Reliability and accuracy of roentgenographic measures in determining the degree of comminution of femoral shaft fractures

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Objective: *The aim of this study was to evaluate both the reliability and accuracy of plain and high resolution radiographs in determining the degree of comminution of femoral fractures.*
Methods: *Eighteen patients were selected for evaluation of femoral fracture using plain and high resolution radiography, followed by computerized tomography (CT) with reconstruction. Three groups of assessors included four orthopedic members of staff, four senior residents, and four junior residents (first and second year). Consensus agreement of the staff reading the CT scans was considered as "the gold standard".*
Results: *The accuracy in determining the degree of comminution of plain radiography was 45.8%, 70.8% and 70.8% for junior resident, senior resident and staff, respectively. Those for high resolution radiography were 50.0%, 68.0% and 73.6%. Interobserver reliability in both plain and high resolution radiography was moderate in both the senior resident and staff groups, but only fair among the junior residents. The intraobserver reliability in the staff group was substantial in both types of x-rays.*
Conclusion: *The difference in accuracy and reliability between plain and high resolution radiographs is marginal when used to define the degree of comminution of femoral shaft fracture, except when interpreted by assessors with less experience.*

Key words: *Reliability, accuracy, comminution, femoral fracture*

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Femoral shaft fracture is common among major fractures[1,2]. The femur is a main weight bearing bone, hence treatment using a poor choice of implant can have serious consequences[3-7]. Two types of implant recommended: plating and nailing. Nailing is preferable because of its mechanical advantage over plating. Two f nailing systems are available: static and dynamic. Static nailing is designed for use in casse where axial stability of the fracture is lost, such as happens in patients with severe fracture comminution. Dynamic nailing is designed to allow some axial motion at the fracture site, and recommended for those fractures having minimal fracture comminution. Plain radiographs are the norm when assessing the degree of comminution. According to the recommendation of Winquist and Hansen[8], if there is cortical abutment more than 50%, the dynamic nailing system is recommended; whereas if cortical abutment is less than 50%, static nailing is preferred. However, previous studies *E-* have reported on a complication: femoral shortening up to two centimeters in patients whose femoral fracture treated by nailing[5-8]. This problem occurs because of misinterpretation of the degree of comminution, and thus an inappropriate selection of the type of nail. The objective of this study was to compare the accuracy and reliability of plain and high resolution radiographs when determining the degree of comminution of femoral shaft fractures.

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Material and Method

This study was a test of diagnostic reliability. It was approved by the Ethics Committee of the Faculty of Medicine, Prince of Songkla University. All patients gave written, informed consent before participation. Study patients included those with a femoral shaft fracture between 2 cm. below the lesser trochanter and 5cm. above the adductor tubercle. The age-range was from eighteen to sixty years. Patients previously treated with internal fixation of the femur, those having pathological fractures, those

pregnant, or needing other emergency care were excluded from the study.

Each patient was evaluated using all three techniques: plain radiography, high resolution radiography, and computerized tomography with 3-D reconstruction (Fig.1). All studies were undertaken by a trained technician. The technique and distance (40 inches) were fixed. The high resolution radiograph was generated by modifying the plain radiograph using computed radiography (Software FUJI CR console ID: 114Y5342001 version: A11-12). This "edge enhance technique provides fine bone tissue contrast (Fig.2).

