Determining the Accuracy of Two Pelvic Ring Classification Systems: AO Tile and Young Burgess- A Systematic Review

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Abstract: Pelvic ring fractures (PRF) are high energy fractures with an incidence of 20/100,000 among all fractures and significant associated morbidity and mortality. PRF are often classified using Young-Burgess classification, and Tile AO classification. This project aims to review the literature comparing the two classification systems for reliability, clinical implications and guide for treatment plan. Google Scholar search was performed with the following words: "Young", "Burgess", "Tile", "presentation", "treatment", "pelvic ring" in the Title/Abstract. After review of 828 results, 11 articles are included in this systematic review. Reliability of the classification systems positively correlated with an increase in years of experience. When comparing the reliability, Young-Burgess is shown to have moderate-to-substantial level of agreement for classifying pelvic fractures when accounting for expertise level, while Tile showed substantial agreement between specialists only. Young-Burgess better predicted mortality as compared to Tile, while another study found no significant difference. Tile B and LC fractures are found to have higher frequency of hemodynamic instability and undergo laparotomies more frequently. When comparing treatment options, there is a moderate level of agreement for the treatment option solely based on images. However, the question of how the classifications guide treatment outcomes remains unanswered. After review of current literature, it appears that Young-Burgess classification has slightly higher reliability and better prediction for mortality than Tile. However, there is a need for further research on how the classification systems can determine the treatment and outcomes to improve morbidity and mortality.

Keywords: Pelvis, Pelvic ring, Pelvic ring fractures, Tile/AO, Trauma, Young-Burgess.

INTRODUCTION

Pelvic ring fractures (PRFs) are some of the common fractures in the elderly. Some population based studies stated the prevalence of pelvic ring fractures to be 20 per 100,000 individuals [1]. The incidence of pelvic ring fractures is estimated to be 2-8% of all fractures [2]. The mechanism of pelvic fracture is different in young adults and the elderly. Pelvic ring fractures are often due to high energy traumas such as motor-vehicle accidents in young adults, low energy blunt traumas, such from falling from one's own height, in the elderly [2]. To determine the appropriate treatment for these fractures, the pelvic ring fractures are often classified into the Young-Burgess classification system, and the Tile AO Classification.

The Young Burgess (YB) Classification was developed in 1986. This system uses the vector of force applied to the pelvic ring to classify the different pelvic fractures. The three different forces that are applied are lateral compression, anterior-posterior compression, and vertical shear force (see Table **1** [3]) [4]. On the other hand, the Tile Classification was developed in 1980. This system is based on the stability of the pelvic ring. It is divided into Type A, Type B, and Type C (see Table **2** [5]) [6]. This systematic review compares the reliability and predictability of Tile and Young-Burgess classification systems.

METHODS

Using a systematic approach, Google Scholar search was performed using various key words: "Pelvic ring fractures classification Young-Burgess Tile" in the Search bar. The search led to 828 results. Only studies on humans and written in English were included. Excluded opinion pieces, commentaries, only included either Young-Burgess classification or Tile/AO classification, case reports and irrelevant topics. Excluded studies that had irrelevant study objectives that included other fractures, wrong population such as pediatric population, wrong publication type such as book chapter and case reports, and wrong study design. After a two-tier review process, 11 articles are

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included in this review. The present systematic review adheres to the PRISMA guidelines. The PRIMSA flowchart is shown in Figure **1**.

Table 1: Young-Burgess Classification

Type	Description
Lateral Compression (LC)	LC I: Oblique or transverse ramus fracture and ipsilateral anterior sacral ala compression fracture LC II: Rami fracture and ipsilateral posterior ilium fracture dislocation (crescent fracture) LC III: Ipsilateral lateral compression and contralateral open-book fracture (APC III)
Anterior-Posterior Compression (APC)	AP I: Symphysis widening < 2.5 cm AP II: Symphysis widening > 2.5 cm. Anterior sacro-iliac (SI) joint diastasis. Posterior SI ligaments intact. Disruption of sacrospinous and sacrotuberous ligaments. AP III: Disruption of anterior and posterior SI ligaments (SI dislocation). Disruption of sacrospinous and sacrotuberous ligaments
Vertical Shear (VS)	Symphyseal diastasis or vertical displacement in anterior or posterior directions, typically through SI joint, but occasionally through the sacrum or iliac wing

