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A CT-Based 3D Morphometric Study of the Acetabular Roof for Safe Placement of the Quadrilateral Surface Plate in Malay Patients

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ABSTRACT

Introduction: Management of quadrilateral plate (QLP) fractures is challenging. Current QLP implants are suboptimal in terms of plate positioning and risk of intra-articular screw penetration, which requires detailed anatomical knowledge. There are limited morphometric data on the acetabulum among Malaysian patients. This study aimed to determine the safe zones for implant placement in QLP fractures among a Malaysian Malay cohort.
Materials and methods: In this retrospective CT-based study, 3D pelvic models were reconstructed using MIMICS v21.0, and measurements of acetabular roof length from pubic tubercle (point A) and safe angles (beyond X-Y angle), area without the risk of intra-articular screw penetration, were recorded. Means ± SD were reported, and sex comparisons were analysed by using independent t tests (α = 0.05).
Results: Out of 56 patients, 82.1% were male. The mean age was 37 years old. All measurements were longer in males. Mean acetabular length or danger zone (B–C) was 58.38mm (SD 4.04) in males and 53.22 (SD 4.55) in females. Statistically significant sex differences were observed for two measurements, A-C and B-C, with p=0.018 and 0.001, respectively. No other measurements showed significant sex differences.
Conclusion: These morphometric data provide population-specific parameters that may inform safer implant placement and screw trajectory planning for QLP fractures in Malay patients. Further multiethnic studies are needed before generalising these findings to the wider Malaysian population.

Keywords:
quadrilateral plate, acetabulum, normal morphological, 3D CT imaging, MIMICS 21.0 software

INTRODUCTION

Acetabular fractures are relatively uncommon injuries, although their incidence appears to be increasing. In the United States and Western Europe, the incidence of pelvic fractures has been reported as 37 cases per 100,000 population annually, with approximately 10% involving the acetabulum[1]. In Qatar, the reported incidence of acetabular fractures is two cases per 100,000 population per year[2]. At our centre, approximately five acetabular fractures are treated each month. These injuries demonstrate a bimodal age distribution, with the first peak occurring in younger patients who sustain high-energy trauma and the second in older patients who sustain low-energy fragility fractures[1].

Acetabular fractures are difficult injuries to manage, which require special attention and expertise. It remains a challenge to orthopaedic surgeons due to its anatomical complexity, fracture morphology, and intricate surgical exposure[3]. Restoration of a stable hip joint by means of anatomic reduction and stable osteosynthesis is the primary principle in treating this fracture[4,5]. Any kind of improper reduction will lead to significant ‘joint incongruency’ complications, such as limb length discrepancy, range of motion limitation, and early onset of hip pain due to osteoarthritis, and overall poor quality of life.

Acetabular fractures involving the quadrilateral plate (QLP) present a persistent surgical challenge because of the complex three-dimensional geometry of the pelvic brim and the proximity of critical neurovascular and intra-pelvic structures[6]. Contemporary fixation strategies for QLP fractures rely on contoured plates and strategic screw placement to restore stability and prevent medial migration; however, available implants and standard trajectories are commonly derived from limited morphometric datasets that

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may not reflect anatomical variation across populations[7]. As a result, implant fit and screw safety margins may be suboptimal, increasing the risk of intrapelvic penetration, fixation failure, and post-traumatic osteoarthritis[5].

In our current practice, the quadrilateral surface plate by Synthes provides adequate buttressing to the quadrilateral surface area. It offers support to both the medial surface through its infrapectineal portion and the superior pelvic brim through its suprapectineal portion. Nevertheless, a significant limitation is the potential for intra-articular screw penetration, particularly when pre-contouring is inadequate (Fig. 1). Pre-contouring is required to get a good flushing of the plate onto the pelvic brim and to prevent intra-articular screw penetration. However, excessive contouring may weaken the implant and increase the risk of loss of reduction and implant failure, which may ultimately lead to post-traumatic osteoarthritis and the need for early total hip replacement.

