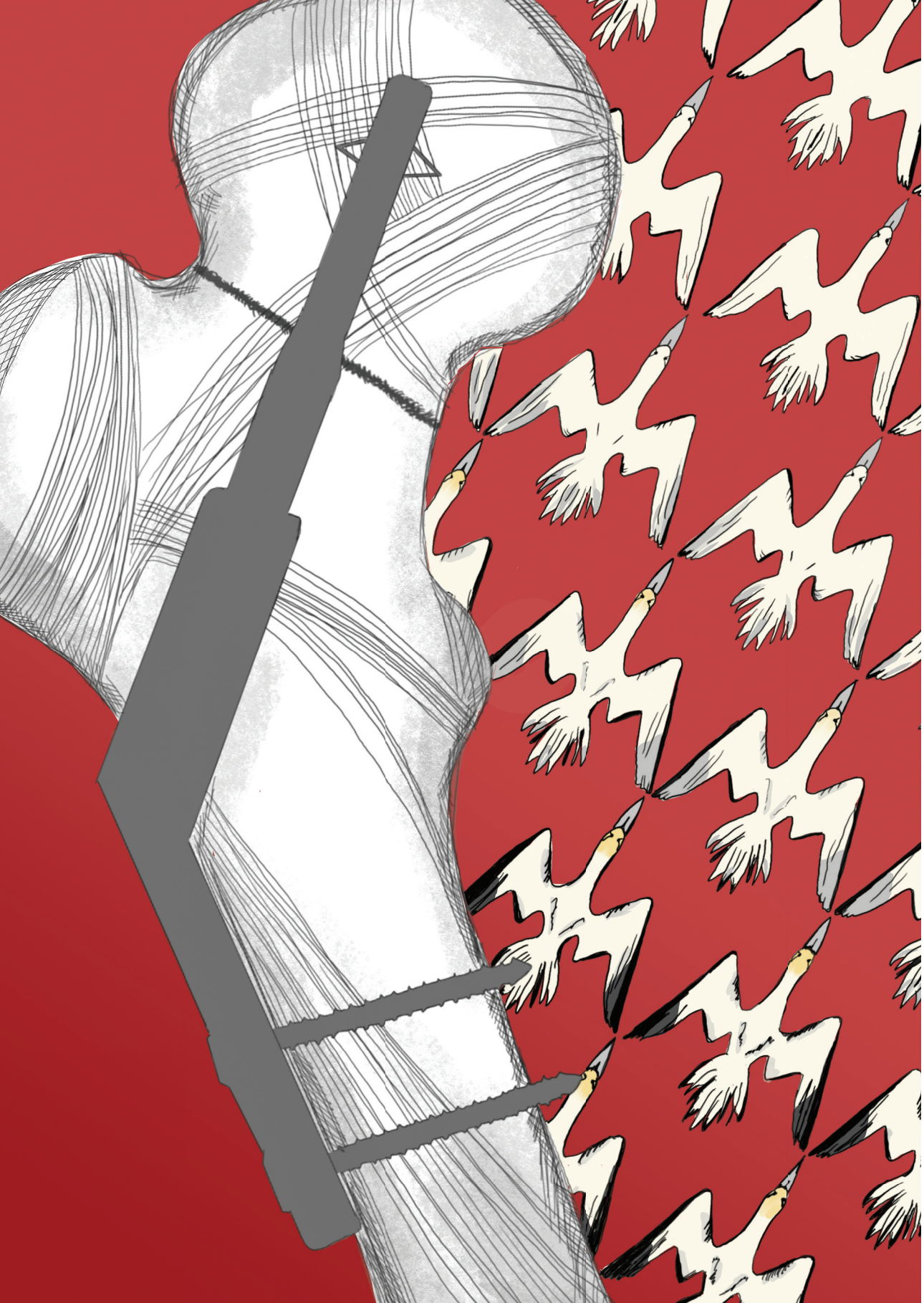
New insights in the treatment of femoral neck fractures

Kalsbeek, J.H.



Chapter 4

Validation of two methods to measure posterior tilt in femoral neck fractures

J.H. Kalsbeek, A.D.P. van Walsum, W.H. Roerdink, A.B. van Vugt, H. van de Krol, I.B. Schipper

Injury. February 2020;51(2):380-383.

