



Outcomes of Direct Infrapectineal Buttress Plate for Quadrilateral Surface Fractures of Acetabulum Using an Anterior Intrapelvic Approach

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Purpose: Reduction and stable fixation of the quadrilateral plate are challenging primarily due to its location in the true pelvis, limited bone stock, juxta-articular nature, and its comminution. The current study aimed to investigate the quality of reduction and functional outcomes after open reduction and internal fixation (ORIF) with infrapectineal buttress plating of the quadrilateral surface via an anterior intrapelvic approach.

Materials and Methods: We conducted a retrospective review of twenty-one patients with acetabular fractures involving quadrilateral plate operated at Ghurki Trust Teaching Hospital between January 2017 and December 2018. Radiological assessment of the quality of reduction was conducted using criteria described by Matta. Functional outcomes were evaluated using a modified Postel Merle d' Aubigné score.

Results: The current study included 15 males and 6 females with a mean age of 40.67 ± 12.17 years (range, 22-62 years). The most common fracture pattern was anterior column and posterior hemi-transverse in eight patients followed by true bicolumn and T-type fractures in seven and four patients respectively. Both transverse fractures were transtectal. The quality of reduction according to Matta criteria was anatomical in 14 patients, imperfect in five and poor in two. Functional outcomes were excellent in 47.6% cases, good in 42.9%, and fair in 9.5% cases. Both patients with fair outcomes had non-anatomical reduction, and one required total hip arthroplasty at a later time.

Conclusion: Quadrilateral plate reconstruction with an infrapectineal buttress plate applied through an anterior intrapelvic approach provides high rates of anatomical reduction and yields good functional outcomes.

Key Words: Quadrilateral plate, Acetabular fractures, Infrapectineal plate, Modified Stoppa approach, Anterior intrapelvic approach

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INTRODUCTION

Displaced acetabular fractures frequently require open reduction and internal fixation (ORIF) to provide restoration of the congruent articular surface which is essential for optimal functional results¹⁻⁴. Acetabular fractures with quadrilateral plate involvement typically involve comminution of fracture fragments, medial displacement of the femoral head, and impaction of the superior articular surface of the acetabulum. In such fractures, the goals of anatomical reduction and stable fixation are difficult to achieve, mainly due to the intrapelvic location of fracture

fragments, limited bone stock, juxta-articular nature, and comminution which is particularly challenging in the presence of osteoporosis^{3,5,6}.

Reduction and stable fixation of acetabular fractures is a challenging procedure⁶. Detailed preoperative planning and selection of an appropriate surgical approach are necessary to avoid complications and achieve optimal results^{4,7}. The use of a standard ilio-inguinal approach, popularized by Letournel⁸, offers limited exposure and access to manipulate fragments of the quadrilateral plate. The approach involves extensive dissection and manipulation of neurovascular structures, increasing the risk of complications^{9,10}. In 1994, Cole and Bolhofner¹¹ introduced the anterior intrapelvic approach which utilized a modified Stoppa technique and was a less invasive alternative to the ilioinguinal approach, providing the additional benefits of intra-pelvic access and direct exposure to the quadrilateral plate. An infrapectineal plate applied using a modified Stoppa approach is seated in the same plane as the fracture displacement, resulting in a biomechanically stronger construct that resists secondary protusio-type displacement. The plate is attached and secured posteriorly using screws placed superior to the sciatic notch and anterior to the superior pubic ramus along the infrapectineal line^{3,12}.

The modified Stoppa technique has gained wide popularity with success rates ranging from 59% to 82% of cases¹³⁻¹⁵ compared to rates of 45% to 74%^{1,16} when performing anatomical reduction using the ilioinguinal approach. However, the number of retrospective studies that have specifically evaluated the utility and outcomes of using the modified Stoppa's technique in acetabular fractures involving the quadrilateral plate are few and have limited patient numbers¹⁷. The goal of the current study was to investigate the quality of reduction, functional outcomes, and perioperative complications after ORIF with infrapectineal buttress plating of the quadrilateral surface via an anterior intrapelvic approach (the modified Stoppa technique).

