Treatment of Geriatric Acetabular Anterior Fractures: Role of “Frame and Buttress”

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Abstract

Background: As the rate of geriatric acetabular fractures was increasing gradually and accompanied with the quadrilateral surface(QLS) involved resulting by impacting from the head of femur, which usually led to the dislocation/subluxation of the head of femur and intra-pelvic medial displacement of the QLS. Traditionally, applying an infra-pectineal buttress plate in the true pelvis to resist the protrusive fragments of the QLS, however, these plates with small contact area could not provide enough buttress effect to age-related fractures. This study was to evaluate the “frame and buttress” fixation strategy for treatment of geriatric acetabular anterior fractures(GAAF).

Methods: A cohort of 28 patients with acetabular fractures involving QLS were managed operatively with the “frame and buttress” fixation strategy with a single pelvic anterior approach. 7 cases were transverse, 3 cases were posterior column, 8 cases were associated both columns, 4 cases were anterior posterior hemi-transverse and 6 cases were T-type patterns fracture. The quality of reduction, functional outcomes and complications were recorded for analyzing.

Results: Functional outcomes were 15 cases in excellent; 9 cases were good; 3 cases were fair, and 1 case was poor. The quality of surgical reduction was evaluated by the Matta score system, which was graded as excellent in 17 cases, good in 9 cases and poor in 2 cases, respectively. No loss or failure of internal fixation, no second dislocation/subluxation of femoral head and no complications like infection were observed.

Conclusions: The “frame and buttress” fixation strategy provided firm method for treating GAAF, the “frame” formed rigid fixation structure for acetabular fractures and the “buttress” resisted protrusive QLS.

Background

Acetabular fractures are a challenging issue of traumatic fractures with its deep and complicated anatomical structure and variant vessels and nerves. With difference to other fractures, acetabular fractures are easily tended to result in rotation and displacement of fracture segments toward various directions, and these types of injury are difficult to restore and fix, which is potentially devastating trauma that may result in durative pain and permanent disability. The treatment “gold standard” is open reduction and stable fixation to restore the weight-bearing anatomical structure and the congruity of the joint,[1, 2] which focuses on allowing elderly patients acquire early postoperative rehabilitation and ambulation reducing the risk of postoperative complications, such as posttraumatic osteoarthritis, joint stiffness, muscle hypotrophy, thrombosis, pneumonia and so on.[3]

As the incidence of acetabular fractures in elderly is expected to rise with the increase in aging population and would keep a sustaining level.[3] Compared to younger acetabular fractures, the spectrum of injuries of are different that the elderly patients often occur as a consequence of a low energy mechanism such as fall from standing height with a lateral blow to the greater trochanter and subsequent geriatric protrusive fracture resulted.[4, 5] These type of fracture commonly accompanies with medial

displacement of the QLS associated with dislocation/subluxation of femoral head and variant level of articular impaction resulting in the “gull sign”.[6] Meanwhile, management of these geriatric fracture involving the QLS is a significant challenge for surgeons, which is additionally accompanied by co-morbidities associated with age-related bone quality and owing to osteoporosis which affected both the fracture pattern and the degree of comminution.[3] The definition of QLS is not accurate, different authors have their presentation of QLS.[7–9] However, it is undoubted that the QLS is the medial osteochondral component of acetabulum. Based on our study and experience of acetabular structure, the QLS is a thin medial wall of acetabulum, forming a cup-shaped cavity located within an arch consisted with labrum and two columns, which is similar to the bottom of a pipkin, to prevent central dislocation. Therefore, the neutralization of the fractured QLS is mandatory to restore the congruity, refrain the secondary medial displacement and dislocation of femoral head.