Table 2: Tile/AO Classification

Type	Description
Type A: Anterior arch only	A1: Avulsion injury A2: Anterior arch or Ala of ilium A3: Across (transverse fracture) the Ala of sacrum or coccyx
Type B: Rotationally unstable, vertically stable	B1: Open-book injury (external rotation) B2: Lateral-compression injury (internal rotation) B2-1: Ipsilateral anterior and posterior injuries B2-2: Contralateral (bucket-handle) injuries B3: Bilateral
Type C: Vertically unstable	C1: Unilateral C1-1: Iliac fracture C1-2: Sacroiliac fracture-dislocation C1-3: Sacral fracture C2: Bilateral, with one side type B, one side type C C3: Bilateral

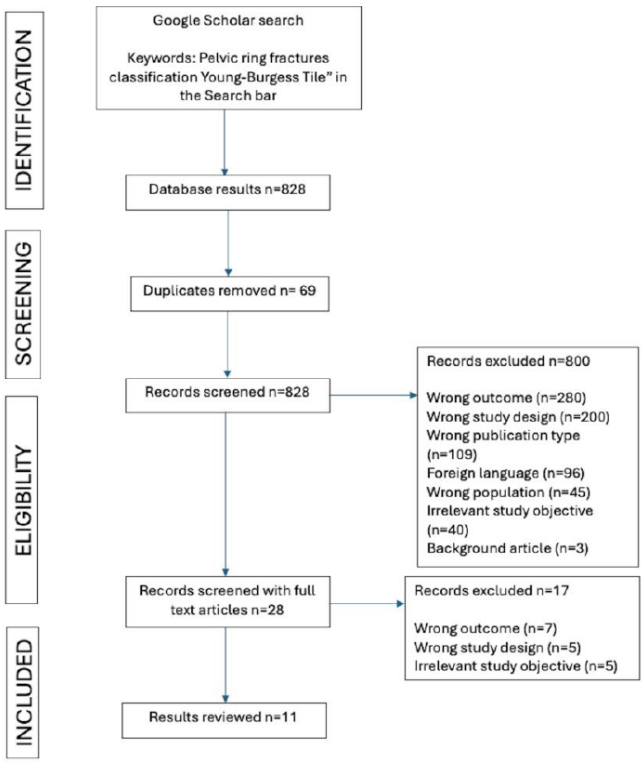

Figure 1: demonstrates the PRISMA flow diagram. It shows the method used for this systematic review.

RESULTS

After review of 828 records, 11 articles are reviewed and included in this systematic review. Table **3** describes the studies that compared the reliability of using Young-Burgess and Tile/AO classifications to classify pelvic ring fractures. Table **4** summarizes studies that investigated how strongly each classification system can predict mortality due to pelvic ring fractures. Table **5** summarizes the studies that compare the usefulness of classification systems to determine treatment modality for pelvic ring fractures.

DISCUSSION

Pelvic ring fractures can have a high mortality. Classifying them and treating them accordingly is necessary for increased survival of the patient. The Young-Burgess and Tile/AO classification systems are often used for treatment of the pelvic ring injuries.

As mentioned in the Table **3**, some of the studies measured reliability of the two classification systems using kappa value, which has is measured from 0 to 1, where 0 means complete disagreement and 1 means complete agreement. Koo H, *et al*. used 30 sets of pelvic ring fracture images were reviewed by two speci-

Table 3: Studies Comparing Reliability of Tile/AO and Young-Burgess Classification Systems

