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Diagnostic imaging concordance study: Are traction radiographs necessary in a hip fracture?

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ABSTRACT

Introduction: Hip fractures are a pathology that have emerged as a major subject over the years, due to increased prevalence and the multiple surgical treatments involved. The characterization and classification of the lesion is essential for proper surgical planning, with anteroposterior (AP), lateral and traction radiograph of the hip, paramount for decision-making.

Patients and methods: This is a retrospective concordance study of 64 patients with hip fracture who consulted the hospital between January and July 2017. Four radiographs were taken of each: AP, AP with traction, lateral and lateral with traction. This set of images was evaluated by 9 observers, with different levels of experience, to answer questions regarding the classification, emphasize in potential instability and requirement of other images. A statistical analysis of concordance between and within observers was performed using Cohen's kappa coefficient.

Results: Of the 64 patients, 70.6% were women; the average age was 69.5 years. 82.8% presented a secondary fracture from falling from their own height. As the observer's experience increases, the need for traction radiograph decreases; interobserver kappa goes from 0.98 in experts to 0.01 in students. Traction radiograph is important in the diagnosis of potentially unstable fractures. Of the 1,503 radiographs with traction, 636 (42.38%) were classified as potentially unstable. And of the 708 without traction, 560 (79.1%) were classified as potentially unstable.

Conclusions: Traction hip radiograph continues to be a useful tool in training environments to adequately classify an intertrochanteric fracture, considering it is a low-cost, minimal morbidity intervention, and is easily accessible. In similar studies, we found similar findings regarding the usefulness of traction to perform an adequate classification in people in training or in young orthopedists. It also influences to determine the potential instability, and this would modify the choice of the implant

Introduction

Hip fractures represent a major economic burden on the health system. They are a frequent public health problem, closely related to osteoporosis and increased age. In addition, they have a high 30% mortality rate during the first year and can represent expenditures of up to 9.8 trillion dollars a year to the health system [1].

Radiographs are critical in the identification, classification, and management of proximal femoral fractures. However, multiple studies in orthopedic literature have reported little inter-observer reliability to adequately classify proximal femoral fractures based on radiographs, as demonstrated by Thomsen et al. and Oakes et al. [2].

Patients with proximal femur fractures generally have the affected limb shortened and in external rotation. This situation of the limb, combined with the natural femoral anteversion, can make it difficult to visualize the fracture, which is a defect that can be improved with hip projection with traction and internal rotation. This projection seeks to decompress the lesion, correcting the femoral anteversion, aligning the fracture with the beam, and delivering a better image.

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Traction view is obtained by positioning of the patient supine and the orthopedic surgeon applying gentle traction force to bend the foot and ankle. Force is gradually increased (up to 10-15 kg of force) in a controlled manner by bringing the leg into slight internal rotation with the knee pointing straight up. After radiographic exposure, the force is released gently and slowly to avoid sudden movements [3]. This process can be painful and bothersome for patients, especially older adults. This study seeks to evaluate the clinical use of internal rotation and traction radiograph in the classification of proximal femur fractures. There are no studies in this regard with the current classification of proximal femur fractures, including the thickness of the lateral wall as a criterion of potential instability. This parameter is part of the new concepts on the probability of intraoperative complications when using the DHS-type system in fractures that were believed to be stable, but due to its thin lateral wall thickness (<20.5 mm), the probability of turning it into an unstable fracture is significant.

Materials and methods

Prior to this project start, the protocol was approved by the Research Ethics Committee of the hospital. A prospective concordance study was conducted with a sample calculated with Epidat 4.1 and an expected kappa coefficient of 0.75, obtaining a total of 203 minimum observations. A convenience sample of 64 patients was taken, who had consulted the hospital for hip fracture, with an evolution of no more than 2 weeks, from January to July 2017, and who, additionally, consented to their participation in the project. These patients were requested with AP pelvis radiograph, AP pelvis radiograph with traction, lateral radiograph, and lateral traction radiograph. We used 10 cm magnification within the institution's management guidelines.