The pivotal step of treating the acetabular fractures involving the QLS is direct and adequate exposure of the fractured part. Recently, some anterior intra-pelvic(AIP) surgical approaches and techniques were developed and published by other authors, which received excellent evaluation from peers. In 1964, Judet and Letournel[1] used the ilioinguinal approach to successfully neutralized acetabular fractures with its middle window visualizing the QLS, however, this approach could not realized a direct visualization from the inside to the outside such as ALP approaches.[10] In 1994, Cole and Bolhofner[11, 12] described an AIP approach named by modified Stoppa to treat acetabular fractures, which realized partial exposure for direct visualization of the QLS compared with ilioinguinal approach, and received fairly satisfactory clinical outcomes. Keel et al[13, 14] introduced an AIP approach, which avoided cutting the rectus and realized direct visualization of the clearly entire QLS in 2012. With the repeating review of these related literatures about the AIP approaches, our team modified the ilioinguinal approach and remained the middle window of it to propose a novel approach called supra-ilioinguinal approach,[10] which allowed entire exposure of the QLS and both columns realizing direct visualization.

Recently, some scholars invented variant types of internal fixations to fix acetabular fractures involving the QLS using above access including the reconstruction plates, lag screws and cerclage wires/cables. [15–21] Nevertheless, the fixation protocol is the same except slight differences. Ulf Culemann et al[22] introduced an novel technique for an additional long infra-acetabular screw placement to form “frame” structure consisting of both columns, the ilioinguinal plate and supra-acetabular screw fixation, which achieved a rigid fixation for acetabular fractures and prevent displacement of fractured segments. Qureshi et al[23] proposed a infrapectineal plate to treat the protrusion-type fracture of acetabulum and found that the infrapectineal plate technique was useful in blocking the femoral head migrated medially, this technique was amazing. M.A. Karim et al[19] used the buttress screw inserting through the reconstruction plate to treat the QLS fractures, which resisted the protrusion of hip avoiding the acetabular medial wall being pushed into the true pelvic cavity again. However, this technique could not form a frame of the QLS except for buttressing it. Kistler et al[18] biomechanically evaluated construct stability of their novel plates with traditional fixation forms and found that the importance of buttressing and forming frame for the QLS emphasizing the necessity of constituting frame and buttressing.

Based on the review of previously published literatures and study of our team in recent years, we proposed a fixation and treatment principle for the QLS fractures named by “frame and buttress”. This frame meant the intact skeletal structure consisted with the fractured region fixed to form a stable QLS as well as a patch,(Fig. 2-B) which was same with “frame” proposed by Letournel and Judet.[24] The role of “buttress” was to resist the protrusion of femoral head preventing the secondary dislocation/subluxation. (Fig. 1-A) The purpose of our team was to propose the new protocol of acetabular treatment and fixation and simply the surgery, optimizing the treatment principles. This is the first time that the protocol combining the frame and buttress proposed for solving the protrusion-type acetabular fracture, and we believe that this protocol will have benefit for the development of acetabular treatment.

Methods

Data of 28 patients aged ≥ 55 years old with acetabular fractures involving QLS were recorded and retro-reviewed between January 2016 and July 2019. Patients included in this study were treated with the “frame and buttress” fixation principle through single anterior approach(supra-ilioinguinal) performed by one surgeon. All patients who needed treatment through posterior approach were excluded from this study. At last, 28 cases were selected for this retrospective study, 7 cases were transverse, 3 cases were posterior column, 8 cases were associated both columns, 4 cases were anterior posterior hemi-transverse and 6 cases were T-type patterns fracture of these cases by classification of Judet and Letournel.[1, 24] Of the 28 consecutive cases, 22 were comminuted fractures of the QLS, 6 were simple fractures of the QLS, and all were medially protrusive fractures. All patients were followed-up for at least 1 year.