Article	Type of Study	Summary
Koo H, *et al*. [7]	Retrospective study	• 30 sets of PRF images were reviewed by two specialists, two trauma surgeons, and two fellows from the same facility. • Interobserver agreement was substantial (kappa = 0.72) for YB, while it was fair (kappa = 0.30) for Tile with plain radiographs (Figure **2**). • With CT scan, the kappa value for Tile increased (kappa= 0.33) and kappa value decreased slightly for YB (kappa= 0.63) (Figure **2**). • Addition of CT scan increased reviewer interpretation of fracture stability from kappa value of 0.59 to 0.93.
Furey AJ, *et al*. [8]	Retrospective study	• 89 sets of PRF injury images were randomly assigned to five orthopedic surgeons from a single level 1 trauma center. • Interobserver agreement for PRFs classification was substantial with YB classification (kappa= 0.72) and moderate with Tile classification (kappa= 0.47) (Figure **3**). • Interobserver reliability was moderate (kappa= 0.61) for PRFs when classified using YB subtype classification (such as LC1, AP1 etc) (Figure **3**).
Gabbe BJ, *et al*. [9]	Retrospective study	• Three experienced orthopedic surgeons from different trauma centers reviewed PRFs. • They found that there is low interobserver reliability using Young-Burgess and Tile Classification systems for classifying PRFs. • Reasons for discrepancy from other research findings: o Use of less views for imaging. According to Australia Advance Trauma Life Support (ATLS) guidelines, only AP view of the pelvis is recommended if CT scan is available. Hence, there was less imaging used to classify the fractures compared to other studies. o The PRFs included in this study were more complicated and "difficult" to classify compared to other studies. o The study included surgeons from different trauma centers.
Berger-Groch J, *et al*. [10]	Retrospective study	• Two specialist pelvic trauma surgeons, a resident and a student reviewed 35 CT scans of PRFs. For intraobserver reliability, they reviewed the CT scans two months apart. • Interobserver agreement was fair for YB (kappa= 0.42), Tile (kappa= 0.55), and Rommens system (kappa= FFP) (0.54). The agreement increased, *i.e*. kappa value increased, if only experienced surgeons were included (Figure **4**). • Intraobserver reliability was weak to moderate for Tile (kappa= 0.36), YB (kappa= 0.39), and FFP (kappa= 0.46).

Table 4: Studies Comparing Predictability of Tile/AO and Young-Burgess Classification Systems in Terms of Mortality and Stability

Article	Type of Study	Summary
Osterhoff G, *et al*. [11]	Retrospective study	• 285 patients with PRFs were evaluated by two senior residents at a Level 1 trauma center. The study excluded pelvic avulsion fractures (Tile A1), isolated anterior arch fractures (Tile A2), and transverse sacral fractures (Tile A3) since they cannot be classified using the YB classification system. • The study divided the subtypes of both classification systems into: o "Partially stable" fractures: Tile B1, B2, B3 and YB LC I and APC I. o "Unstable" fractures: Tile C1, C2, C3 and YB LC II, LC III, APC II, APC III, and VS. • Predicting Mortality: o The study found no clinically relevant differences between YB and Tile with regards to predicting mortality. o However, the "unstable" YB fractures had high mortality compared to "partially stable" YB fractures. o There was no statistically significant difference between "unstable" and "partially stable" Tile fractures in terms of mortality.