Currently, prevention of intra-articular screw placement is dependent solely on intra-operative use of image intensifier, imagination capacity of the surgeon, and essentially through trial and error[8]. Over the years, several studies have been published to report safe screw placement for quadrilateral plate fractures. These studies have attempted to outline safe and danger zones of the quadrilateral surface, posterior acetabular wall, anterior and posterior acetabular column[9]. To date, there is no study guide to delineate the 'danger zone' over the acetabular roof to avoid intra-articular screw penetration. Therefore, measurement of the acetabular roof will help surgeons to quickly and precisely identify the 'danger zone' to facilitate safe screw placement, assist in pre-contouring the plate, and design a proper implant to avoid complications perioperative and post-operatively. This will subsequently reduce the length of hospital stay and improve the patient's quality of life.

Although several morphometric studies have described acetabular dimensions in East Asian, European, and other populations, high-resolution CT-based data for Malaysian and other Southeast Asian populations remain scarce. Population-specific differences in pelvic and acetabular anatomy may influence implant design, pre-operative planning, and intra-operative decision-making. A better understanding of the acetabular roof and quadrilateral plate morphology in the local population is therefore essential.

This retrospective CT-based study aimed to quantify key acetabular roof dimensions and define the safe angular limits for screw placement in quadrilateral plate fixation in a Malaysian Malay cohort. We measured defined linear distances and angles on three-dimensional reconstructions and examined sex differences. By providing population-specific ranges for these parameters, we intend to inform surgeons and implant designers about typical anatomic constraints in this cohort and to highlight the need for caution when extrapolating implant dimensions derived from other populations.

MATERIALS AND METHODS

The study was conducted in the Radiology Department and Orthopaedic Department Hospital Universiti Sains Malaysia. The subjects include those who had a normal CT scan of the pelvis or abdominopelvic done in the same hospital. CT images were retrospectively retrieved by searching from the Picture Archiving Communications System (PACS) using key word 'pelvis', 'pelvic', 'abdomen', and 'abdominopelvic' in the CT slot, dating between 2014 and 2021. The inclusion criteria include patients who are 18 years and older at the time CT was performed, regardless of gender or ethnicity. Those with bilateral acetabular region fracture (new or old), prior instrumentation of the pelvis, congenital abnormalities or pathology of the pelvis, and image artefacts were excluded from the study.

Raw data obtained were stored in Data Imaging and Communication in Medicine (DICOM) format. The DICOM file was then imported to MIMICS (Materialise Interactive Medical Image Control System) version 21.0 software [Materialise, Belgium] for conversion into a 3D pelvic model. Then, the 3D pelvic model was edited to only display the hemipelvis for easier measurement. Measurement of acetabular roof dimensions was performed on the 3D pelvic model and was documented in millimetres (mm) for the length and in degrees (deg) for the angle. The data collection and measurement were done only by the principal investigator with the help of the radio technologist and under the supervision of senior co-authors.

A surgical reference point that is easily identified intra-operatively is first marked. Pubic tubercle is chosen as a reference point and labelled as Point A. This is because of its easy identification during surgical approach for fixation of QLP fractures via ilio-inguinal or Stoppa approach. Then, pelvis is positioned such that acetabular roof is parallel to Y-axis. The pelvic model is later rotated along X-axis to visualise acetabulum end-on where its margin is outlined, and the largest anteroposterior diameter measured (Fig. 2). Then pelvis is rotated again along X-axis to reflect this outline over pelvic brim. Area that falls within these reflected lines represents the acetabular roof. This area is regarded as the 'danger zone' as screw placed within this area risks penetration to the hip joint (Fig. 3). The point at which these lines intersect the pelvic brim is marked as Point B, being the anterior limit of acetabulum/anterior margin of danger zone and Point C representing posterior limit of acetabulum/posterior margin of danger zone. Intra-operatively, surgeons will be able to draw an imaginary 'danger zone' territory based on the distance of these two points from pubic tubercle (Point A). Then the distance

Table I: Demographic and clinical characteristics of the study cohort (n=56).

Variables	n (%)
Age in years (mean ± SD)	37.02 ± 17.23
Gender	
Male	46 (82.1)
Female	10 (17.9)
Race	
Malay	56 (100.0)

Table II: Comparison of QLP measurements between gender (n=56).