MATERIALS AND METHODS

This current study is a retrospective review of 21 patients with acetabular fractures involving the quadrilateral plate who underwent ORIF with infrapectineal buttress plating using the modified Stoppa technique at Ghurki Trust Teaching Hospital in Lahore, Pakistan between January 2017 and December 2018. All patients had a minimum follow-up period of one year. Approval by the Institutional

Review Board of Ghurki Trust Teaching Hospital was obtained prior to beginning the study. As our study was retrospective in nature and did not influence patient care, the need for ethical approval was waived by the institutional review board. Medical records were reviewed to collect demographic patient data including age, sex, co-morbidities, mechanism of injury, time elapsed since injury, and concomitant injuries other than acetabular fractures. All fractures were evaluated by both simple radiography (x-ray pelvis and Judet views) and computed tomography and classified according to the Letournel classification⁸. The appearance of a "Gull sign" (superomedial impaction), central dislocation, or comminution of the quadrilateral surface was specifically noted. The assessment of the quality of postoperative reduction was based on x-rays using the system proposed by Matta². Postoperatively, anteroposterior and 45-degree oblique (Judet) radiographs were taken, and residual displacement was measured in each. For all radiographs, the maximum displacement seen at any of the normal radiographic lines of the acetabulum or the innominate bone was recorded in millimeters, and the highest of the three values was used to grade the reduction according to one of four categories: anatomical (zero to one millimeter of displacement), imperfect (two to three millimeters), poor (more than three millimeters), or surgical secondary congruence (the acetabulum is reduced anatomically but displacements in the innominate bone alter the position of the joint). At final follow-up, x-rays were evaluated for loss of reduction and functional outcomes which were assessed using the Postel Merle d'Aubigné score¹⁸ to evaluate pain, gait, and mobility on a scale of 1 to 6, where 1 reflects the worst possible state of the patient and 6 the best. The total lowest possible score is 3, and the maximum is 18. A perfect score of 18 is categorized as excellent, 15-17 as good, 12-14 as fair, and less than 12 as poor.

1. Surgical Technique

The same surgical approach was used for all patients. The patient was placed in a supine position on a radiolucent table to allow for fluoroscopic imaging and the ability to obtain Judet views. After the patient was prepped and draped in a standard fashion, keeping the affected limb free for manipulation by an assistant, the main surgeon placed himself opposite to the injured hip with one assistant on each side. An anterior intrapelvic approach (the modified Stoppa technique¹⁰) in combination with the lateral window of the ilio-inguinal approach⁷ was utilized. Manual longitudinal

or trochanteric traction was used for preliminary reduction of centrally displaced femoral head. After proper exposure, fracture components were reduced and stabilized in a centripetal direction. The iliac wing, which was easier to access through the lateral window of the ilio-inguinal approach, was addressed first to stabilize high anterior column fractures and was fixed temporarily with screws or plates.

Fracture of the quadrilateral plate (and posterior column if present) was addressed through the medial window with direct visualization of the intra-pelvic region. The dissection was performed posterior to the sacro-iliac joint if needed. The hip joint was accessible through the fractured quadrilateral plate and allowed for the removal of osteochondral fragments. Depression in the weight-bearing area could be corrected by disimpacting the roof with an elevator through the joint line. Reduction was obtained with lateral traction combined with a ball spike impactor along the quadrilateral surface. Provisional reduction was maintained with a pelvic clamp, K-wires, 3.5 mm lag screws, or a short 3 to 4 holes pelvic recon plate. Although different plate configurations were possible, an under-contoured 3.5 mm locally manufactured recon plate (316 L stainless steel) was used to provide a spring effect when fitting the infra-pectineal region inside the true pelvis. Two 40 mm screws were routinely placed in the sciatic buttress area and 1 to 2 screws in superior pubic ramus. A suction drain was inserted, and layered closure was performed in the standard fashion.

The same postoperative rehabilitation protocol was implemented for all patients. Only toe-touch weight-bearing was allowed for the first 6 weeks followed by partial weight bearing until the 12th week and full weight-bearing thereafter. Physiotherapy included gait training and quadriceps/abductor strengthening exercises starting postoperatively. Range of motion exercises were added at six weeks postoperative. Mechanical and chemical (Enoxaparin 40 mg subcutaneously daily) thromboprophylaxis was prescribed for six weeks. Patients were reviewed clinically and radiologically at 3, 6, 12, and 24 weeks and biannually thereafter.