		● Blood Transfusion/total fluid infusion requirement: ○ There was a significant relationship between fracture type and need for blood transfusion/fluids. Unstable fracture types required more total fluid and blood units than stable fractures for both classification systems. ○ There was an increase in need for blood transfusion Tile C1 to Tile C3 (the need increased with increase in level of fracture of type). Tile B1 fracture required 5200 mL more total fluid and 2 more units of blood then Tile B2 fractures. ○ There was an increase in need for blood transfusion YB L1 to L3 and APC 1 to APC 3 (the need increased with increase in level of fracture of type). Patients with APC fractures required 4100 mL more total fluid than patients with LC fractures. ● Concomitant injuries: ○ Unstable fracture types had significantly higher Abbreviated Injury Severity (AIS) than stable fractures for both classification systems. ○ YB APC fracture pattern had higher AIS scores than YB LC fracture pattern. ○ Tile B1 fractures had more severe abdominal, spine and extremities' injuries than Tile B2 fractures.
Ruatti S, *et al*.[12]	Retrospective study	● 179 patients were classified using YB, Tile, Letournel, Denis. Then the patients were divided into embolized (E) and non-embolized (NE) groups. ● Tile C had an increased incidence of arterial bleeding and needed embolization. ● There was no significant difference between E and NE with YB classification. ● This study concluded that Tile was better suited for predicting embolization for PRFs than YB.
Cortina Gualdo J, *et al*. [13]	Retrospective study	● 100 patients with PRFs were classified into YB and Tile and evaluated. ● The study divided the subtypes of both classification systems into: ○ "Stable" fractures: Tile A (A1, A2, A3), B1 and YB LC I and APC I. ○ "Unstable" fractures: Tile B1, B2, C1, C2, C3 and YB LC II, LC III, APC II, APC III, and VS. ○ Calculations were done with LCII being considered as a "stable" fracture type. ● No statistically significant association between hemodynamic instability and pelvic fracture pattern for both classification systems (with LCII as stable and unstable fracture type). ● Tile and YB classifications were not predictive of mortality (not statistically significant association). However, Tile B and YB APC fractures had the highest mortality rate in their respective classification systems.
Ashkal A, *et al*.[14]	Retrospective study	● 325 patients with PRFs were reviewed and classified using YB and Tile classification systems. They also cross-tabulated the classification systems (Figure **5**). ● YB LC and Tile B were shown to be more hemodynamically unstable. ● Study found that YB classification had greater accuracy (statistically significant) in predicting death than Tile classification. ● Limitation: The study had small sample size for Tile A, Tile C, YB APC, and YB VS.

Table 5: Studies Comparing Treatment Modalities for Tile/AO and Young-Burgess Classification Systems

Article	Type of Study	Summary
Karl-Ludwig Klingebiel F, *et al*. [15]	Clinical study	● The study classified APC II, APC III, VS, Tile B and Tile C as unstable fractures. The study conducted a survey worldwide to determine the level of agreement regarding treatment of unstable PRFs. ● Majority of trauma surgeons worldwide indicated routine pelvic binding use for initial stabilization. In addition, most surgeons report temporizing stabilization of pelvic ring with external fixation for unstable fractures. ● Most surgeons indicated utilizing minimally invasive surgical techniques for definitive fixation of unstable PRFs.

Furey AJ, *et al*.[16]	Prospective agreement analysis	● 89 randomized images were selected based on variety of isolated fractures. Five orthopedic surgeons (fellowship training at the same institution with different levels of experience) were asked to classify the PRFs using Tile and YB classification systems independently and summarize the treatment plans. ● There was moderate (kappa= 0.47) level of agreement for treatment plans based on radiographic assessment. The level of agreement for treatment plans increased (kappa= 0.56) when the radiographs were reviewed eight weeks later. ● Consistency in treatment plans for APC I, APC III, VS LC I, Tile A, and Tile C. Significant variability in treatment plans for LC II, LC III, APC II, and Tile B fractures.
Halawi MJ, *et al*. [17]	Literature review	● This review article suggests that YB APC I and LC I are commonly treated nonoperatively since they are considered stable. ● The author indicates that APC II, APC III, LC II, and LC III require surgical intervention due to rotational instability. In addition VS needs surgery for treatment due to rotation and vertical instability. VS is often treated with external fixation with or without skeletal traction as a temporizing measure until definitive fixation because of hemodynamic instability. ● APC II can be definitively treated with an external fixator for 8-12 weeks. ● APC III can be treated with a modified external fixator with a second anterior articulation (X-frame) to provide more posterior compressive forces. ● Treating Tile B1 and C fractures with posterior screw fixation allowed 86% of patients to return to pre-injury activities.
Cortina Gualdo J, *et al*. [13]	Retrospective study	● 100 patients with PRFs were classified into YB and Tile and evaluated. ● The study divided the subtypes of both classification systems into: ○ “Stable” fractures: Tile A (A1, A2, A3), B1 and YB LC I and APC I. ○ “Unstable” fractures: Tile B1, B2, C1, C2, C3 and YB LC II, LC III, APC II, APC III, and VS. ○ Calculations were done with LCII being considered as a “stable” fracture type. ● There was a statistically significant association between application of external fixator and unstable Tile fractures. ● There was statistically significant association between application of external fixator and unstable YB fractures only if LC II was considered a stable fracture pattern.