Variables	Male Mean (SD)	Female Mean (SD)	Total Mean (SD)	Mean difference (95% CI)	P-value[a]
A to B	33.55 (3.68)	33.18 (3.29)	33.48 (3.58)	0.37 (-2.16, 2.90)	0.772
A to C	91.78 (6.29)	86.41 (6.49)	90.82 (6.61)	5.38 (0.95, 9.80)	0.018
B to C	58.38 (4.04)	53.22 (4.55)	57.46 (4.55)	5.16 (2.27, 8.05)	0.001
A to D	62.05 (4.69)	59.24 (4.54)	61.56 (4.75)	2.81 (-0.45, 6.08)	0.090
XY angle (degree)	26.98 (5.01)	24.99 (2.99)	26.62(4.75)	1.98 (-1.33, 5.29)	0.236

[a]Independent t-test was applied; normality and equal variance assumptions fulfilled. SD = standard deviation, CI = 95% confidence interval. A to B = distance from anterior acetabular margin (point A) to anterior brim point (point B). A to C = distance from point A to posterior brim point (point C). B to C = anteroposterior diameter of the reflected acetabular roof. A to D = distance from point A to midpoint of B-C (point D). XY angle = angular span denoting the high-risk territory for suprapectineal screw placement.

between points ‘A-B’ (distance between anterior limit of danger zone to pubic tubercle), ‘A-C’ (distance between posterior limit of danger zone to pubic tubercle), ‘B-C’ (anteroposterior length of danger zone of acetabular roof) and ‘A-D’ (point D is described in below paragraph- ideal distance of QLP implant from pubic tubercle) are measured respectively. ‘B-C’ represents the largest AP diameter of the acetabulum reflected on the pelvic brim (Fig. 4).

Next, measurement of safe angle of suprapectineal portion of QLP implant was made. This involves measuring X-Y angle. This angle is high risk for intra-articular screw placement. For this, the midpoint between B-C along pelvic brim is first determined and labelled as Point D (Fig. 5). This denotes the central point of acetabulum which is the ideal location for implant placement. A line perpendicular to pelvic brim is drawn from point D towards acetabular roof. This line is labelled ‘X’, denoting the original position of suprapectineal portion of QLP implant which inevitably falls within the ‘danger zone ‘. Then, another line labelled ‘Y’ is drawn from Point D to most lateral part of greater pelvic intersected by posterior margin of danger zone. X-Y angle is then calculated (Fig. 6). Screws placed on the suprapectineal portion of the plate within this angle risk intra-articular penetration. In other words, suprapectineal plate angulation or contouring greater than X-Y angle is required to ensure safe positioning of screw.

Finally, all measurements tabulated in excel spreadsheet and were entered in SPSS Statistical Package for the Social Sciences (SPSS) Version 26 for data analysis. Descriptive statistics and an independent t-test were used for statistical analysis. The data is presented as the mean and standard deviation for the normally distributed numerical variable (age), and frequency and percentage were shown for categorical variables (gender and race).

Independent t-test was applied to identify the mean differences of all items in acetabular roof measurements between the genders. The histogram and Levene’s test for equality of variances were applied to check the normality and equal variance assumptions that need to be fulfilled by the independent t-test. Statistically significant result will be set at $p<0.05$.

This study has been approved by ‘Jawatankuasa Etika Penyelidikan Manusia Universiti Sains Malaysia’ (JEPeM-Universiti Sains Malaysia) (Universiti Sains Malaysia/JEPeM/21090619).

RESULTS

A total of 56 patients met the inclusion criteria. The cohort comprised 46 males (82.1%) and 10 females (17.9%), all of Malay ethnicity. The mean age was 37.02 ± 17.23 years. Demographic details are presented in Table I.

The measurements of danger zone of acetabular roof and its territory outline were using anatomical landmark identifiable during surgery, denoted by length ‘A-B’, ‘A-C’, ‘B-C’ and ‘A-D’. All measurements were observed to be longer in males than in females’ population. Summary of the QLP measurements and its statistical analysis were shown in Table II and illustrated in Fig. 2 – 6. Statistically significant

Fig. 1: (a) Position of the quadrilateral plate on the medial column of the acetabulum. (b) Position of the suprapectineal portion on acetabulum. (c) Position of the plate after plate contouring.