ABSTRACT

Introduction

Posterior tilt of the femoral head in femoral neck fractures (FNF) may influence stability of the fracture and may therefore affect the treatment outcome. Posterior tilt can be measured with different methods. The Lateral Garden Angle (LGA) has been used for this purpose for decades and more recently the Posterior Tilt Measurement (PTM) was introduced. Despite the fact that both methods (LGA and PTM) are used in multiple studies, they have never been compared for reliability in a direct study. The aim of this study is to analyze the intra and inter observer variability of the LGA described by Garden and the PTM according to Palm.

Methods

Four observers measured the posterior tilt on the radiographs of 50 FNF two times with both methods. Intra and inter observer reliability were determined for the LGA and the PTM.

Results

The intra observer reliability for both methods is substantial with an intra class coefficient of 0.75. The inter observer reliability of the PTM is also substantial with an intra class coefficient of 0.75 compared to a moderate reliability of the LGA with an intraclass coefficient of 0.60.

Conclusion

Based on our results we believe the LGA and the PTM are both reliable methods to measure posterior tilt. Yet the Posterior Tilt Measurement seems to have a better inter observer reliability and therefore has a slight preference over the Lateral Garden Angle.

INTRODUCTION

Posterior tilt, also known as retroversion or anterior angulation of the femoral head, is diagnosed on the lateral radiograph of the hip. If there is displacement in the transverse plane, it often concerns posterior tilt of the femoral head due to the mechanism of the trauma and the anatomy of the hip. FNF are usually classified using the Garden Classification.[1] This classification is solely based upon the AP radiographs. Consequently the tilting of the femoral head in the anterior and posterior direction is not included in this classification.[2] Over the years several authors described the influence of pre-operative posterior tilt on the risk of reoperation rate, avascular necrosis or non-union of femoral neck fractures (FNF).[3-11]

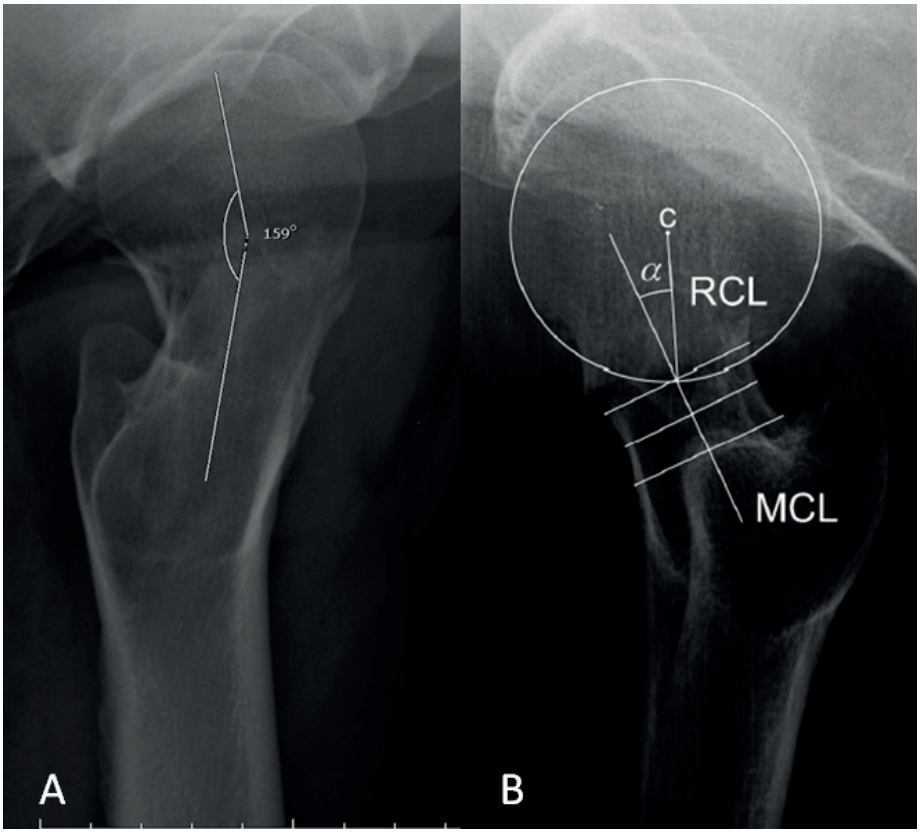


Figure 1. A. Lateral Garden Angle (LGA) is measured according to Gardens description using the trabeculae on the lateral view of the X-ray. The central axes of the femoral head and the neck normally lie in a straight line 180°.[2,12] **B.** The posterior tilt of the femoral head is determined by the angle between two lines, the mid-collum line (MCL) and the radius collum line (RCL). The middle of the collum (femoral neck) is determined by drawing three perpendicular lines across the narrowest part of the collum, with 5 mm between each line. The RCL is drawn from the middle of the femoral head to the intersection of the MCL and the caput circle.[7]