The images were taken as follows:

- AP pelvis radiograph
  - Patient in supine position with the chassis in the posterior region in the AP plane and with the beam perpendicular to it and a 10 cm magnifier in the trochanteric lateral region of the fractured side
- AP pelvis traction radiograph
  - Patient in supine position with the chassis in the posterior region in the AP plane and with the beam perpendicular to it and a 10 cm magnifier in the trochanteric lateral region of the fractured side. The assistant holds the patient from armpits and the position is marked on the table.

Traction is applied to the limb of the fractured hip until the limb length is clinically equalized and it is internally rotated 10-15 degrees until the knee lies in the anteroposterior plane. The position is marked on the table where the patient is placed, as well as the final position of the foot.

- Lateral radiograph
  - The patient is tilted 15 degrees towards the side of the fractured hip, fixing the chassis in the lateral region of the fractured hip in a direction parallel to the floor and perpendicular to the axis of the beam, with the 10 cm magnifier in the lateral region trochanteric on the fractured side
- Lateral radiograph with traction
  - The patient is tilted 15 degrees towards the side of the fractured hip, the chassis is fixed in the lateral region of the fractured hip in a direction parallel to the floor and perpendicular to the axis of the beam, with a 10 cm magnifier in the trochanteric lateral region on the fractured side. The patient is fixed at the height on the table where the AP radiograph was previously taken, then the limb is applied traction until it equals the previously achieved length, internally rotating the limb until the knee is in the AP plane.

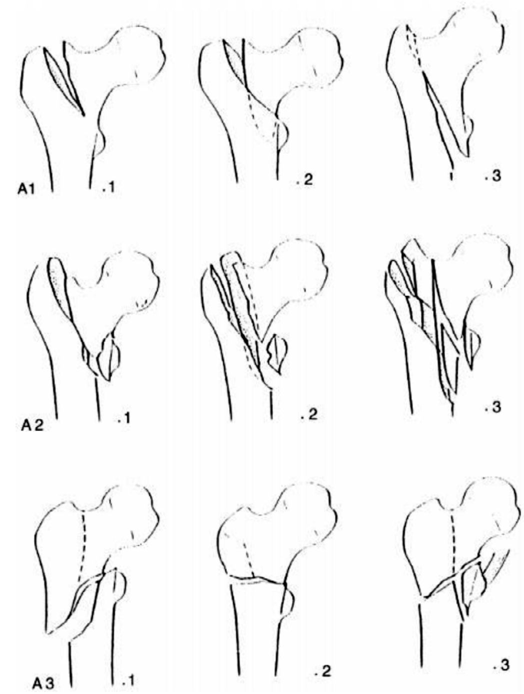

Fig. 1. Illustration 1. AO classification Illustration 2. Distribution of the fractures.

Before evaluating the images, the evaluators were familiarized with the concepts of stable, unstable, or potentially unstable intertrochanteric fracture and the AO classification. (Fig. 1). In our study we use the AO classification before 2018 update. This 2018 updated version includes potentially unstable fracture and uses lateral wall thickness as a parameter of instability.

Patient personal data was encrypted to keep patient confidentiality. Upon completion of the database, the images were randomized into a unified presentation, with no patient information or radiograph description, and were delivered to 3 first-year orthopedic residents, 3 general orthopedists and 3 trauma specialists with over 5 years of experience in their field. They were required to answer the following questions of the 256 images:

1. Is the radiograph evaluable?
2. Does the fracture present with calcar, posteromedial cortical comminution? (lesser trochanter avulsion does not apply).
3. Does the fracture present with lateral cortical comminution?
4. Does the fracture have an inverted line?
5. Does the fracture extend to the diaphysis?
6. Is the fracture potentially unstable?
7. Is an additional image required? Which?

Each radiograph was evaluated by all the evaluators, totaling 2,304 readings.

Reference or gold standard

Consensus responses were recorded between one of the trauma experts, with more than 5 years' experience and the interpretation of radiology.