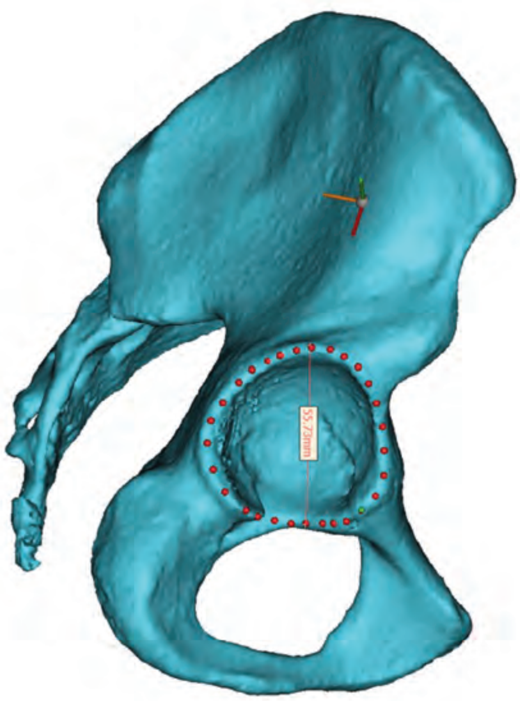

Fig. 2: Acetabular outline and measurement of its largest AP diameter.

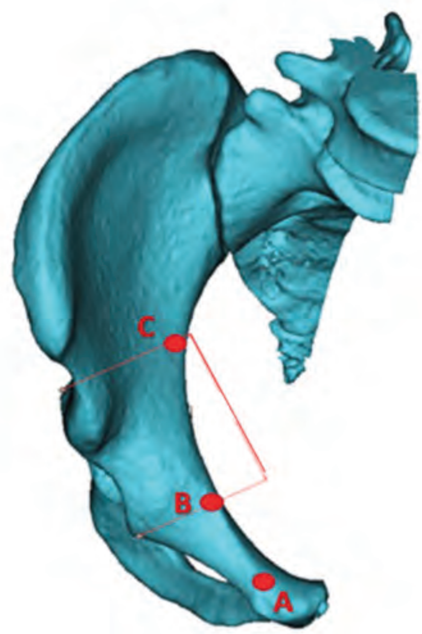

Fig. 3: Reflected line of the acetabular diameter onto acetabular roof.

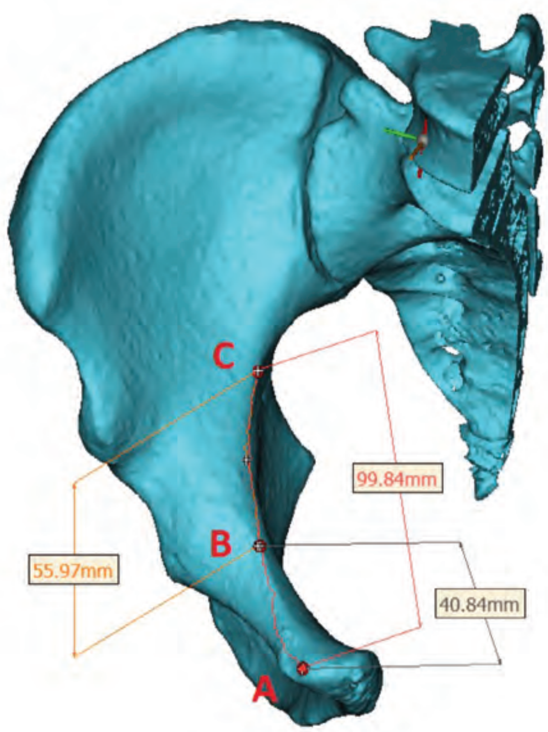

Fig. 4: Measurement of 'A-B', 'A-C', and 'B-C' distance.

sex differences were observed for two measurements, A–C and B-C. Otherwise, there were no significant mean differences in other measurements.

Safe angle of suprapectineal portion of the QLP implant (X-Y angle) was also seen to be greater among males than females. However, T-test analysis showed no significant mean difference for this angle between gender.