There are several ways to measure posterior tilt. Most used is the Lateral Garden Angle (LGA), which originates from the Garden Alignment Index (GAI) that was introduced by Garden to determine the position of the femoral head after reduction (Figure 1A).[2,12] This index describes the anteriorposterior fracture angle(APA) and the Lateral Garden Angle (LGA) of the femur. The LGA is used by several authors for measuring posterior tilt.[3-5]

In 2009 Palm et al. suggested a new method to measure posterior tilt, the Posterior Tilt Measurement (PTM) (Figure 1B). He stated the LGA to be a too unreliable method.[7] Yet literature provides no evidence regarding the reliability of the LGA. The PTM is also widely used.[6,8-11,13] According to some authors this new way of measuring posterior tilt has an excellent inter and intra observer reliability. The interclass coefficient varies between 0.77–0.94 and the intraclass coefficient varies between 0.77–0.97.[6,7,13]

However, despite the fact that both methods (LGA and PTM) are used in multiple studies, they have never been compared for reliability in a direct study. The aim of this study is to analyse the intra and inter observer variability of the LGA described by Garden and the PTM according to Palm.

METHODS

Fifty radiographs of pre-operative undisplaced FNFs were collected from a database of undisplaced FNFs.[14] The radiographs were randomly selected, using SPSS to generate a random sample from the database. No radiographs were excluded because of 'inadequate quality' to avoid selection bias and to create a realistic setting of clinical practice. All radiographs were collected from one hospital, anonymized and all saved in random order, varying per CD-ROM, on four different CD-ROMs. The posterior tilt angle of all 50 FNF radiographs was assessed four times by four different observers (JHK, ADPW, ABV, EK). The observers were three trauma surgeons (two senior consultants (ADPW, ABV) and one junior consultant (EK), and a last year medical student (JHK) specifically trained for the purpose). The measurements were performed according to the schedule in Table 1: Each observer measured every two weeks 1 CD-ROM with the same 50 radiographs in different order, alternating the LGA and the PTM measurements for all 50 radiographs on one CR-ROM, both two times. All observers were familiar with the LGA, still the description was given. The PTM was explained to all the observers individually and the observers were allowed to practice the PTM on 10 separate radiographs before they participated in the study. Also all the observers were obliged to read the article of Palm.[7]

Table 1. Design of the intra and inter observer measurements

Time	Week 1	Week 3	Week 5	Week 7
Observer 1	cd 1	cd 4	cd 3	cd 2
Observer 2	cd 2	cd 1	cd 4	cd 3
Observer 3	cd 3	cd 2	cd 1	cd 4
Observer 4	cd 4	cd 3	cd 2	cd 1
Method	*LGA*	*PTM*	*LGA*	*PTM*

cd= CD-ROM

Position of the patient

All radiographs were taken in one hospital using a standard positioning technique according to the hospital protocol for hip fractures: Patients were positioned in supine position, the contralateral leg positioned with both hip and knee in ninety degrees flexion. If needed the foot was supported. The injured leg was positioned in its natural position, showing slight exorotation of the foot. The X ray generator was positioned horizontal, perpendicular to the detector and the detector was positioned parallel to the femoral neck at the lateral side of the pelvis.

Measurements

Lateral Garden Angle: This angle is measured according to Gardens description using the trabeculae on the lateral view of the X-ray. The central axes of the femoral head and the neck normally lie in a straight line 180°.[2,12]

Posterior Tilt Measurement: The posterior tilt of the femoral head is determined by the angle between two lines, the mid-collum line (MCL) and the radius collum line (RCL). The middle of the collum (femoral neck) is determined by drawing three perpendicular lines across the narrowest part of the collum, with 5 mm between each line. The RCL is drawn from the middle of the femoral head to the intersection of the MCL and the caput circle.[7]

Statistics

We determined inter observer and intra observer reliability of both measurement tools by comparison of the measurement results of the four observers. Statistical analysis were performed using SPSS v. 21 ((IBM Corp., Armonk, NY, USA) for Windows 7. The intra class coefficients were calculated to assess intra and inter observer reliability using a two-way random effects model with absolute agreement. The intra class coefficients were interpreted according to the method of Landis & Koch: <0.00 reflects poor, 0.00–0.20 'slight', 0.21–0.40 'fair', 0.41–0.60 'moderate', 0.61–0.80 'substantial' and 0.80–1.00 'almost perfect'.[15] P-values less than 0.05 were considered to be statistically significant.