RESULTS

The study cohort was comprised of 21 patients (15 male and 6 female) with a mean age of 40.67 ± 12.17 years (range, 22-62 years). A road traffic accident was the predominant mode of injury in 15 patients. The most common fracture pattern was anterior column and posterior hemi-transverse in eight patients followed by true bicolonn⁷⁾ and T-type

fractures⁹⁾. Both transverse fractures were transtectal. The mean operative time was 178 minutes and the mean drop in hemoglobin was 1.8 g/dL. Patients remained in the hospital for an average of five days postoperatively. Table 1 summarizes data on demographics, type, and mechanism of injury, and radiological and functional outcomes.

All patients had a minimum of 1 year of follow-up (mean, 14.3 ± 2.1 months). The quality of reduction was assessed according to Matta criteria and found to be anatomical in 14 patients, imperfect in five, and poor in two. Functional outcomes, assessed in terms of Postel Merle d' Aubigné score, were excellent in 47.6% cases, good in 42.9%, and fair in 9.5% of cases with a mean overall score of 16.62 ± 1.66 . Both patients with fair outcomes had non-anatomical reduction, one of which required a total hip arthroplasty during the follow-up period. Superficial surgical site infection occurred in three patients, all of which were treated conservatively and did not require any additional surgical procedures. There were no cases of hernia, heterotopic ossification, vascular or genitourinary injury. Case studies are illustrated in Fig. 1 and 2.

DISCUSSION

The results of the current study indicate that in the majority of patients with acetabular fractures involving the quadrilateral plate, ORIF with an infrapectineal plate applied using an anterior intrapelvic approach yields excellent radiological and functional outcomes. Additionally, this approach lessens the operative time and intraoperative bleeding without any significant increase in perioperative complications. These findings are in line with the published literature. Notably, the mean age of patients in the current study was lower than patients included in prior reports.

Over the last 50 years, substantial progress has been made in the treatment of acetabular fractures. All treatment protocols share the same goal of providing pain relief, allowing early mobilization, and restoring normal hip joint anatomy; thereby limiting the risk of early post-traumatic arthritis^{2-4,6,8,19,20)}. Various factors including age, functional status, fracture pattern, degree of displacement, associated injuries, pre-existing local and general conditions, and available surgical expertise influence the choice of treatment modality^{3,21,22)}. Though the quadrilateral plate, which refers to the medial wall of the acetabulum, is not considered a separate parameter in acetabular fracture classifications, it is notorious for making ORIF challenging^{12,17,23)}. Quadrilateral plate fractures are typically associated with bicolonn fractures,

anterior column and posterior hemitransverse fractures, posterior column fractures, and transverse or T-type fractures^{17,24,25}). Anatomical reduction and stable fixation are difficult to achieve, mainly due to the location in the true pelvis, limited bone stock, juxta-articular nature, and its comminution, particularly in the presence of osteoporosis. Failure to restore the buttressing function of the medial wall and reduce the central displacement results in incongruous hip and poor outcomes^{3,8,12,25}).

A multitude of direct and indirect reduction techniques, surgical approaches, and implants have been described in the literature in an effort to address the challenges of this specific anatomic area¹⁷). A standard ilio-inguinal approach, popularized by Letournel⁸), does not allow ample exposure to adequately reduce and fix fractures of the quadrilateral plate. Additionally, this approach poses an increased risk to neurovascular structures due to direct manipulation^{3,6}). By contrast, it is possible to expose 80% of quadrilateral plate as well as the greater part of both columns and the anterior wall of the acetabulum by utilizing a modified Stoppa approach^{6,26}).

In addition to excellent exposure, the modified Stoppa approach permits fixation of the fracture with multiple

implant configurations including suprapectineal or infrapectineal plates or a combination of buttress plates and peri-articular screws²⁷). In their biomechanical study, Ryan et al.²⁸) compared the stability of three fixation strategies for transverse acetabular fractures: a reconstruction plate with anterior and posterior column screws; an infrapectineal precontoured quadrilateral surface buttress (iPQSB) plate alone; and an anterior column lag-screw and iPQSB plate. It was concluded that under anatomical loading, iPQSB plates with anterior column lag-screw fixation demonstrated increased stability. By using finite element modeling, Yücens et al.²⁷) sought to compare the stability and implant stress of a suprapectineal plate with an infrapectineal plate in three subconfigurations of screw types for anterior column fractures. Infrapectineal plate fixation with unlocked screws was found to be the most stable fixation method. The superiority of the infrapectineal plates in terms of stability could be attributed to three factors. First, the infrapectineal plate supports the pelvic ring from the inner side, in which both ends of the plate form a sealed and more stable structure. Second, mechanically it is easier to band a plate on the frontal aspect (2-3 mm) than on the side aspect (10 mm) due to differences in the inertia