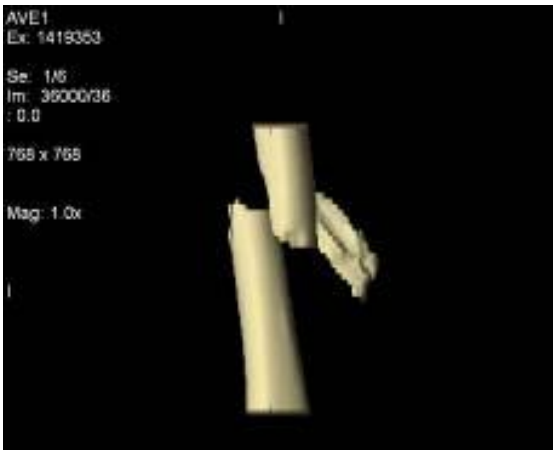
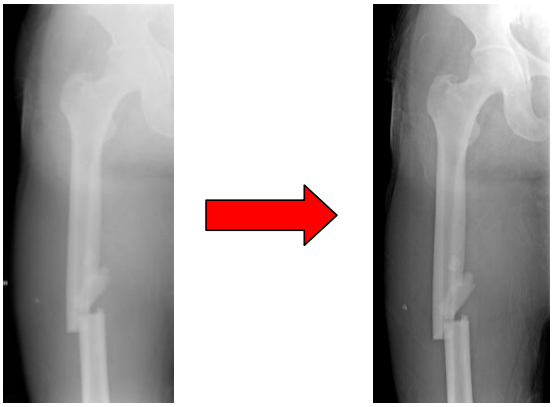


Fig. 1 CT scan with 3-D reconstruction

Three groups of assessors were involved in the evaluation process: four orthopedic staff members, four senior residents, and four junior residents. All assessors were informed of the process prior to starting the evaluation. Each assessor evaluated the radiographs of all sest to determine the degree of comminution, which was categorized into 4 level: 0-24.9%, 25-49.9%, 50-74.9%, and 75-100%.



Plain film **High resolution film**

Fig. 2 Process of transformation of a plain radiograph, using the edge enhance technique to produce a high resolution radiograph.

The concordance result of CT scan 3-D reconstruction interpreted by four orthopaedic staff members was used as a gold standard. The evaluation of each assessor was independent and blind, as to the clinical results. The assessments were repeated in every group with 1-month intervals to assure intraobserver consistancy.

Statistical analysis

The accuracy of plain and high resolution radiograph assessment in each assessor group was calculated by cross tabulation, using 3-D computerized tomography as a gold standard. Kappa statistics were used to test the reliability of both investigations in each assessor group. The agreement was categorized into six levels, according to Landis and Koch[9]: poor: less than 0.00, slight: 0.00-0.20, fair: 0.21-0.40, moderate: 0.41-0.60, substantial: 0.61-0.80, perfect: more than 0.80.

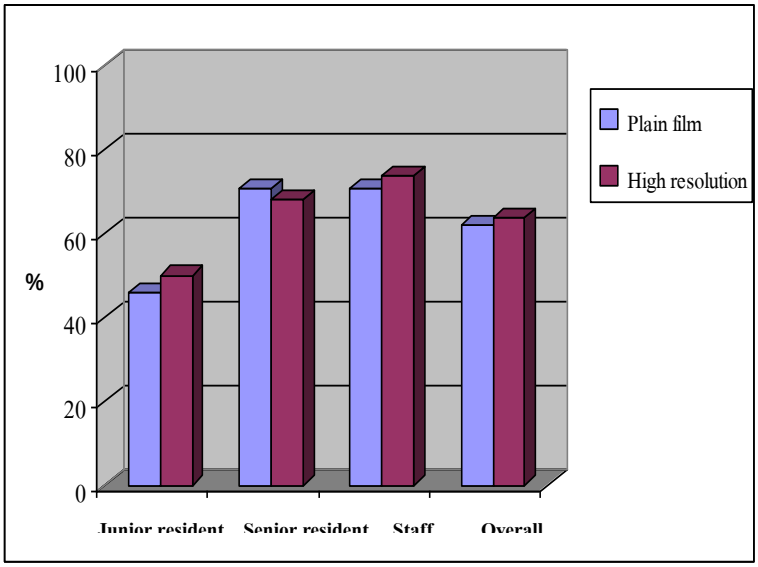


Fig. 3 Accuracy in determination of the degree of comminution of femoral shaft fracture in each assessor group