Ethics

The measurements and analysis are in line with earlier performed studies in this research line which were assessed by the regional Medical Research Ethics Committee (MREC). The MREC approved of this study and decided that no written informed consents were required.

RESULTS

Intra and inter observer reliability were determined for the LGA and the PTM. The results demonstrate a substantial intra observer reliability for the LGA as well for the PTM with an intraclass coefficient of 0.75 (95% CI 0.60–0.85) for the LGA and also 0.75 (95% CI 0.60–0.85) for the PTM. Yet the inter observer reliability for the PTM seems better with an intra class coefficient of 0.75 (95% CI 0.64–0.83) compared to 0.60 (95% CI 0.47–0.73) of the LGA (Table 2). A complete overview of the results of the different observers is shown in Table 2. The measured angles were also divided into 2 categories (<20° and ≥20°) according to both measurements methods to evaluate clinical validity for both measurement methods. Yet no reliable analyses could be achieved due to too few fractures with an angle of ≥20° within the 50 fractures measured by the observers.

Table 2.1. Intra- and inter rater reliability of the **Lateral Garden Angle (LGA)**

Intra rater reliability LGA	Intra class coefficient	95% CI	Agreement
Observer 1	0.77	0.62-0.86	Substantial
Observer 2	0.76	0.61-0.86	Substantial
Observer 3	0.71	0.54-0.83	Substantial
Observer 4	0.76	0.61-0.86	Substantial
Mean observer 1/2/3/4	**0.75**	0.60-0.85	**Substantial**
Inter rater reliability LGA			
Observer 1/Observer 2	0.74	0.57-0.84	Substantial
Observer 1/Observer 3	0.53	0.29-0.70	Moderate
Observer 1/Observer 4	0.63	0.41-0.77	Substantial
Observer 2/Observer 3	0.59	0.37-0.75	Moderate
Observer 2/Observer 4	0.66	0.46-0.79	Substantial
Observer 3/Observer 4	0.54	0.31-0.71	Moderate
Observer 1/2/3/4	**0.60**	0.47-0.73	**Moderate**

Intra class coefficient was interpreted as follows: <0.00 'poor', 0.00-0.20 'slight', 0.21–0.40 'fair', 0.41–0.60 'moderate', 0.61–0.8 'substantial' and 0.80–1.00 'almost perfect'.[15]

Table 2.2. Intra- and inter rater reliability of the **Posterior Tilt Measurement (PTM*)***

Intra rater reliability PTM	Intra class coefficient	95% CI	Agreement
Observer 1	0.79	0.65-0.88	Substantial
Observer 2	0.61	0.40-0.76	Substantial
Observer 3	0.72	0.55-0.83	Substantial
Observer 4	0.89	0.81-0.94	Almost perfect
Mean observer 1/2/3/4	**0.75**	0.60-0.85	**Substantial**
Inter rater reliability PTM			
Observer 1/Observer 2	0.71	0.53-0.83	Substantial
Observer 1/Observer 3	0.76	0.60-0.86	Substantial
Observer 1/Observer 4	0.80	0.67-0.88	Almost perfect
Observer 2/Observer 3	0.72	0.55-0.83	Substantial
Observer 2/Observer 4	0.75	0.59-0.85	Substantial
Observer 3/Observer 4	0.76	0.61-0.86	Substantial
Observer 1/2/3/4	**0.75**	0.64-0.83	**Substantial**

Intra class coefficient was interpreted as follows: <0.00 'poor', 0.00–0.20 'slight', 0.21–0.40 'fair', 0.41–0.60 'moderate', 0.61–0.80 'substantial' and 0.80–1.00 'almost perfect'.[15]

DISCUSSION

Our results show a substantial intra and inter observer reliability for both the LGA and the PTM. The intra observer reliability (0.75) is the same for both methods; the inter observer reliability (0.75 vs. 0.60) seems to be slightly better using the PTM.