alists, two trauma surgeons, and two fellows from the same facility. The study measured the inter- observer and intra-observer reliability of Tile/AO classification and Young-Burgess classification with and without using CT scan for PRFs [7]. The agreement among observers in classifying pelvic fractures using the Young-Burgess (YB) and Tile classification systems varies. Without CT scans, the Young- Burgess classification shows a moderate to substantial level of agreement, while the Tile Subgroup classification demonstrates a slight to moderate level of agreement. With CT scans, the agreement in the Young-Burgess classification decreases slightly, while the agreement in the Tile Subgroup classification increases slightly. Overall, the Young-Burgess classification system tends to exhibit better agreement among observers compared to the Tile classification system, and the presence of CT scans may influence the agreement levels to some extent (Figure **2**) [7]. In addition, Furey AJ, *et al*. utilized 89 sets of PRF injury images, which were randomly assigned to five orthopedic surgeons from a single Level 1 trauma center. These surgeons classified the images using Young- Burgess classification with and without subtypes and Tile/AO classification [8]. They concluded that agreement among the surgeons varies across the different classification systems. The use of Young-Burgess classification with no subtypes demonstrates relatively higher agreement among the surgeons, with kappa values of 0.64 to 0.76. The use of Young-Burgess classification with subtypes also shows moderate agreement, with kappa values of 0.52 to 0.69. However, the Tile classification system exhibits slightly lower agreement, with kappa values of 0.25 to 0.56 (Figure **3**) [8]. On the other hand, Berger-Groch J, *et al*. had two specialist pelvic trauma surgeons, a resident and a student reviewed 35 CT scans of PRFs. For intraobserver reliability, they reviewed the CT scans two months apart [10]. Senior 1 observer had better intraobserver reliability across both classification systems, while Resident and Student observers demonstrate low intraobserver reliability across both

