RESEARCH ARTICLE / *Araştırma Makalesi*

Does Computed Tomography Provide an Advantage over X-ray in the Treatment of Intertrochanteric Fractures?

Bilgisayarlı Tomografi İntertrokanterik Kırık Tedavisinde X-ray'e Göre Avantaj Sağlar mı?

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Abstract

Objective	Successful treatment of intertrochanteric femur fractures depends on an appropriate implant and is decided according to fracture classification and stability. In the present study, the purpose was to investigate the interobserver and intraobserver consistency of x-ray and/or Computerized Tomography (CT) in fracture classification and implant preference for treatment in intertrochanteric femur fractures.
Materials and Methods	The patients who were diagnosed with 80 intertrochanteric femur fractures by two orthopedists with 5 or more years of trauma experience and who had pelvic CT scans for suspected accompanying fractures were evaluated in the study. Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association (AO/OTA) classification and implant preference for treatment were based on x-ray and/or CT. Second evaluations were made two weeks later. Cohen's Kappa was calculated for interobserver reliability in the first evaluation and intraobserver reliability in the first and second evaluations.
Results	Intra-observer Intraclass Correlation Coefficient (ICC) ranged between 0.861 and 0.973 for Observer-1 and between 0.893 and 0.993 for Observer-2 in all evaluations. Inter-observer ICC was within the range of 0.865-0.961 based on primary evaluations. These data represented excellent intra- and inter-observer consistency for both observers (P<0.001).
Conclusion	Preoperative CT scans may provide diagnostic benefits for implant preference, especially in intertrochanteric femur fractures evaluated as stable (AO/OTA-31A1) according to x-ray. Although CT scan analysis results are excellent, this imaging modality should be used on a case-by-case basis to plan and optimize surgical procedures.
Keywords	Intertrochanteric femur fracture; Implant preference; Inter-observer consistency; Optimize surgical procedures

Öz

Amaç	**İntertrokanterik femur kırıklarında başarılı bir tedavi uygun bir implanta bağlıdır ve buna kırık sınıflaması ve stabilitesine göre karar verilir. Çalışmamızda intertrokanterik femur kırıklarında x-ray ve/veya bilgisayarlı tomografi (BT)'nin kırık sınıflamasında ve tedavi için implant seçiminde gözlemciler arası ve gözlemci içi tutarlılığını araştırmayı amaçladık.**
Gereç ve Yöntemle	*Travma tecrübesi beş yıl ve üzerinde olan iki ortopedist tarafından 80 intertrokanterik femur kırığı tanısı almış aynı zamanda eşlik eden kırık şüphesine yönelik pelvis BT taraması yapılmış hastalar değerlendirmeye alındı. Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association (AO/OTA) sınıflaması ve tedavi için implant seçimi x-ray ve/veya BT ye göre yapıldı. İki hafta sonra ikinci değerlendirme yapıldı. Birinci değerlendirme gözlemciler arası güvenilirlik, birinci ve ikinci değerlendirmelerde gözlemci içi güvenilirlik açısından Cohen's Kappa hesaplandı.*
Bulgular	*Tüm değerlendirmelerde Gözlemci-1 için gözlemci içi Intraclass Correlation Coefficient (ICC) 0,861 ile 0,973 aralığında, Gözlemci-2 için ICC 0,893 ile 0,993 aralığındaydı. Birinci değerlendirmeler dikkate alındığında gözlemciler arası ICC 0,865-0,961 aralığındaydı. Bu veriler her iki gözlemci için gözlemci içi ve gözlemciler arası mükemmel uyumu temsil ediyordu (P<0.001).*
Sonuç	*Preoperatif BT taraması, özellikle x-ray'e göre stabil (AO/OTA-31A1) olarak değerlendirilen intertrokanterik femur kırıklarında tedavide implant tercihi için tanısal bir yarar sağlayabilir. Her ne kadar BT tarama analizi sonuçları mükemmel olsa da bu görüntüleme yöntemi cerrahi prosedürü planlamak ve optimize etmek için duruma göre kullanılmalıdır.*
Anahtar Kelimeler	*İntertrokanterik femur kırığı; İmplant tercihi, gözlemciler-arası tutarlılık; Optimize cerrahi prosedür*

INTRODUCTION

Intertrochanteric femur fractures are the most common fractures in people over 65 years of age with a gradually increasing incidence in geriatric population.[1] Surgery is one of the options for the treatment of intertrochanteric femur fractures. After stable fixation of intertrochanteric femur fractures, patients can move more quickly and return to their previous level of functioning.[2]