All patients were conventionally required to undertake x-ray, CT and 3D construction preoperation. With the radiographic data, surgeons would evaluate the fracture severity, confirm the classification and ensure the operation methods. In this study, the Matta scoring system[25] was used to evaluate the reduction quality: 1 mm and less was excellent reduction; 2 mm ~ 3 mm was good reduction; and greater than 3 mm was poor reduction. All patients were required to received functional evaluation such as pain, walking gait and range of motion of the affected hip joint with the Merle D'Aubigné-Postel scoring system[26, 27]: 18 to 17 points was an excellent outcome; 16 to 15 points was a good outcome; 14 to 13 points was a fair outcome; and less than 13 points was a poor outcome as last follow-up. And the Brooker classification[28] was used to evaluate the ectopic ossification level for patients in this study at last follow-up.

SURGICAL TECHNIQUE

All patients involved in this study were received surgical treatment through the AIP approach by a same surgeon using the “frame and buttress” fixation principle.(Fig. 1-A,B) Before operation, all cases who combined with central dislocation/subluxation of the femoral head were received traction treatment refraining muscle rigidity. The patients were positioned supinely on a flat radiolucent operative table allowing all kinds of intra-operative pelvic positions imaging could be acquired, including anteroposterior, inlet, outlet, and oblique (Judet) views, with C-arm machine for the injured acetabulum. A folded

radiolucent drape was folded and piled under the buttocks to slightly elevate. The lower limb of the injured side was entirely disinfected in order to remain intra-operative flexing of hip and knee joint conveniently, which could relax nerves, iliac vessels and iliopsoas reducing the iatrogenic damaging risks in operation even facilitating the surgical exposure.

A single AIP approach was performed to treat the GAAF involving the QLS. Some different AIP approaches could be used to gain access to the intra-pelvic structure such as standard ilioinguinal, modified ilioinguinal and modified Stoppa. However, all cases performed surgery were treated with our modified approach named supra-ilioinguinal approach,[10] which realized a direct visualization of the anterior column(AC), QLS and posterior column(PC), could be adopted to resolve some complex geriatric acetabular fractures except for some posterior wall involved. With regular skin incision along the pre-set trajectory and the approach was exposed to four anatomical windows of this approach, the first window locating between the psoas and the ilium, the second window locating between the psoas and the iliac external vessels, the third window locating the iliac external vessels and the spermatic cord or round ligament, the fourth window locating between the spermatic cord or round ligament and the rectus abdominis, as described previously.[10] As the geriatric fractures were frequently severely comminuted and more components involved, operation was achieved with a nearly similar series of steps for each patient following the reduction principle of the acetabulum as described by Matta[29] from the lateral to the medial hip. The iliac fractures were firstly managed through the first window of our modified approach. Two Schantz pins were inserted into ilium and connected with a rod and two clamps constituting an external fixator, which was convenient for surgeons to unlock and reduce the broken ilium and AC by manual maneuver and provisionally stabilized with a 2.5-mm K-wire or reduction clamp. The broken ilium was stably fixed with two or one reconstruction plates after the iliac edge was reduced by direct intra-pelvic manipulation and rotating the ilium. If the fracture was amenable, the use of lag screw was the preferred method of fixing the AC and PC whenever possible.[30] If not, a type of anatomic reduction plate along the superior ramus to the dome of acetabulum could be a management of choice as a way for fixation of AC. The PC was reduced via a hook retractor placed in the greater sciatic notch to properly lift the PC and temporarily stabilized with 2.5-mm K-wire toward to ischial tuberosity or ischial spine following a 6.5-mm cannulated screw was inserted, whether the PC fracture was present and permitted. It should be noted that the control of the hook retractor must be stable avoiding the sharp end poking surrounding vessels, especially for the iliac artery and vein, and nerves. If the PC fracture was not amenable for screw stabilization, the use of reconstruction plate was selectable.