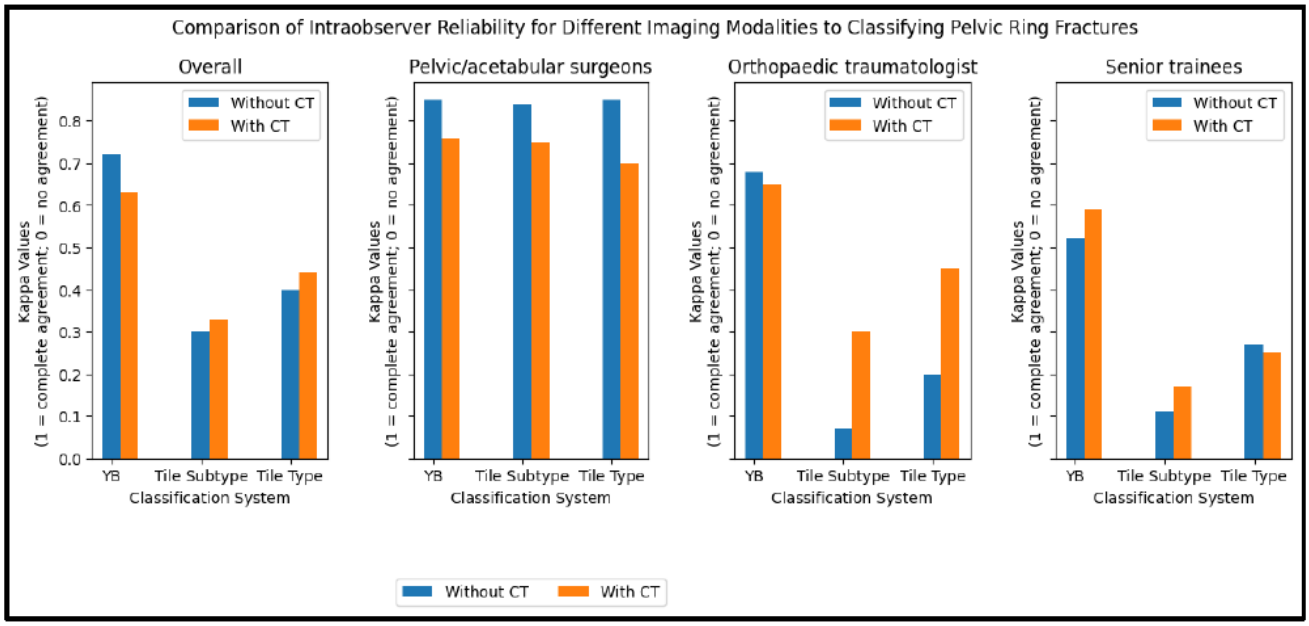

Figure 2: Based on the kappa values, the agreement among observers in classifying pelvic fractures using the Young-Burgess (YB) and Tile classification systems varies. Without CT scans, the Young- Burgess classification shows a moderate to substantial level of agreement, while the Tile Subgroup classification demonstrates a slight to moderate level of agreement. With CT scans, the agreement in the Young-Burgess classification decreases slightly, while the agreement in the Tile Subgroup classification increases slightly. Overall, the Young-Burgess classification system tends to exhibit better agreement among observers compared to the Tile classification system, and the presence of CT scans may influence the agreement levels to some extent [7].

classification systems. Overall, Young-Burgess classification system had a higher inter-observer reliability because of higher kappa values (Figure **4**) [10]. Furthermore, Gabbe BJ, *et al*. had three experienced orthopedic surgeons from different trauma centers reviewed PRF images using Young-Burgess and Tile/AO classifications. The study found that there is low interobserver reliability using Young-Burgess and Tile classifications for PRFs. They attributed this discrepancy in the results compared to other study findings to the limited number of images reviewed and the high complexity of the PRFs classified in the study [9].

Another component of this systemic review is comparing the predictability of mortality and need hemodynamic stabilization with using Young-Burgess and Tile/AO classifications for pelvic ring fractures. Osterhoff G, *et al*. had 285 patients with PRFs were evaluated by two senior residents at a Level 1 trauma center. The study determined that there was no significant clinical difference between Tile/AO classification and Young-Burgess in terms of predicting mortality [11]. Ruatti S, *et al*. had 179 patients classified using Young-Burgess, Tile/AO, Letournel, and Denis classifications. The study determined that Tile was better suited for predicting embolization for PRFs than YB [12]. Cortina Gualdo J, *et al*. reviewed 100 patients with PRFs and found that there was no statistically significant association between hemodynamic instability and pelvic fracture pattern for both classification systems. In addition, the study found that Tile and YB classifications were not predictive of mortality as there was not statistically significant association [13]. However, Ashkal A, *et al*. reviewed 325 patients with PRFs and found that Young-Burgess classification had greater accuracy in predicting death than Tile classification [14]. In addition to determining the usefulness of the classification systems for predictability mortality and stabilization, one study also investigated the overlap between the classification systems. The results of the cross-tabulation of pelvic ring fractures using both classification systems. The cross-tabulation results provides insights into the relationship between the Young-Burgess Classification (LC, APC, VS) and the Tile Classification (Tile A, Tile B, Tile C) systems. It highlights the predominant classifications for each category and allows for comparisons between different classifications within the same category. Additionally, it's worth noting that the

