

Original Research Article

Effect of lateral radiograph on interobserver agreement in Garden classification of intracapsular femoral neck fractures

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ABSTRACT

Background: Garden classification is widely used to guide treatment of intracapsular femoral neck fractures, but interobserver reliability remains variable. This prospective observational study assessed agreement in Garden classification and management planning using anteroposterior radiographs alone versus combined anteroposterior and lateral radiographs.

Methods: Thirty-five anonymized radiographic sets from adults with intracapsular femoral neck fractures were independently reviewed by 10 orthopaedic observers. Fleiss kappa was used to quantify interobserver agreement.

Results: Agreement for Garden classification improved from kappa 0.64 on anteroposterior view alone to 0.76 after adding the lateral view. Agreement for management planning improved from kappa 0.56 to 0.74. Addition of the lateral view changed fracture classification in 61 of 350 observer-case assessments (17.43%) and changed proposed management in 111 of 350 assessments (31.71%). Observers with less than 5 years of experience showed more changes than those with 5-10 years of experience.

Conclusions: Addition of the lateral radiograph improved consistency of both Garden classification and treatment planning for intracapsular femoral neck fractures.

Keywords: Femoral neck fracture, Garden classification, Hip fracture, Interobserver agreement, Lateral radiograph

INTRODUCTION

Intracapsular femoral neck fractures are common injuries in orthopaedic practice, particularly in older adults and in patients with osteoporotic bone. Radiographic classification influences treatment selection, prognosis, and communication between clinicians.¹

The Garden classification, introduced by Garden, remains one of the most frequently used plain radiograph-based systems for assessment of intracapsular femoral neck fractures and is commonly used to separate undisplaced from displaced fractures for clinical decision-making.^{2,3}

Despite its widespread use, several studies have shown interobserver variability in Garden classification because

interpretation depends on subjective assessment of displacement, trabecular alignment and fracture stability.^{4,5}

The reliability of the traditional four-stage Garden system may improve when the classification is simplified into non-displaced and displaced groups, but such simplification may not fully address clinically important uncertainty in borderline fractures.⁶

The role of the lateral radiograph in femoral neck fracture assessment remains debated. Some studies have suggested that routine lateral radiographs add little to management decisions, whereas other studies have shown that lateral views can reveal posterior tilt, angulation or displacement not apparent on the anteroposterior radiograph.⁷⁻¹¹

Recent studies on radiological classification of femoral neck fractures have further emphasized that a classification system should have acceptable reproducibility before it can be used reliably for communication, research and treatment planning.¹²

The present study was designed to assess interobserver variation in Garden classification of intracapsular femoral neck fractures in adults and to determine whether adding a lateral radiograph improves agreement in fracture classification and proposed management planning.

METHODS

This hospital-based prospective observational study was conducted in the Department of Orthopaedics, SMS Medical College and attached hospitals, Jaipur, after approval by the institutional ethics committee (778/MC/EC/2023; 05/07/2023). The study period extended from May 2023 to April 2024.

Adults older than 18 years with intracapsular femoral neck fractures who gave written informed consent were included. Patients with pathological fractures were excluded. The minimum required sample size was 32 radiographic sets at 80% power and alpha error of 0.05, assuming partial and complete displacement in 50% of films and an expected kappa coefficient of 0.52 as reported in a previous study. The final sample comprised 35 cases.¹³

All patients underwent an anteroposterior pelvis radiograph with both hips internally rotated by approximately 20 degrees and a cross-table lateral radiograph of the affected hip. Radiographs were anonymized, coded from 1 to 35, and shown independently to 10 qualified orthopaedic surgeons.

Observers represented a range of clinical experience from 3 to 10 years. There were 3 senior residents with 3-4 years of experience, 2 assistant professors with 4-5 years of experience, 3 junior specialists with 6-7 years of experience and 2 senior specialists with 8-10 years of experience. For analysis, observers were grouped as less than 5 years of experience and 5-10 years of experience.

For each case, observers assigned a Garden fracture type (I-IV) and selected one management option: multiple cannulated cancellous screw fixation, sliding hip screw with or without anti-rotation screw, proximal femoral nail, or hemiarthroplasty. These options were retained as per the original study proforma used during observer assessment.