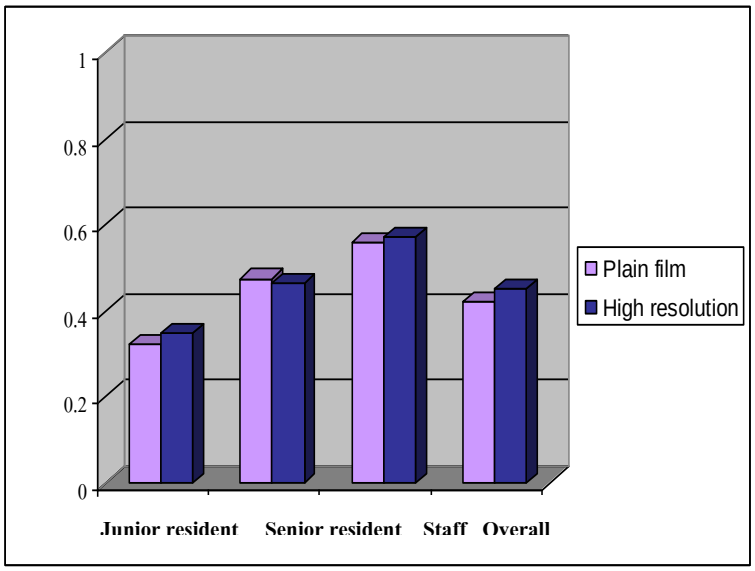


Fig. 4 Interobserver reliability between assessor groups

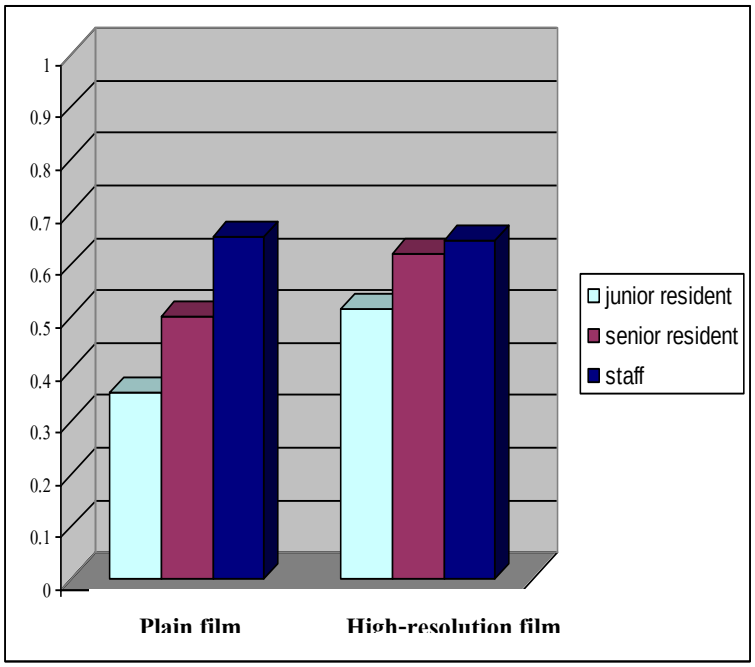


Fig. 5 Intraobserver reliability between assessor groups

Results

This study included sixteen men and two women, with mean age of thirty four years (18.2). All patients sustained injury from car accidents. There were twenty femoral shaft fractures: sixteen closed and four open. Using CT scan with reconstruction, nine were classified as grade I, two as grade II, seven as grade III, and two as grade IV.

In the plain film group, accuracy was 45.8%, 70.8% and 70.8% for the junior resident, senior resident, and staff groups respectively. In the high resolution film group, the accuracy was 50.0%, 68% and 73.6% (Fig.3).

The interobserver reliability of plain and high resolution films was moderate in the staff group (K= 0.557, 0.570), and the senior resident group (K= 0.474, 0.462). In contrast however, reliability was only fair in the junior resident group (K= 0.321, 0.349) (Fig.4).