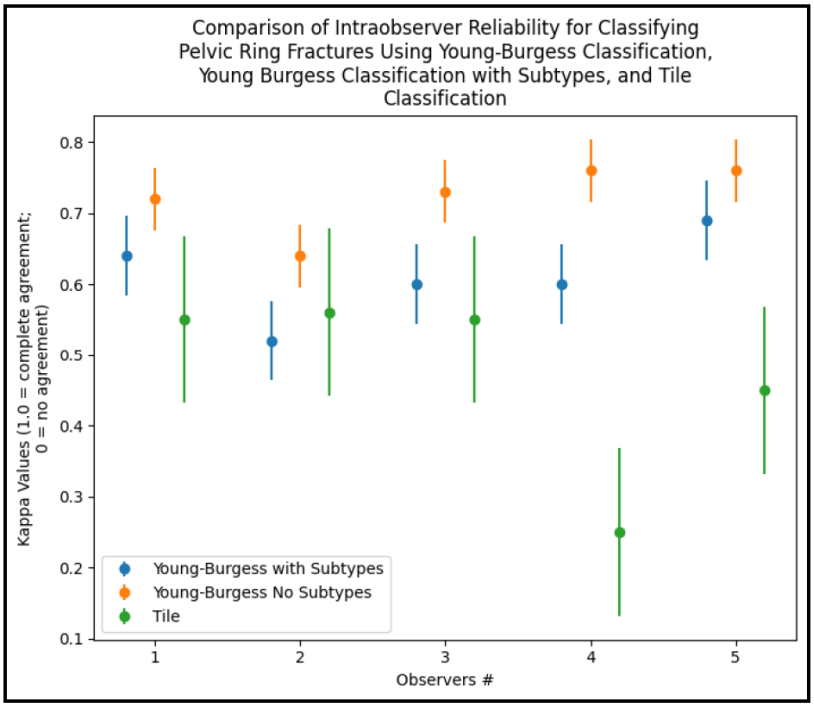

Figure 3: Agreement among the surgeons varies across the different classification systems. The Young-Burgess No Subtypes classification demonstrates relatively higher agreement among the surgeons, with kappa values of 0.64 to 0.76. The Young-Burgess with Subtypes classification also shows moderate agreement, with kappa values of 0.52 to 0.69. However, the Tile classification system exhibits slightly lower agreement, with kappa values of 0.25 to 0.56 [8].

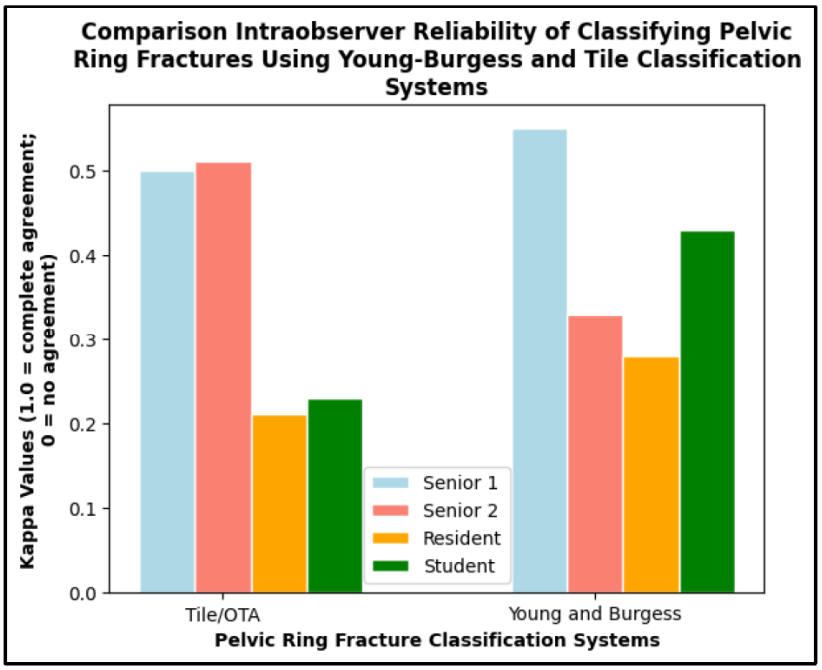

Figure 4: The kappa values indicate the agreement levels among different observers for classifying pelvic fractures using the Tile/OTA and Young and Burgess classification systems. Senior 1 shows the highest agreement across both systems, while Resident and Student observers demonstrate lower agreement levels. Overall, Senior 1 exhibits better consistency in fracture classification compared to the other observers. Young-Burgess classification system has a higher intra-observer reliability because of higher kappa values [10].

results suggest a strong association between VS and Tile C, as all VS cases were classified as Tile C (Figure **5**) [14].