The significantly larger A–C and B–C distances in males indicate greater anteroposterior acetabular roof dimensions in male patients within this Malay sample, which may influence choice of implant length and screw selection during QLP fixation. The X–Y angle (mean 26.62° ± 4.75°); Fig. 6, which defines the high-risk angular territory for

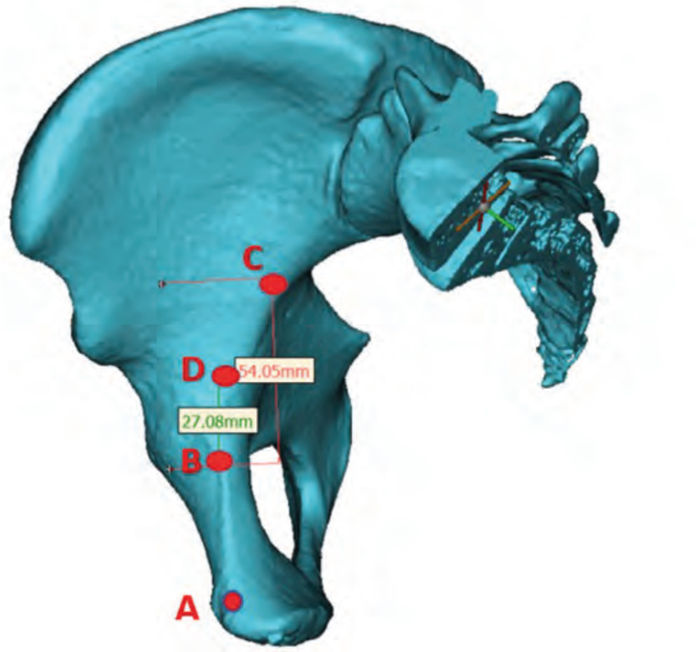

Fig. 5: Point D identification and measurement of 'A-D' distance.

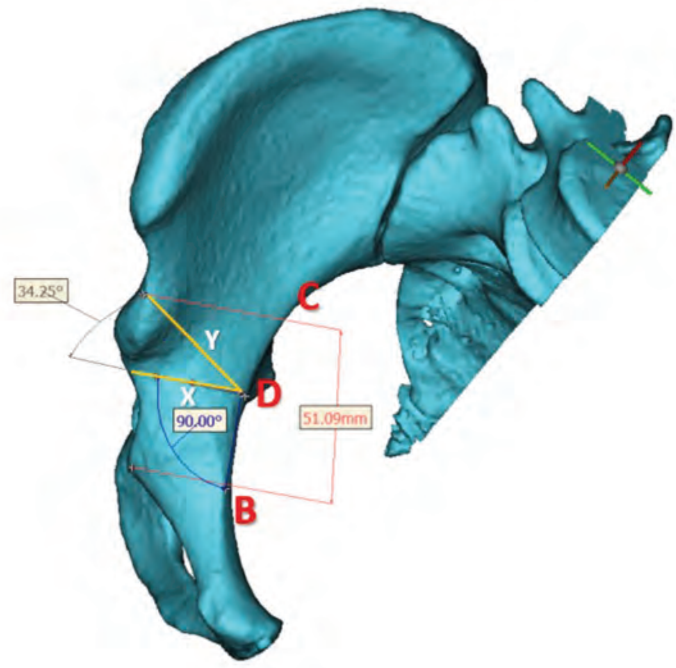

Fig. 6: Measurement of 'X-Y' angle. Noted that line X was drawn perpendicular to the pelvic brim.

suprapectineal screw placement, did not differ significantly by sex; screws placed within this angle risk intra-articular penetration, whereas plate angulation exceeding the X–Y angle is expected to reduce that risk. Representative 3D measurement technique and danger zone delineation are shown in Fig. 2 – 5.

DISCUSSION

Acetabular fractures, particularly those involving the quadrilateral plate (QLP), remain among the most technically demanding injuries in orthopaedic trauma surgery[10]. Before the 1960s, these injuries were managed conservatively using prolonged skeletal traction and extended periods of non-weight-bearing ambulation. However, non-operative treatment frequently resulted in