Statistical analysis

The precision of the classification was calculated with the proportion of cases classified correctly with respect to the answers given by the gold standard. The inter- and intra- observer agreement of the evaluators' responses was calculated and analyzed using the Epidat 4.1 program, with a kappa agreement coefficient.

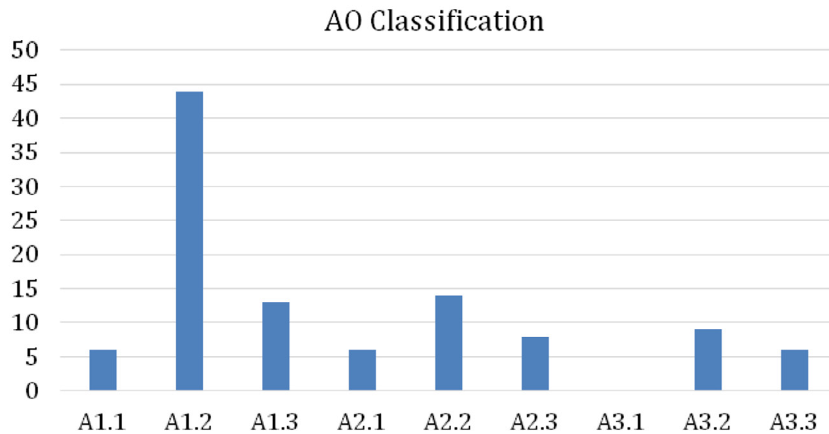

Fig. 2. Distribution of the fractures.

The kappa coefficient can take values between -1 and +1. The closer to +1, the greater the degree of interobserver agreement; conversely, the closer to -1, the greater the degree of interobserver mismatch. A value of $\kappa = 0$ reflects that the observed agreement is precisely what is expected, due exclusively to chance.[1]

The interpretation of the kappa coefficient is made by correlating its value with a qualitative scale that includes six levels of strength of agreement: “poor” less than 0.0, “slight” between 0.0 and 0.2, “fair” between 0.21 and 0.4, “moderate” between 0.41 and 0.6, “substantial” between 0.61 and 0.8, and “almost perfect” between 0.81 and 1, simplifying its understanding.[2]

Results

Demographic characteristics of the patients

The sample involved 48 women (70.6%) with an average age of 74 years, 16 men (29.4%) with an average age of 65 years. The trauma mechanism was broken down into 53 patients (82.8%) due to trauma from falling from their own height, 3 (4.6%) due to a traffic accident as co-pilots and 8 (12.5%) as pedestrians. The distribution of the fracture classification is shown in Fig. 2.

Results of the questionnaire

Each question is broken down with the respective results:

1. Is the radiograph evaluable?

Of the 2,304 readings, 93 images (4%) were rated as “not evaluable” by observers at all levels of experience. Since they were not evaluable, the other responses of these images were not considered, which left 2,211 images for analysis: 1,503 with traction and 708 without traction.

2. Does the fracture present with calcar, posteromedial cortical comminution (lesser trochanter avulsion does not apply)?

541 (36%) of the traction radiographs and 270 (38%) of those that did not have traction presented the lesion.

3. Does the fracture present with lateral cortical comminution?

Of the 1,503 images with traction, 96 (15.8%) show a lateral cortical comminution and of the 708 without traction, 33 (21.4%).

4. Does the fracture have an inverted line?

In both traction and non-manipulation radiographs, 2.3% had an inverted line, that is, 34 and 16, respectively.

5. Does the fracture extend to the diaphysis?

148 (9.9%) of the traction radiographs show extension to the diaphysis, and 90 (6%) of those without traction

6. Is the fracture potentially unstable?

Of the 1,503 radiographs with traction, 636 (42.38%) were classified as potentially unstable. And of the 708 without traction, 560 (79.1%) were classified as potentially unstable.

7. Is an additional image required? Which?

Of the images that have traction, the evaluators indicated that they would request an additional image for 46 (3.09%). And of the radiographs without traction, for 92 (13.1%), they would ask for an additional image, among which are tomography or traction radiograph.