The most significant and indispensable step of the whole operation was the management of the QLS, which was managed through direct vision from some AIP approaches. On the basis of the fracture severity of the QLS, the fixation strategy was selectable. If the QLS fracture was not comminuted and fractures were not located at low site, it was not necessary to form entirely buttress.(Fig. 2-C,D) Traditionally, an infra-pectineal plate was regularly applied to resist the protrusive QLS and prevent the secondary dislocation/subluxation of hip.[23] Because of a wide variety of muscles, ligaments and incarceration of fracture parts, which would refrain the reduction of QLS, it was necessary to apply traction of the lower limb and at the same time a bucking bar was applied to push the protrusive QLS

within the operative window, afterwards, an infra-pectineal plate was placed. If the reduction effect was not satisfactory, a reduction clamp was used for assistant forcing. However, the bone quality of elder patients was low, the use of bucking bar should constituted with a cap in order to preventing iatrogenic fractures. If the QLS was broken with free fragments, it was mandatory to reduce the integrity of the QLS as far as possible and in the meantime the entire buttress effect on the protrusive hip must be formed. (Fig. 2-A,B)

Postoperatively, patients with medial dislocation/subluxation were managed with continuous traction at least for 2 weeks and others were managed as was standard for acetabular fractures. All patients were not permitted to perform weight bearing exercises including passive and active hip motion within 4 weeks postoperatively. All patients were encouraged to perform weight bearing gait with a pair of crutches and a single crutch 4 ~ 6 weeks, 6 ~ 12 weeks after operation, respectively. The accurate time when patients could walk was based on the union level of fracture and reduction quality.

Results

Conventionally, all patients aged ≥ 55 years were acquired followed-up for at least 1 years, and functional recovery evaluation outcomes of fracture was performed at last follow-up based on the Merle D'Aubigné-Postel scoring system, 15 cases were excellent; 9 cases were good; 3 cases were fair, and 1 case was poor.(Table.1) The quality of surgical reduction was evaluated by the Matta score system, which was graded as excellent(anatomical) in 17 cases, good(imperfect) in 9 cases and poor in 2 cases, respectively. (Table.1) No loss or failure of internal fixation, no second dislocation/subluxation of femoral head and no complications like infection were observed, but 1 case graded as level IV ectopic ossification because of the severe fracture of acetabulum and associated with femoral head fracture and finally total hip replacement was performed.(Table.2)

Discussion

Although some authors have published their internal fixation algorithm for treating acetabular fractures at any age, however, the special fixation protocol was not proposed especially for the senior patient population. This manuscript was aimed to address such a particular GAAF involving the QLS in elderly patients with “frame and buttress” principle. As the senior aged patients frequently accompanied with age-related osteoporosis and other significant comorbidities, which would result in the comminuted fractures of QLS by even falling from a standing height or other low-energy injury. Therefore, the goal of such operation was to achieve a congruent and stable hip joint at the expense of a perfect reduction to minimize the surgical insult on a more senior patient. Additionally, a stable hip joint could allow patients for early functional exercise and even afford a favorable opportunity for future hip arthroplasty. Forming a skeletal frame structure to reconstruct the broken QLS and afford a base to resist the tendency of protrusion were the hinge to treat the type of fractures for whether old or young patients.

Reviews from researches published recently about the exact definition of QLS, however, the description of the QLS was unclear. W.A. ElNahal et al[31] published that the QLS extended from the pelvic brim superiorly till a line joining the ischial spine and obturator foramen inferiorly, and was bound by the greater sciatic notch posteriorly and the obturator foramen anteriorly. Inspired by the work above and the work by Letournel E and Judet R,[24] we redefined the “frame” treatment of the QLS and described the components of the new definition. The “frame” was constituted with three consecutive borders of the QLS: the first border was the AC, superior of the QLS, the second border was the PC, posterior of the QLS and the third border was the obturator foramen, anterior of the QLS. There were various of methods to rebuild up the consecutive construction of above three borders, including lag screws placement and plates fixation, which depended on whether the bone quality was allowable. Lag screws fixation was a classical method to perform and achieve well clinical effect. The insertion direction of PC lag screw was decided by the height of fracture line on the PC, the PC lag screw was inserted directing to ischial spine if the fracture line was superior to the ischial spine, otherwise, the direction was inserted to the ischial tuberosity, which rebuilt up the construction of the broken PC superior of the QLS. However, if the PC fracture was not amenable to this screw fixation, the iliosciatic plate fixation was a selectable method to stabilize the PC. Conventionally, the AC was fixed by a reconstruction plate positioned on upper surface of the pelvic brim with cancellous screws, which had more potential holding power for osteoporosis patients,[32] when open operation was performed to rebuild up the integrity of the QC, superior border of the QLS. Culemann et al[22] employed an additional infra-acetabular lag screw, which significantly increased the fixation strength of acetabular fracture and rebuilt up the third border of QLS, however, the placement of the infra-acetabular screw was challenging and need professional skills, because it was accessible to penetrate into joint. Therefore, the placement of a plate was an alternative method to stabilize the third border of QLS. On the base of the reconstructed frame of QLS, which was one of the pivotal steps to reduce and stabilize the QLS.