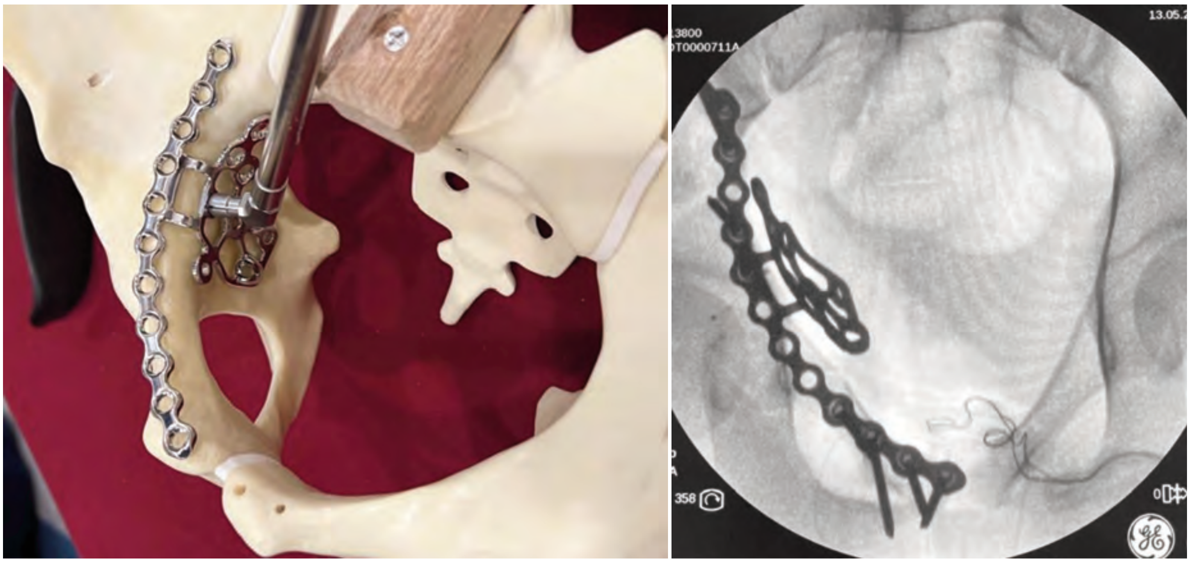

Fig. 7: New Synthes Quadrilateral Surface Plate and its application.

unsatisfactory outcomes, including persistent pain, joint incongruity, and post-traumatic osteoarthritis[5]. Contemporary management emphasises accurate anatomical reduction and stable internal fixation to restore hip joint congruity and prevent secondary displacement[5]. Surgical intervention is now widely recognised as essential for achieving better results. The primary goals of surgical treatment are to achieve precise anatomical reduction and ensure stable fixation, particularly to prevent redisplacement of QLP[6]. Additionally, in managing acetabular fractures, infrapectineal buttressing plays a critical role in stabilising QLP fractures by counteracting medial displacement forces and preventing femoral head subluxation[10,11]. This technique complements column fixation strategies and is integral to achieving optimal outcomes.

One of the significant challenges encountered during intra-operative procedures is the inability to accurately visualise acetabular coverage over the acetabular roof and its corresponding pelvic brim. This limitation raises safety concerns, particularly regarding the potential penetration of the hip joint by screws[5]. Currently, the prevention of intra-articular screw placement relies heavily on intra-operative use of image intensifier, the surgeon's spatial awareness, and a trial-and-error approach[8]. While an image intensifier provides multiple angled views of the pelvis to guide screw fixation, its output is limited to two-dimensional imaging. Egli *et al* recommended utilising advanced intra-operative 3D imaging for better accuracy; this approach demands significant logistical resources and may not be universally available in all hospital settings[5].

A review by Sen *et al* highlights that standard intrapelvic implants are often inadequate for supporting QLP fixation. The primary challenge with standard plates lies in their cumbersome intra-operative contouring, which is necessary to match the anatomical surface of the quadrilateral plate[11]. If performed inaccurately, this process can lead to premature loss of reduction, implant failure, and eventual development of secondary hip osteoarthrtitis[11,12]. Additionally, plate contouring weakens the implant and is time-consuming[11]. To optimise intra-operative efficiency, we utilised a 3D reconstruction model in complex cases by mirroring the unaffected hemipelvis of the affected patient. This model represents the anatomically reduced affected side, allowing us to pre-contour the quadrilateral plate before sterilisation in an autoclave. As a result, the plate is ready for fixation during surgery, significantly reducing intra-operative time.