The intraobserver reliability of plain and high resolution film assessment was substantial in the staff group (K= 0.652, 0.645); an increase from fair (K= 0.355) to moderate (K= 0.513) was noted inthe junior resident group, and an increase from moderate (K= 0.500) to substantial (K= 0.619) in the senior resident group (Fig.5).

Discussion

We found the determination of the degree of femoral comminution using plain radiographs was neither accurate, nor reliable, especially when the fims were read by individuals having low levels of orthopaedic experience. High resolution films marginally improved the accuracy of the interpretation in that same group. This probably explains the improvement in both accuracy and reliability that is found when degree of femoral comminution is determined by experienced orthopedic surgeons.

The kappa coefficient is a statistic that accounts for the effect of chance in the determination of agreement. Although it has been commonly used in most reliability tests, no consensus agreement regarding an acceptable level has been established. A number of factors affect the results. These include the number and level of experience of the assessors, the number and variability of subjects, the method of evaluation, and the complexity of classification[10,11]. In this study, we standardized the process of evaluation, and used an adequate number of assessors. However, the kappa coefficient should be used with caution, since high reliability does not mean high accuracy, or high predictability.

Three options exist to solve the problem of inaccurate determination of the degree of fracture comminution using plain radiographs. First, consultation with more experienced orthopedists; second, routine requests for 3-D computerized tomography, and finally, routinely using interlocking nails[12]. Since no such study exists to resolve this problem, any decision will have both advantages and disadvantages. Therefore the ultimate decision must rest on consideration by the doctor and the patient.

The major limitation of this study was the small number of patients, resulting in a diminished variety of fracture, and degrees of severity. This may affect the generalizability of the results of the study.

Conclusion

Determination of the degree of comminution of femoral shaft fracture using plain or high resolution radiograph may not be accurate nor reliable, especially when interpreted by assessors with limited experience.

Acknowledgement

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ความน่าเชื่อถือและความถูกต้องของการประเมินระดับความปวดของกระดูกต้นขาหักจากภาพถ่ายรังสี

วีระ ชัยมงคล, พบ., บุญสิน ตั้งตระกูลวนิช พบ., ปร.ด.

จุดประสงค์: *เพื่อศึกษาความน่าเชื่อถือและความถูกต้องของการใช้ภาพถ่ายรังสี ในการประเมินระดับความปวดของกระดูกต้นขาหัก*

วัสดุและวิธีการ: *ผู้ป่วยกระดูกต้นขาหัก 18 ราย ได้รับการตรวจภาพถ่ายรังสี 3 ประเภท ได้แก่ ภาพรังสีปกติ ภาพถ่ายรังสีเพิ่มความคมชัด และภาพถ่ายรังสีคอมพิวเตอร์ 3 มิติ มีผู้ประเมินจำนวน 12 คน ประกอบด้วยอาจารย์แพทย์ แพทย์ประจำบ้านอาวุโสและแพทย์ประจำบ้านกลุ่มละสี่คน*

ผลการศึกษา: *ความถูกต้องของการประเมินระดับความปวดโดยภาพถ่ายรังสีมีค่าร้อยละ 45.8, 70.8 และ 70.8 ในกลุ่มแพทย์ประจำบ้าน แพทย์ประจำบ้านอาวุโสและอาจารย์แพทย์ตามลำดับ ความน่าเชื่อถือของการประเมินจากภาพถ่ายรังสีและภาพถ่ายรังสีเพิ่มความคมชัดมีค่าในระดับปานกลางในกลุ่มแพทย์ประจำบ้านอาวุโสและอาจารย์แพทย์ แต่มีค่าระดับต่ำในแพทย์ประจำบ้าน*

สรุป: *ความถูกต้องและความน่าเชื่อถือของการประเมินระดับความปวดของกระดูกต้นขาหัก จากการใช้ภาพถ่ายรังสีมีค่าอยู่ในเกณฑ์ต่ำ*