Table 1. Patient Demographics, Fracture Characteristics, and Outcomes

Age (yr)	Sex	MOI	AO classification	Fracture pattern	Pelvic fracture	Gull sign	Quadrilateral plate comminution	Matta radiological classification	Postel Merle d'Aubigné score
28	M	RTA	62C1	True bicolumn	-	-	Yes	Anatomical	Excellent
62	M	Fall	62B3.1	ACPHT	-	Yes	Yes	Imperfect	Good
38	F	RTA	62B3.3	ACPHT	-	-	-	Anatomical	Excellent
51	M	RTA	62B3.3	ACPTH	-	Yes	Yes	Anatomical	Excellent
33	F	RTA	62B2.2	T-type	LC II	-	-	Anatomical	Good
22	M	RTA	62B3.3	ACPHT	-	-	Yes	Anatomical	Good
33	F	RTA	62B1.3	Transverse	-	-	-	Anatomical	Excellent
28	M	RTA	62C1	True bicolumn	-	-	-	Imperfect	Good
44	M	Fall	62B2.1	T-type	VS	-	Yes	Imperfect	Excellent
57	F	RTA	62B3.1	ACPHT	-	Yes	-	Anatomical	Excellent
40	M	RTA	62C2	True bicolumn	-	-	-	Anatomical	Good
42	M	Fall	62B1.3	Transverse	APC II	-	-	Anatomical	Good
50	M	Fall	62C2	True bicolumn	-	Yes	Yes	Poor	Fair
33	M	RTA	62C1	True bicolumn	-	-	-	Anatomical	Good
59	F	RTA	62B3.2	ACPHT	-	-	-	Anatomical	Excellent
27	M	RTA	62B3.3	ACPHT	LC II	-	Yes	Imperfect	Good
36	F	RTA	62B2.3	T-type	-	-	-	Anatomical	Excellent
47	M	Fall	62C2	True bicolumn	-	-	Yes	Poor	Fair
60	M	Fall	62B3.2	ACPHT	-	-	Yes	Anatomical	Good
38	M	RTA	62B2.2	T-type	-	-	-	Imperfect	Excellent
26	M	RTA	62C2	True bicolumn	-	-	-	Anatomical	Excellent

M: male, F: female, MOI: mechanism of injury, RTA: road traffic accident, ACPHT: anterior column and posterior hemitransverse, LC: lateral compression injury, VS: vertical shear jury, APC: anterior posterior compression.