Recent advancements in biomechanical studies have contributed to the evolution of plate design and configuration for the buttressing effect on QLP surface, such as the standard pelvic plate used as a spring plate or other options like T-plate, H-plate,1/3rd tubular plate, and reconstruction plate with different configurations[10,11]. The concern with these plates is contouring them to the pelvic bone surface intra-operatively, which is both time-consuming and technically demanding[4,11]. Therefore, in recent times, the development of newer anatomical plates, such as anatomical quadrilateral surface plate, acetabular fracture reduction internal fixator, acetabular wing plate, two anatomical pre-shaped plates, and anatomic quadrilateral plate, has reduced the need for contouring but with expense to some loss of reduction in cases of imperfect fitting[11]. Wang *et al* and Kilinç *et al* were using a square bracket-shaped tubular plate, an anatomical plate for the quadrilateral surface, and claimed that the plate was providing better support and stability while at the same time, reducing complications such as intra-articular screw penetration[13,14]. Even though it is 'anatomical', in most of the cases some bending is still required to match the different anatomy of the acetabular region. Apart from that, it has a variable outcome based on clinical trials. Among these, two prominent osteosynthetic constructs available in the Malaysian market are manufactured by Synthes and Acumed. These implants feature a suprapectineal portion that rests on the acetabular roof, which may predispose screws to misplacement into the hip joint. To address this issue, intraoperative bending of the plate is often required. However, the most recent plate by Synthes has incorporated the anterior column plate with a quadrilateral portion of the plate (Fig. 7). This recent plate can provide a better buttressing effect, cover a wider area of the quadrilateral surface, and not require plate contouring. There is no suprapectineal portion of the plate that reduces the incidence of the intra-articular screw penetration. Careful insertion of the screws in the anterior column plate, particularly within the acetabulum region, is required. This study can indirectly guide the surgeon to avoid intra-articular screw insertion in spite of the intra-operative image intensifier guide. However, the cost for this new implant is five times than the standard quadrilateral plate discussed in this study. For a low socioeconomic population, it is going to be a very significant burden to pay for the implant. In my practice, even with the introduction of more anatomically contoured new plate designs, the standard plate is still popular and still able to achieve a satisfactory function.

This study aims to delineate the danger zone on the acetabular roof and determine the optimum angle for the suprapectineal portion of the implant to minimise intra-articular screw penetration. Utilising CT scan combined with 3D pelvic reconstruction, this study provides precise measurements to enhance surgeons' understanding of their acetabular morphology. Furthermore, pre-operative planning incorporating 3D printing technology has demonstrated its efficiency in reducing operative time, minimising blood loss, and ensuring effective fracture management. The importance of proper anatomical plate design for the management of this fracture has been supported by the study by Yoon *et al*, who compared the radiological outcome between the standard reconstruction plate and the anatomical quadrilateral surface plate. He demonstrated that there was 84.2% satisfactory outcome in the patient fixed with an anatomical quadrilateral surface plate and only 57.1% in the other group[15]. His study drew a similar conclusion to the study by Kwak *et al*, who showed that the conventional fixation technique with a reconstruction plate might provide less stability in complex acetabular fractures involving the quadrilateral plate[16]. Another important issue raised by the studies was related to the safety of the plate placement, particularly intra-articular screw penetration. Strong anatomical knowledge about the area around the hip joint is very important to avoid such complications.

In this CT-based morphometric study of acetabular roof measurements among a Malaysian Malay cohort (n=56), we quantified linear and angular parameters that are directly relevant to quadrilateral plate fixation. Our principal findings were that distances B-C and A-C were significantly greater in males than in females, while other measured parameters showed no statistically significant sex differences. Particularly important for B-C measurement, which directly correlates with the length of the danger zone on the acetabular roof. These results suggest sex specific differences in some acetabular dimensions that may have practical implications for implant selection and screw length planning[4,5]. A similar study conducted among the Northern Indian population reported comparable results, showing that the acetabular diameter was larger among males, 59.94mm, than in female; 59.72mm[17]. Comparison with previously published series shows both concordance and differences. Several international CT morphometry studies report similar trends of larger acetabular dimensions in males; however, absolute measurement ranges vary between cohorts, likely reflecting ethnic and anthropometric variation as well as differing landmark definitions and measurement techniques[4-6]. Apart from that, in our study, the danger zone on the acetabular roof was determined based on the distance from the pubic tubercle (Point A). Pubic tubercle was selected as a reference point due to its ease of identification and reproducibility across different surgical approaches.

Clinically, the finding of longer B–C and A–C distances in males suggests that, where appropriate, slightly longer screws or modified plate contours may be used in male patients without increasing the risk of intra-pelvic penetration- but only when guided by pre-operative CT and intra-operative imaging[3,8]. Conversely, the narrower dimensions observed in females reinforce the need for individualised pre-operative planning rather than routine reliance on standardised screw lengths or plate templates[2,5]. For implant designers, our data provide population-specific benchmarks that could inform modular plate sizes or variable screw length options targeted at Southeast Asian anatomies.