Interobserver agreement

The interobserver agreement was based on the response of each of the observers with the gold standard response. The results are shown in Table 1.

Intraobserver agreement and percentage change

Each evaluator reviewed the images twice, once initially and after 6 months, answering the 7 questions, to assess how much the response changed over time. The results are described in Table 2. Additionally, Table 3 shows the calculation of the percentage change between the responses of each of the evaluators.

Discussion

Selecting the proper management of hip fractures requires the most accurate classification possible, which entails having the images necessary to identify the bone injury. The complex anatomy of the hip, associated with the potential displacement that the fracture, impaction and angulation may present, creates challenges for the accurate classification of the fracture, so tools such as traction radiograph tend to be used for proper diagnosis, classification and surgical planning. There are drawbacks regarding the regular use of traction radiographs, which include the need for trained personnel in the radiology room, radiation of the person applying traction, pain and discomfort of the patient due to positioning, need for more analgesia and additional costs.

[1] López de Ullibarri I, Pita S: Medidas de concordancia: el coeficiente kappa. Cad aten primaria 1999; 6: 169- 71. Available at www.fisterra.com [consulted 01/10/07]
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Table 1
Kappa values – interobserver agreement.

	Unstable fracture	Calcar fractur	Lateral cortical fracture	Inverted line	Extension to diaphysis	Potentially unstable fracture
Gold standard	-	-	-	-	-	-
Trauma expert b	0.76	0.98	0.72	0.704	0.845	0.94
Trauma expert c	0.89	0.76	0.91	0.84	0.62	0.74
Orthopedist a	0.56	0.9	0.6	0.76	0.5	0.498
Orthopedist b	0.6	0.56	0.64	0.64	0.8	0.65
Orthopedist c	0.634	0.7	0.61	0.5	0.54	0.71
Resident a	0.4	0.43	0.23	0.38	0.56	0.505
Resident B	0.01	0.3	0.21	0.34	0.011	0.24
Resident c	0.6	0.3	0.65	0.75	0.67	0.45

* kappa values

Table 2
Intraobserver agreement

	Unstable fracture	Calcar fracture	Lateral cortical fracture	Inverted line	Extension to diaphysis	Potentially unstable fracture
Trauma expert a	0.65	0.68	0.79	0.89	0.9	0.83
Trauma expert b	0.87	0.67	0.92	0.76	0.71	0.78
Trauma expert c	0.9	0.78	0.83	0.73	0.84	0.92
Orthopedist a	0.55	0.54	0.67	0.76	0.65	0.53
Orthopedist b	0.52	0.65	0.61	0.57	0.58	0.59
Orthopedist c	0.5	0.59	0.51	0.55	0.56	0.61
Resident a	0.42	0.55	0.44	0.47	0.42	0.41
Resident b	0.33	0.49	0.31	0.37	0.302	0.27
Resident c	0.56	0.65	0.72	0.48	0.46	0.37

*kappa values

Table 3
Percentage change between the responses of each of the evaluator‘s intraobserver agreement

	Unstable fracture	Calcar fracture	Lateral cortical fracture	Inverted line	Extension to diaphysis	Potentially unstable fracture
Trauma expert a	1%	5%	4%	3%	6%	2%
Trauma expert b	4%	4%	4%	5%	7%	2%
Trauma expert c	6%	10%	8%	2%	8%	9%
Orthopedist a	15%	12%	24%	11%	32%	21%
Orthopedist b	22%	34%	43%	22%	11%	44%
Orthopedist c	32%	33%	21%	21%	22%	43%
Resident a	44%	23%	32%	44%	43%	55%
Resident b	64%	66%	34%	54%	53%	43%
Resident c	27%	27%	27%	6%	13%	48%

The use of traction radiograph to increase sensitivity in the detection of subtle hip fractures was initially described in 1974 by Dr. Wiltse [4], where it became a tool for hip fracture detection and classification and was included in the set of radiographs requested in multiple health institutions [5]. Orthopedists and radiologists seem to have more accurate diagnoses when implementing this technique, as expressed by Khurana et al. in their 2018 study.