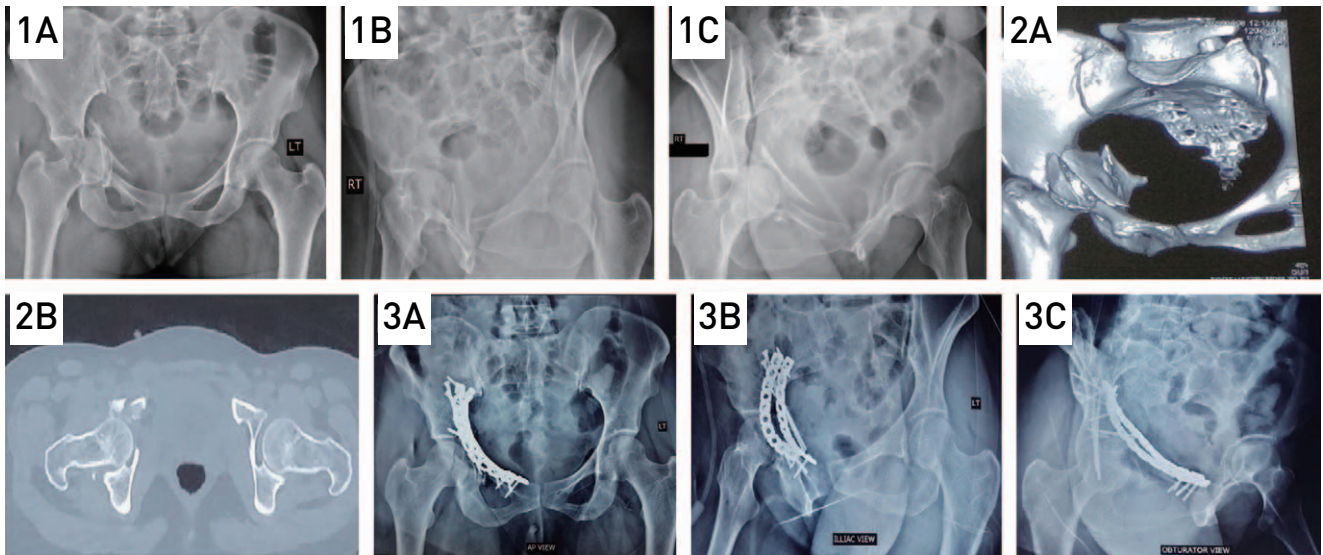


Fig. 1. A 38-year-old female sustained pelvic trauma in a road traffic accident. Preoperative x-rays and computed tomography (CT) scan show a low anterior column and posterior hemitransverse fracture with anterior wall and quadrilateral plate displacement. Postoperative images show fixation with a suprapectineal plate plus infrapectineal buttress plating for a quadrilateral plate and antegrade posterior column screw via a small lateral window. (1A-C) Preoperative x-ray pelvis AP view, iliac oblique, and obturator oblique views. (2A, B) CT scan axial view and 3D reconstruction view. (3A-C) Immediate postoperative x-ray pelvis AP view, iliac oblique, and obturator oblique views.