In 2004, Qureshi et al[23] published a internal fixation technique for the treatment of acetabular fracture, who used a 9-hole reconstruction plate applied as an infra-pectineal buttress plate along the QLS and described that there was no occupation of reduction or fixation loss with the infra-pectineal plate. The infra-pectineal plate was effective to provide the desired buttress effect and resist the medial displacement of the QLS, which reduced the rate of secondary dislocation/subluxation of head and fixation loss. Nevertheless, it was invalid for comminuted fractures. Mears[33] and Farid[34] reported a technique that they used braided cables or heavy wires for encircling the QLS, which tied up the fracture fragments and refrained the displacement. The tighten wires provided buttress effect to the protrusion-type acetabular fractures, however, the wires technique was merely used for QLS fractures without small-size fragments, which could not buttress the comminuted fractures. M.A. Karim et al[19] used a row of screws inserting through a reconstruction plate placed along the pelvic brim to resist the protrusive QLS, which resisted the protrusion of hip. However, it only provided resistance to the hip not formed desired buttress effect to the QLS, if the gap was existing between the screws and the QLS, the tendency of reduction loss would never disappear. Kistler et al[35] and R.K. Sen et al[21] published their innovation of QLS buttress plates, their plates provided partial buttress and resistant effect to the broken QLS reducing

the rate secondary displacement of fractures. Chen et al reported biomechanical comparison of different fixation techniques including a special infrapectineal QLS buttress plate, compared with other plates, which not only provided entire buttress and resistant effect to the broken QLS especial the comminuted fractures, but also formed entire frame of the QLS. This technique fully reflect the “frame and buttress” fixation strategy.(Fig. 1-A,B) In addition, the maintenance of gap between the QLS with the plate about 2mm could afford a more mechanically stable support effect to the fracture region.[36] In the metaphor of this fixation strategy, reconstructing the frame was similar to piece the broken bottom of a bowl and the internal fixators were similar to some patches used for stabilizing and buttressing the bottom.(Fig. 1-A)

A direct view to the QLS in the help of surgical approaches would assist surgeons to reduce and fix the fracture region. The supra-ilioinguinal approach[10] was performed only in all patients involved, in despite of there were various AIP approaches such as Sttopa and modified Ilioinguinal could be selectable for treatment of acetabular fractures. With the third and the fourth windows of the approach, we realized a direct visualization and direct management of the QLS, which was convenient for surgeons to rebuild up the congruity of the intra-pelvic fractures.

