plate with double configuration could be the alternative forposterior fixation of the distal humerus,besides theparallel and perpendicularplating,in order to obtain adequate fixation with easier approach and anatomically and functionally secured.

CONCLUSION

This study showedthat biomechanics of double posterior plate is more stable than parallel plate and perpendicullar plate but not significantly different. Double posterior platein the distal humerus fracture is one of the alternative fixations with easier and safer approach .

Based on the results above, it maybe concluded that double posterior plate can be used as one of the implant configurations for post-fracture fixation of the distal humerus. However, Prospective clinical studies are needed to assess the stability, function, and complications of the double posterior plates.

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Conflict of ethics

The authors hereby declare that no conflict of ethics and interests exist.

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