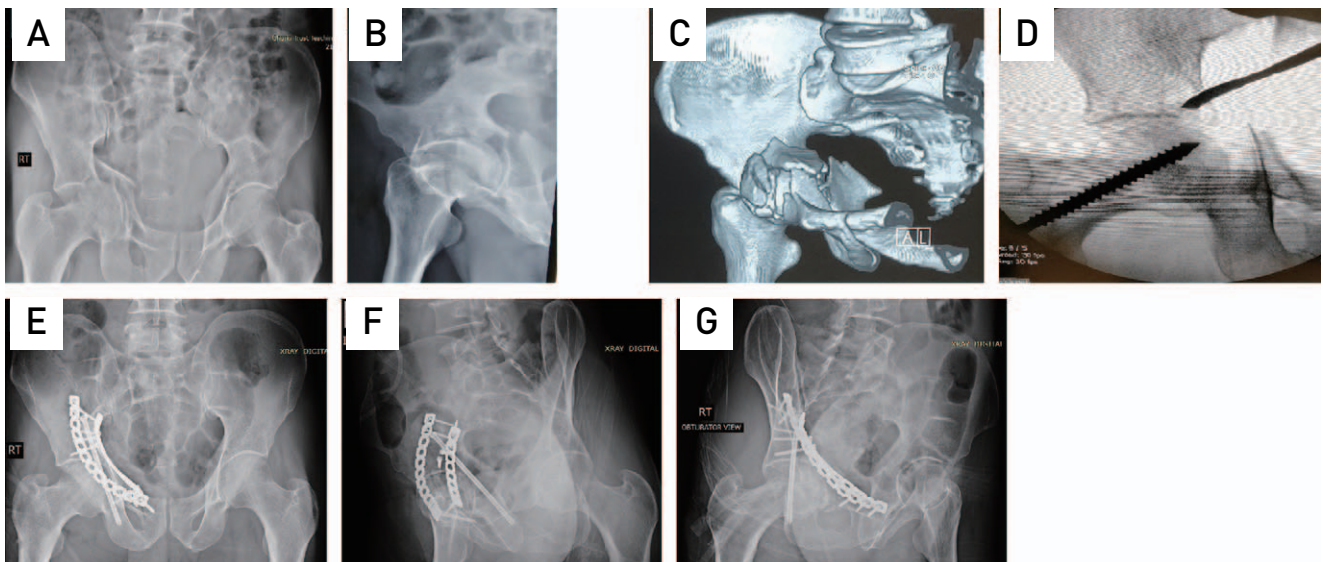


Fig. 2. A 51-year-old male sustained pelvic trauma in a road traffic accident. Preoperative x-rays show low anterior column and posterior hemitransverse fracture with a positive Gull sign of superomedial dome impaction. Computed tomography (CT) scan shows comminuted fractures of the anterior column/wall and quadrilateral plate. Intraoperative fluoroscopic views demonstrate articular dome disimpaction and autografting. Postoperative images show fixation with a suprapectineal plate plus infrapectineal buttress plating for a quadrilateral plate and antegrade posterior column screw via a small lateral window. (A) X-ray pelvis anteroposterior (AP) view. (B) X-ray pelvis iliac oblique view. (C) CT scan with 3D reconstruction. (D) Intraoperative fluoroscopic view. (E-G) Immediate postoperative X-ray pelvis AP, iliac oblique and obturator oblique views.

bending moment. In standing positions, the loads act vertically and the suprapectineal plate faces the loads frontally, whereas the infrapectineal plate faces loads on its side

aspect. Third, the infrapectineal plate supports four critical corners of the fractured acetabulum in a balanced manner, converting the standing loads to compression forces with-

out evident shear. The current clinical study substantiates biomechanical analyses finding that an infrapectineal plate applied in the same plane as the fracture displacement rather than perpendicular to it provides better fixation and prevents secondary protrusion²⁵. This mechanical advantage, in conjunction with the biological advantage of the modified Stoppa approach, may explain our low rate of complications. The Stoppa approach is associated with faster hip abductor rehabilitation and lower rates of heterotopic ossification around the hip. Future reconstruction including total hip arthroplasty may similarly be performed unhampered¹².

Unfortunately, not all fracture components can be managed using a modified Stoppa approach including fractures of the iliac fossa, fractures running high in the anterior column, or fractures of the posterior wall. In such situations, it becomes essential to either create the first window of the classical ilioinguinal approach or to combine with a posterior approach⁶. In recent studies, the lateral window combination has been reported in up to 40% of surgeries^{15,29,30}, but was reported in only 28.6% of procedures in the current study.

Direct comparisons between studies reporting outcomes of infrapectineal plating via the Stoppa approach are hampered by the great variance in the way fractures of the quadrilateral plate have been described in published literature. Therefore, the summation of results from case series and correlation of outcomes to different treatment modalities is not possible³. Hirvensalo et al.¹⁴ reported that by using the anterior intrapelvic approach in 164 cases of pelvic and acetabular surgery, anatomic reduction was obtained in 138 (84.1%) cases. Sagi et al.¹⁵ and Andersen et al.³¹ reported anatomic reduction rates of 92% and 82% respectively; however, inclusion criteria differed between these studies. In a retrospective series of 16 acetabular fractures with quadrilateral plate involvement treated using the modified Stoppa approach, Andrés-Peiró et al.⁶ reported that the quality of reduction was anatomical in nine cases, imperfect in three and poor in four. However, seven patients had complications related to the procedure, four required additional surgical procedures and despite good radiological results, a high infection rate was reported. Laflamme et al.¹² investigated the appropriateness of ORIF using an infrapectineal buttress plate via a modified Stoppa approach in 21 cases of osteopenic acetabular fractures involving the quadrilateral plate. Anatomic reduction was obtained in 66.7% (14/21) of cases, imperfect reduction in 23.8% (5/21) of cases, and poor reduction in 9.5% (2/21) of cases. Significant loss of reduction was seen in two patients. Functional assessments

were obtained in 19 patients and 71% of patients required no walking aid. According to the Postel Merle d'Aubigné score, results were excellent in 47.6% of patients, good in 42.9%, and fair in 9.5%.

The findings of the current study are limited by the small sample size and retrospective nature of the study. Additionally, follow-up in the current study was too short to evaluate the subsequent development of post-traumatic arthritis.

CONCLUSION

Quadrilateral plate reconstruction with an infrapectineal buttress plate applied through an anterior intrapelvic approach provides a high rate of anatomical reduction and yields positive functional results.

CONFLICT OF INTEREST

The authors declare that there is no potential conflict of interest relevant to this article.

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