Last decade several authors preferred to use the PTM in their studies despite the lack of evidence on the superiority of the PTM over the LGA.[6-11] Several studies published an intra observer reliability ranging from 0.77–0.97 for the PTM and an inter observer reliability ranging from 0.77–0.94.[6,7,13] We could not reproduce these results. In our study three of the observers had no experience with the PTM apart from the 10 radiographs to practice on. In studies in which the observers had experience with the PTM the reliability was higher. An intra observer reliability of 0.95–0.97 and an inter observer reliability of 0.90–0.94 is seen in studies with experienced observers.[6,7] Yet an intra observer reliability of 0.77 and an inter observer reliability of 0.77 was published in a study with inexperienced observers.[13] These studies, including our study, show a tendency towards a learning curve which might improve the reliability of the PTM if it is used over a longer period of time. All our observers used the LGA in their clinical practice. Still the inter observer reliability of the PTM seems superior to that of the LGA.

One of the factors that may have affected our results and those of previous studies on the reliability of the posterior tilt measurements in hip fractures, is the fact that the lateral view of the hip is often difficult to obtain and even more difficult to standardize. Many lateral images are actual oblique views. This influences the way the trabeculae are projected and therefore effects the LGA measurement because the LGA, officially, is measured using the trabeculae. Furthermore the three perpendicular lines, used to measure the PTM, often cannot be drawn due to the oblique view in which the major trochanter blocks the view of the narrowest part of the femoral neck. Hoelsbrekken investigated the influence of the position of the hip on the PTM.[16] He used a 3D-printer generated hip with an undisplaced FNF from which lateral view radiographs were taken in different positions. His study showed that the PTMs can differ 3.8°–9.8° if the hip is positioned from 10° internal rotation to 40° external rotation and 0° to 30° flexion. They concluded that different positions of the hip result in rather similar PTM values and that the difference in PTMs induced by non-standardized positioning is negligible in clinical practice. We feel differently about this aspect of the PTM. The minimal detectable change in study of Hoelsbrekken was lower than the difference in measurements in one of the observers (7.2 versus 9.8), so the position of the hip can induce a valid change in measurements. Moreover, a dispersion of almost 10° can make a big difference in clinical practice and treatment related strategies. FNF treatment decisions are based on the amount of displacement of the femoral head. Garden type III and IV fracture are usually treated with an arthroplasty. Whereas patients with an undisplaced FNF, Garden type I and II FNFs will according to the current guidelines mostly be treated with cannulated hip screws or a sliding hip screw device. Yet the posterior tilt is not included in the Garden classification. Several studies suggest 20° posterior tilt in Garden type I&II FNF as a cut-off point to discriminate between non displaced and displaced FNF at the axial view radiograph.[6,17] We believe the posterior tilt should be measured in daily practice and should be included in the treatment decision plan.

The PTM and the LGA are used for measurements on pre- and postoperative radiographs. Yet during the intra operative reduction of the fracture no objective measurement methods are used to determine if the fracture is adequately reduced. The surgeon uses the compass in his eye to determine whether the reduction is adequate or not and this could have consequences for the treatment. If the fracture cannot be properly reduced during the operation the surgeon may choose to convert the operation from internal fixation to a prothesis. Yet, do surgeons measure the same posterior tilt angles using a simple morphological classification? We could not find any literature on using posterior angular measurements during surgery. Dolatowski did include a morphological classification for preoperative radiographs in his reliability study.[6] For this morphological classification the observers described the FNF on the lateral radiograph as undisplaced or displaced without measuring the posterior tilt angle. The inter observer reliability for PTM was 0.90 (95% CI 0.87–0.92) versus 0.68 (95% CI 0.60–0.76) for the morphologic classification. Based on this study the PTM seems superior to

a morphologic classification however this is never tested intra operatively. Further research should be conducted regarding the reliability of the PTM and a morphologic classification during surgery. Also the feasibility of angular measurements during the operation in day to day practice should be evaluated.

The results of this study are limited by the fact that three of the four observers had no experience using the PTM, but were experienced with the LGA. If the observers had already been familiar with the use of the PTM, the ICCs might have been higher and the difference in inter observer reliability might have been more outspoken as compared to that of the LGA.

Several studies describe a cut off point for the significance of posterior tilt.[6-8,10] We could not perform reliable subgroup analyses for radiographs of fractures in a posterior tilt of <20° and ≥20°. Therefore, no conclusion could be drawn about the observer reliability for a cut-off point for the LGA and the PTM.