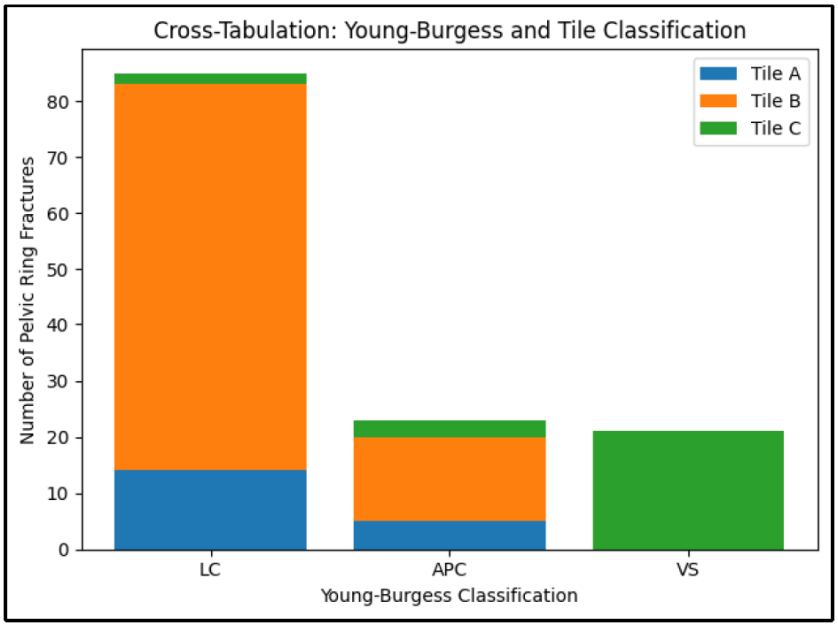

Figure 5: This cross tabulation provides insights into the relationship between the Young-Burgess Classification (LC, APC, VS) and the Tile Classification (Tile A, Tile B, Tile C) systems. It highlights the predominant classifications for each category and allows for comparisons between different classifications within the same category. Additionally, it's worth noting that the results suggest a strong association between VS and Tile C, as all VS cases were classified as Tile C [14].

Furthermore, the systematic review also reviewed and compared the usefulness of Young-Burgess and Tile/AO classification systems to determine treatment plans. According to the clinical study by Karl-Ludwig Klingebiel F, *et al*., majority of trauma surgeons worldwide indicated routine pelvic binding use for initial stabilization and use temporizing stabilization of pelvic ring with external fixation for unstable fractures. In addition, most surgeons indicated utilizing minimally invasive surgical techniques for definitive fixation of unstable PRFs [15]. Furey AJ, *et al*. had 89 randomized images for PRFs reviewed by five orthopedic surgeons (fellowship training at the same institution with different levels of experience). They classified the PRFs using Tile/AO and Young-Burgess classification systems independently and summarized the treatment plans. There was moderate (kappa= 0.47) level of agreement for treatment plans based on radiographic assessment. The level of agreement for treatment plans increased (kappa= 0.56) when the radiographs were reviewed eight weeks later [16]. Halawi MJ, *et al*. summarized that APC II, APC III, LC II, and LC III require surgical intervention due to rotational instability, and that Tile B1 and C fractures that are fixed with posterior screw fixation allowed 86% of patients to return to pre-injury activities [17]. Furthermore, Cortina Gualdo J, *et al*. had 100 patients with PRFs classified into Young- Burgess and Tile/AO classifications. The study summarized that statistically significant association between application of external fixator and unstable Tile fractures and unstable Young-burgess fractures only if LC II fracture was considered stable fracture [13].

CONCLUSION

Overall, YB and Tile classification systems are reliable classification systems for PRFs. They can often be used to predict mortality and hemodynamic instability if they are classified as “unstable” and “stable” fracture patterns. In addition, classifying YB and Tile subtypes into “unstable” and “stable” fracture patterns can also help with associating concomitant injuries and treating them accordingly. However, there is no significant evidence regarding all YB and Tile subtypes predicting treatment plan and outcomes. In addition, there is limited standardization of treatment options for all the different YB and Tile subtypes. Further studies need to be conducted to determine the standard treatment plans for each of the fracture subtypes and associated outcomes for both classification systems. This can have educational value for residents who are training as well as limit any discrepancy in outcomes between patients.

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CONFLICT OF INTEREST

The Author(s) declare(s) that there are no relevant financial or non-financial competing interests to report.

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