Interobserver agreement beyond chance was assessed using the Fleiss kappa reliability test for multiple raters.¹⁴

Agreement for Garden classification and management planning was calculated for anteroposterior radiographs alone and again after combined review of anteroposterior and lateral radiographs. Kappa values were interpreted according to Landis and Koch grading: less than 0.20 poor,

0.20-0.40 fair, 0.41-0.60 moderate, 0.61-0.80 substantial and 0.81-1.00 almost perfect agreement.¹⁵

Changes after inclusion of the lateral view were also analyzed according to observer experience. Data were entered in Microsoft Excel, and categorical variables were summarized as frequencies and percentages. A p value of less than 0.05 was considered statistically significant.

RESULTS

Among 35 patients, 14 (40.00%) were older than 60 years, 11 (31.42%) were 51-60 years and 10 (28.58%) were 50 years or younger. Twenty-four patients (68.58%) were women. Low-energy fall was the commonest mechanism of injury, accounting for 25 cases (71.42%) (Table 1).

Table 1: Baseline characteristics of included cases.

Characteristics	Number (%)
Age ≤50 years	10 (28.58)
Age 51-60 years	11 (31.42)
Age >60 years	14 (40.00)
Female	24 (68.58)
Low-energy fall	25 (71.42)

Interobserver agreement for Garden classification was substantial on anteroposterior radiographs alone (kappa 0.64, $p < 0.001$) and improved further after the lateral radiograph was added (kappa 0.76, $p < 0.001$). Agreement for management planning improved from moderate on anteroposterior view alone (kappa 0.56, $p < 0.001$) to substantial after addition of the lateral view (kappa 0.74, $p < 0.001$) (Table 2).

Table 2: Interobserver agreement for classification and management.

Assessment	Fleiss kappa	Interpretation	P value
Garden classification, AP only	0.64	Substantial	<0.001
Garden classification, AP + lateral	0.76	Substantial	<0.001
Management plan, AP only	0.56	Moderate	<0.001
Management plan, AP + lateral	0.74	Substantial	<0.001

Addition of the lateral view changed fracture classification in 61 of 350 observer-case assessments (17.43%) and changed the proposed management in 111 of 350 assessments (31.71%). The effect was more pronounced among observers with less than 5 years of experience, in whom management plans changed in 78 assessments (44.57%), compared with 33 assessments (18.85%) among those with 5-10 years of experience (Table 3).

Table 3: Changes after adding the lateral radiograph according to observer experience.

Change after adding lateral view	Overall, N/N (%)	<5 years experience, N (%)	5-10 years experience, N (%)
Garden classification	61/350 (17.43)	37 (21.14)	24 (13.71)
Management plan	111/350 (31.71)	78 (44.57)	33 (18.85)

These findings indicate that the lateral radiograph had greater influence on treatment planning than on Garden classification alone, suggesting that even when classification remained similar, perception of displacement and treatment choice became more consistent after the additional view was reviewed.

DISCUSSION

The present study demonstrated that addition of the lateral radiograph improved interobserver agreement for both Garden classification and management planning in intracapsular femoral neck fractures. Classification agreement increased from kappa 0.64 on AP view alone to 0.76 after adding the lateral view, while management agreement increased from kappa 0.56 to 0.74. According to the Landis et al interpretation, this represents substantial agreement for classification and an improvement from moderate to substantial agreement for management planning.¹⁵

For Garden classification, the present AP-only kappa value of 0.64 was higher than many earlier reliability studies. Frandsen et al and Thomsen et al reported important observer variation with the four-stage Garden system, and Thomsen et al found poor agreement with the original system, improving when the classification was simplified into displaced and non-displaced categories.^{4,5}

Van Embden et al similarly reported that the traditional Garden classification had poor reliability and that simplifying it into displaced and non-displaced fractures improved agreement. The higher kappa in the present study may reflect use of a defined radiographic set, focused observer assessment and a study population limited to intracapsular femoral neck fractures.⁶

Addition of the lateral view improved Garden classification agreement from 0.64 to 0.76. This finding is consistent with Aggarwal et al, who evaluated 35 femoral neck fractures with 10 orthopaedic surgeons and found that agreement improved after adding the lateral view; their classification changes occurred in 15.42% of cases, which is close to the 17.43% classification change seen in the present study.¹³