The standard QLP implant used in our setting needs to be pre-contoured over its suprapectineal portion to avoid the risk of screw penetration into the hip joint. The limited space within the pelvic cavity poses challenges for anatomical contouring of the plate. Based on our measurement, the minimum safe angle represented by X-Y was 26.98° and 24.99° for males and females, respectively. This information can guide future modifications of the existing implant design to enhance its safety and usability. The main problem in our practice is to position the plate flush to the superior pelvic brim after plate contouring. This procedure requires some intraoperative time, and sometimes the infrapectineal portion needs to be adjusted to achieve a good bone-to-plate contact. This will predispose to failure of reduction and inadequate buttressing effect of the plate. So, by having a good objective measurement of the danger zone and safety angle, a proper anatomical plate can be designed and tested. Additionally, further investigations are necessary to evaluate implant rigidity and stability following QLP fracture fixation using the proposed design modification.

Quadrilateral plate fractures among the elderly population pose a significant challenge due to poor quality of bone. Stability of the fixation without a locking plate is the main concern. The standard reconstruction plate has two available options: a non-locking and a locking plate. However, the locking plate is commonly stiffer and needs to be pre-contoured before the fixation, making it less popular to use. An anatomical quadrilateral plate, which commonly has locking features, would give better fixation stability in osteoporotic fractures. This problem has been addressed by a few studies, which demonstrated that the majority of the patients treated with standard reconstruction plates would eventually end up with hip replacement surgery due to implant failure and loss of initial stability, which leads to painful osteoarthritis due to joint incongruency[18-20].

The primary strength of this study lies in its use of a 3D pelvic model to accurately measure normal pelvic anatomy. This approach ensures precise and reliable measurements of the acetabulum. The measurement technique is straightforward and can be easily replicated using widely available software equipped with basic commands and measurement tools. Furthermore, this study focuses on the Malaysian population, providing valuable insights into acetabular morphometry specific to the local demographic. These findings can assist surgeons in pre-operative planning for not only acetabular fractures but also other hip-related surgeries, ultimately contributing to improving patient outcomes.

Our study has several limitations. First, the cohort consisted exclusively of Malay patients from a single institution, which limits the generalisability of the findings to Malaysia’s multiethnic population and to other geographic regions. Second, the sample size was relatively small, particularly with respect to female subjects, which may have reduced the power to detect clinically meaningful sex-based differences. Although statistically significant differences were observed for certain measurements, the magnitude of these variations was modest and may not warrant gender-specific implant modifications.

Third, the safe screw trajectory was simplified by assuming a perpendicular orientation relative to the pelvic brim, which may not fully represent the range of trajectories used in clinical practice. More complex angular adjustments may further refine safe screw placement and help avoid potential danger zones. Finally, the morphometric findings were not validated through cadaveric studies, biomechanical testing, or three-dimensional printed simulation models.

Future studies should include larger, multiethnic cohorts to better characterise anatomical variability within the Malaysian population and to determine the clinical relevance of sex-related differences. Additional cadaveric, biomechanical, and 3D-printed model studies are warranted to validate these measurements and to support the development of improved implant designs and surgical techniques for quadrilateral plate fracture fixation.

CONCLUSION

Fractures involving the quadrilateral plate surface require precise anatomical reduction and stable fixation. Current implant designs often require pre-contouring to minimise the risk of intra-articular screw penetration. In this CT-based three-dimensional morphometric analysis of the acetabular roof in a Malay cohort, the mean X–Y angle was 26.62° ± 4.75°. Placement of the suprapectineal portion of the quadrilateral surface plate within this angle carries a risk of intra-articular screw penetration. Therefore, the X–Y angle serves as a useful intra-operative guide for plate contouring and safe screw placement.

In addition, this study provides population-specific morphometric parameters of the acetabular roof that may assist surgeons in pre-operative planning and implant selection. The observed sex differences in the A–C and B–C measurements may have implications for implant length and contouring. However, because the study was limited to a single-ethnicity cohort from one institution, these findings should not be generalised to the broader Malaysian population without further validation in larger, multiethnic studies.

CONFLICT OF INTEREST

The authors declare no potential conflict of interest.

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