CONCLUSION AND RECOMMENDATIONS

Based on our results we believe both the Lateral Garden Angle and the Posterior Tilt Measurements are reliable methods to measure posterior tilt in preoperative radiographs of femoral neck fractures. Yet the Posterior Tilt Measurement seems to have a better inter observer reliability and therefore has a slight preference over the Lateral Garden Angle.

REFERENCES

(1) Zlowodzki M, Bhandari M, Keel M, Hanson BP, Schemitsch E. Perception of Garden's classification for femoral neck fractures: an international survey of 298 orthopaedic trauma surgeons. Arch Orthop Trauma Surg 2005 Sep;125(7):503-505.

(2) Garden RS. Reduction and fixation of subcapital fractures of the femur. Orthop Clin North Am 1974 Oct;5(4):683-712.

(3) Alho A, Benterud JG, Ronningen H, Hoiseth A. Prediction of disturbed healing in femoral neck fracture. Radiographic analysis of 149 cases. Acta Orthop Scand 1992 Dec;63(6):639-644.

(4) Conn KS, Parker MJ. Undisplaced intracapsular hip fractures: results of internal fixation in 375 patients. Clin Orthop Relat Res 2004 Apr;(421)(421):249-254.

(5) Clement ND, Green K, Murray N, Duckworth AD, McQueen MM, Court-Brown CM. Undisplaced intracapsular hip fractures in the elderly: predicting fixation failure and mortality. A prospective study of 162 patients. J Orthop Sci 2013 Jul;18(4):578-585.

(6) Dolatowski FC, Adampour M, Frihagen F, Stavem K, Erik Utvag S, Hoelsbrekken SE. Preoperative posterior tilt of at least 20 degrees increased the risk of fixation failure in Garden-I and -II femoral neck fractures. Acta Orthop 2016 Mar 3:1-5.

(7) Palm H, Gosvig K, Krasheninnikoff M, Jacobsen S, Gebuhr P. A new measurement for posterior tilt predicts reoperation in undisplaced femoral neck fractures: 113 consecutive patients treated by internal fixation and followed for 1 year. Acta Orthop 2009 Jun;80(3):303-307.

(8) Riaz O, Arshad R, Nisar S, Vanker R. Serum albumin and fixation failure with cannulated hip screws in undisplaced intracapsular femoral neck fracture. Ann R Coll Surg Engl 2016 Apr 8:1-4.

(9) Bajada S, Smith A, Morgan D. Pre-operative nutritional serum parameters as predictors of failure after internal fixation in undisplaced intracapsular proximal femur fractures. Injury 2015 Aug;46(8):1571-1576.

(10) Lapidus LJ, Charalampidis A, Rundgren J, Enocson A. Internal fixation of garden I and II femoral neck fractures: posterior tilt did not influence the reoperation rate in 382 consecutive hips followed for a minimum of 5 years. J Orthop Trauma 2013 Jul;27(7):386-90; discussion 390-1.

(11) Song HK, Choi HJ, Yang KH. Risk factors of avascular necrosis of the femoral head and fixation failure in patients with valgus angulated femoral neck fractures over the age of 50 years. Injury 2016 Dec;47(12):2743-2748.

(12) Keller CS, Laros GS. Indications for open reduction of femoral neck fractures. Clin Orthop Relat Res 1980 Oct;(152)(152):131-137.

(13) Dolatowski FC, Hoelsbrekken SE. Eight orthopedic surgeons achieved moderate to excellent reliability measuring the preoperative posterior tilt angle in 50 Garden-I and Garden-II femoral neck fractures. J Orthop Surg Res 2017 Sep 19;12(1):133-017-0632-x.

(14) van Walsum ADP, Vroemen J, Janzing HMJ, Winkelhorst T, Kalsbeek J, Roerdink WH. Low failure rate by means of DLBP fixation of undisplaced femoral neck fractures. Eur J Trauma Emerg Surg 2017 Aug;43(4):475-480.

(15) Landis J, Koch G. The measurement of observer agreement for categorical data. Biometrics Mar 1977;33(1):159-174.

(16) Hoelsbrekken SE, Dolatowski FC. The influence of the hips position on measurements of posterior tilt in a valgus-impacted femoral neck fracture. Injury 2017 Oct;48(10):2184-2188.

(17) Palm H, Krasheninnikoff M, Holck K, Lemser T, Foss NB, Jacobsen S, et al. A new algorithm for hip fracture surgery. Reoperation rate reduced from 18 % to 12 % in 2,000 consecutive patients followed for 1 year. Acta Orthop 2012 Feb;83(1):26-30.