The management agreement improved more than the classification agreement in the present study. Management kappa increased from 0.56 on AP view alone to 0.74 with AP plus lateral view, and management changed in 31.71% of observer-case assessments. Aggarwal et al reported a smaller management change of 23.14%, whereas Kumar et

al found that the lateral view was considered necessary only in a few cases and did not alter management in their series.^{7,13}

This difference may be explained by variation in study design, observer mix and local management preferences. In the present study, multiple management options were provided to observers, making it possible for subtle changes in perceived displacement or angulation on the lateral view to influence treatment choice.

The present findings also differ from Mauffrey et al, who concluded that lateral radiographs should be requested only when the AP view is insufficient, and from Naqvi et al, who reported that lateral views generally did not provide substantial additional information for treatment planning.^{8,10}

Almazedzi et al and Riaz et al reported that lateral radiographs improved classification particularly for intracapsular fractures, but did not show similar benefit for extracapsular fractures. This supports the interpretation that the value of the lateral view is most relevant when displacement of an intracapsular fracture is uncertain on the AP radiograph.^{9,16}

Novillo et al found high agreement between AP-only and AP plus lateral assessment, but noted that a small proportion of patients changed between displaced and non-displaced categories after lateral view assessment. Macke et al reported that lateral views had no consequence in displaced proximal femoral fractures in elderly patients. Taken together, these studies suggest that the lateral view may be most useful in borderline or apparently undisplaced intracapsular fractures rather than in obviously displaced fractures.^{17,18}

In the present study, the lateral view had a larger effect on management planning than on Garden type. This is clinically important because operative choice in femoral neck fracture depends on displacement, stability, age, bone quality and functional demand. Studies comparing internal fixation and arthroplasty for displaced femoral neck fractures have shown that treatment selection can influence reoperation risk, function and cost.¹⁹⁻²³

Observer experience was another important parameter. Observers with less than 5 years of experience showed more changes after adding the lateral view than observers with 5-10 years of experience. This suggests that lateral radiographs may be especially useful in teaching hospitals, emergency departments and units where initial interpretation is often performed by junior surgeons.

Turgut et al studied whether surgeon experience influenced reliability of Garden, Pauwels and AO classifications and found that experience did not consistently eliminate reliability problems. Crijns et al also reported that simpler proximal femur fracture classification categories were more reliable and that clinical experience did not substantially change classification accuracy. These observations support the need for clear radiographic protocols rather than relying only on observer seniority.^{24,25}

The present results also align with Masionis et al, who found that simplified two-stage classification was more reliable than the original Garden and AO classifications. This supports the view that reproducibility improves when observers have clearer radiographic information and clinically meaningful classification categories.²⁶

Although Garden classification remains the focus of this study, Pauwels and AO/OTA classifications also describe femoral neck fractures from biomechanical and anatomical perspectives.^{27,28}

However, for day-to-day decision-making in intracapsular femoral neck fractures, Garden classification remains widely used because it directly separates fractures by displacement, which is closely linked to fixation versus arthroplasty decisions.

The strengths of this study include prospective design, use of 35 radiographic sets, assessment by 10 observers with different experience levels, and direct comparison of AP-only and AP plus lateral radiographic assessment. The results provide practical evidence that the lateral radiograph improves reproducibility not only for Garden classification but also for treatment planning.

The study has limitations. It was conducted at a single center, used a relatively modest sample size, and assessed agreement only on plain radiographs. Intraobserver reliability was not studied, and advanced imaging such as computed tomography or magnetic resonance imaging was not incorporated. Long-term follow-up to correlate preoperative radiographic decisions with final clinical outcomes was also not available.

CONCLUSION

In this prospective observer-based study, addition of the lateral radiograph to the anteroposterior view improved interobserver agreement for Garden classification and management planning in intracapsular femoral neck fractures. The lateral view changed Garden classification in 17.43% and management decisions in 31.71% of observer-case assessments, with a greater effect among less experienced observers. These findings advance practical understanding by showing that routine AP plus lateral radiographic assessment can make fracture interpretation and treatment planning more consistent, particularly in training and high-volume trauma settings.

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