This study reveals multiple strengths: the number of observers and the variety of experience levels, most inter and intra-observer correlation studies to assess the need for traction radiograph have been performed with up to 15 observers of the same level, as in the study conducted in 2008 by Chong et al. [6], or by a maximum of 4 observers of different levels, such as Khurana's article in 2018. This allows us to compare whether the experience variable modifies the need for traction radiograph. In fact, in our study, as shown in Table 1, traction radiograph is much more useful for people in training, an advantage that wanes as it is evaluated by experts in hip trauma, becoming less necessary for an adequate classification of the fracture, just as the literature has shown [7, 8].

The main reason that first-year residents were included is because, both in our hospital and in many others [11], they are the first to care for patients with hip fractures. The great variety of fractures is another strength. Multiple studies have been published comparing the different classifications of hip fracture, including the AO system, Tronzo and Jensen as reported by Burstein [9] and Urrutia et al. [7]. However, it may be a weakness to use only one classification.

Hip fracture stability depends on the degree of comminution, osteoporosis, and the configuration of the fracture [4,5]. Posteromedial cortical continuity is the main criterion described for the stability of these fractures [10], that is, those with a comminuted posteromedial wall are unstable [12, 14]. The results of this study showed no significant difference in classifying the fracture as unstable or stable. However, the inclusion of the variable "potentially unstable" is novel in this type of study. We found this as a fundamental variable for an adequate classification for pertrocanteric fractures as modified by the AO group in 2018. Identifying this criterion can completely change the planning of the surgery and the choice of the implant to be used in management [13]. In our study, a statistically significant change in the diagnosis of potentially unstable hip fracture was demonstrated: from 42.38% in traction radiographs to 79.1% in those without traction. In similar studies, we found similar findings regarding the usefulness of traction to perform an adequate classification in people in training or in young orthopedists. It also influences to determine the potential instability, and this would modify the choice of the implant [15].

Finally, it is evident in the last question that the systematic use of traction radiographs can reduce the need for other imaging studies by 8%, which implies a decrease in radiation for the patient and costs. Embden et al. [16] indicates that the use of CT scanning is not necessary to improve concordance in the adequate classification of hip fractures, like Isida et al [17,20]. CT scanning has not been shown to be superior to standard X-rays for classifying intertrochanteric fractures; however, it has better sensitivity for detecting certain fracture lines that are not visible on X-rays [18]. It is known that a full body CT scan is beneficial in polytraumas because it reduces mortality [19]. Possibly in this context, the CT scan of proximal femur fractures would be justified in literature. The dose of a standard pelvic CT scan is 5 mSv and a total body scan is around 20 mSv [18]. Therefore, routine CT imaging should be avoided in intertrochanteric fractures.

Our study has two strengths compared to the current literature that demonstrate the usefulness of using traction radiographs in pertrochanteric fractures: a. We have three groups (orthopedic residents, junior orthopedists and senior orthopedists) and b. The lateral cortex thickness variable is specified as an additional potentially unstable fracture parametron. A similar study is the reference Khurana et al [15] where they found a difference in the correct classification of proximal femur fractures from 44.9% without traction to 72.4% with traction. In this study, all proximal femur fractures including femoral neck and subtrochanteric fractures were included and only two orthopedists and one radiologist were evaluators. They differentiate between unstable vs. stable pertrochanteric fractures but do not specify the use of lateral cortex thickness as an additional current parameter. Among other weaknesses of the study is the non-comparison of the answers by level of experience and the lack of a gold standard for imaging such as computed tomography.

Conclusions

Traction radiograph is a useful tool in training environments to adequately classify an intertrochanteric fracture, considering it is a low-cost, minimal morbidity intervention, and is easily accessible. We consider that this instrument still has a place in the protocols for diagnosis and treatment of fractures of the proximal femur specially on university hospitals with people in training.

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Declaration of Competing Interest

The authors declare no conflict of interest.

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