As for our study, 28 patients with age ≥ 55 years and acetabular fractures involving the QLS were treated using the our fixation strategy. 17(60.7%) patients acquired excellent reduction, 9(32.1%) patients acquired good reduction evaluating by the Matta scoring system. Meanwhile, the clinical functional recovery results were evaluated by Merle D'Aubigné-Postel system at the last follow-up: 24(85.7%) patients were graded as excellent or good. In the period of follow-up time, there was only one patient occurred reduction loss and lastly performed total hip operation. We were applying ourself to analyzing the reasons, the loss of fixation might be the result of severe osteoporosis and the insufficient post-operative traction time, which resulted the medial wall in being struck by the femoral head and eventually the stabilization of fixation was fault. As geriatric acetabular fractures were usually resulted by low-energy trauma and combined with other comorbidities, some patients could not tolerate the procedure of operation. Therefore, the patients enrolled in our study were limited, it was necessary to include more patients to verify the fixation strategy. On the other hand, our study was focusing on the elderly patients, the fixation effect to young patients was lack, but this fixation strategy was also able to treat young patients with acetabular fractures involving the QLS requiring further clinical validation.

The reconstruction of the frame was to rebuild up the integrity of the QLS and achieve a congruent and stable hip joint to minimize the surgical insult on elderly patients. With the use of some special plates to resist the medial protrusive QLS buttressing these medial displaced fragments, which efficiently refrained secondary dislocation/subluxation of femoral head and medial displacement of QLS.(Fig. 3)

Conclusions

In conclusion, using of the fixation strategy for treatment of GAAF provided excellent technique for reducing and stabilizing the fracture region. Furthermore, this strategy was able to directly guide the

operative steps and be the core of acetabular fracture treatment.

Abbreviations

QLS: quadrilateral surface; GAAF: geriatric acetabular anterior fractures; AIP: anterior intra-pelvic; CT: computerized tomography; AC: anterior column; PC: posterior column; 3D: three-dimensional

Declarations

Ethics approval and consent to participate

All participants in this study were informed and confirmed to participate on this clinical trial, and written informed consent was obtained. Procedures performed in this study involving human were consistent with the ethical standards of the institutional and the national research committee (Ethics Committee of the Union Hospital, Tongji Medical College, Huazhong University of Science and Technology) and the 1964 Helsinki declaration and its later amendments.

Consent for publication

No applicable

Availability of data and materials

All data generated and/or analyzed during this study are available from the corresponding author by reasonable request.

Competing interests

All authors declared that there are no competing interests.

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Authors' contributions

YZW and XDG conceived and designed the study. KFC, SMC and LZ contributed to the data collection. YZW, YLW and GXH analyzed the data. ZYQ and YM helped to draft the manuscript. YM and SY carried out the image review. All authors read and approved the final manuscript.

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Tables

Table 1
Fundamental statues and post-operative prognosis of
acetabular fractures.

Parameter	Value
Judet and Latournel classification	
Both columns	8(28.6%)
T-shaped	6(21.4%)
ACPHT	4(14.3%)
Transverse	7(25.0%)
PC	3(10.7%)
Matta score	
Excellent	17(60.7%)
Good	9(32.1%)
Poor	2(7.1%)
Merle D'Aubigné-Postel score	
Excellent	15(53.6%)
Good	9(32.1%)
Fair	3(10.7%)
Poor	1(3.6%)

Table 2
Fracture degree of QLS of included patients.

Fracture degree of QLS	Value
Simple fracture	22(28.6%)
Comminuted fracture	6(21.4%)

Figures

Figure 1

Frame and buttress fixation principle of treating geriatric acetabular fractures. A Schematic diagram showing the protrusive and comminuted QLS of the elderly, it is necessary to afford an enough power of buttress to resist the protrusive QLS. B Schematic diagram showing the frame structure of acetabulum,

and variant internal fixators are used to recover the broken frame, whether it is necessary to form entire or partial frame depending on the fracture degree and lines on the QLS.

Figure 2

A,B The fracture of QLS were low, an entire frame must be formed to buttress the protrusive and comminuted QLS. C,D The fracture of QLS were high, only a partial frame is enough to buttress the broken QLS.

Figure 3

A~C A supra-pectineal buttress plate was used to form partial frame and resistance for fixation of the protrusive QLS. D~F A infra-pectineal buttress plate and supra-pectineal plate were used to form entire frame and resistance for fixation of the protrusive QLS.