Evaluation of preoperative stability is very important for surgical planning in intertrochanteric femur fractures. Successful treatment depends on an appropriate implant and is judged by fracture classification and stability.[3] An ideal classification must be simple and highly reproducible, provide information on stability evaluation, and more importantly, guide treatment preference. Although stable intertrochanteric femur fractures can be successfully treated with the Dynamic Hip Screw (DHS), it is accepted that unstable intertrochanteric femur fractures may require an Intra-Medullary Nail (IMN) or a modified DHS.[4] The most popular classification systems are Jensen et al. (EVJE) and Muller et al. Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association (AO/OTA).[5,6] In their study, in which they used the AO/OTA classification evaluated by x-ray, Fung et al. showed that interobserver reproducibility is better than the EVJE classification system.[7] In addition, in studies conducted with the AO/OTA classification system, it was determined that the inter-observer and intra-observer evaluations had high consistency, but low consistency was observed when subgroups were used.[8,9]

The classification systems for intertrochanteric femur fractures are based on Pelvis Antero-Posterior (AP) x-ray results.[10] Postero-lateral area fractures, which play important roles in stability, may go undetected because of insufficiency of the pelvis AP in the sagittal area.[11] More recently, researchers have tried to overcome the limitations of direct radiography by using advanced imaging methods such as CT.[12,13] CT scans provide much clearer information on fracture morphology and fracture line than x-rays.[14]

In the present study, the purpose was to investigate the interobserver and intraobserver consistency in the main group AO/OTA classification and in the preference of implants for treatment by evaluating the Pelvis x-ray and/or Pelvis CT imaging of intertrochanteric femur fractures.

MATERIAL and METHODS

This is a methodologic and retrospective study. The radiological and medical data of patients who were treated with the diagnosis of intertrochanteric femur fracture in the Orthopedics and Traumatology Clinic of the Marmara University Pendik Training and Research Hospital between January 2018 and October 2019 were analyzed retrospectively. Participant data were collected from the electronic database of the training and research hospital. The ethics approval was obtained from The Marmara University Faculty of Health Sciences Ethics Committee for Non-Invasive Clinical Studies (Approval date and number: 30.12.2020/80).

The patients were excluded from the study in the absence of patient imaging, pathological fractures (because of primary or metastatic tumors), femoral neck fractures, periprosthetic fractures, previous intertrochanteric femur surgery, and proximal femoral deformity.

A total of 85 patients who were diagnosed with intertrochanteric femur fracture in the pelvic AP x-ray evaluation and who had pelvic CT scan for suspected accompanying fracture were found to be eligible for the study. Five patients were excluded because of incomplete imaging evaluation. Among the remaining 80 patients, 49 (61.30%) were female, 31 (38.70%) were male, mean age was 76.53±13.79 years, and left hips were affected in 37 (46.20%) and right hips were affected in 43 patients (53.80%).

We used a random number table to organize the order in which the images were evaluated again. Before the eva-

luation began, two experienced trauma surgeons held a colloquial discussion about the AO/OTA classification system.[4,6] Images obtained for each patient were anonymized, analyzed independently, and blinded to patients' names and medical record numbers. Two observers (MK and HK) were asked to classify each fracture according to the AO/OTA three main group classification systems with two different imaging modalities (X-ray and/or CT scan), interpret them separately without knowing the results of the other. After the first evaluation of all the images of 80 patients, a second evaluation session was performed after a two-week period.

In all cases, imaging evaluation consisted of fracture hip Pelvis AP x-ray and/or axial, coronal, and sagittal section CT scans. Pelvis AP x-ray examinations were performed by using x-ray device (DRGem, GXR 825D, Republic of Korea). Non-contrast CT examinations were performed by using Philips Ingenuity 128 scanner (Philips Healthcare, Cleveland, OH, USA) in 0.50 mm axial slices with 3 mm coronal and sagittal reconstructions.

Statistical Analysis

All analyses were performed on SPSS v22 (SPSS Inc., Chicago, Illinois, USA). Study data were evaluated (mean, standard deviation, min-max). The comparisons between groups were analyzed using the Pearson chi-square test for categorical variables. ICC (Intraclass Correlation Coefficient) values were obtained for AO/OTA classification to X-ray, Implant choice to X-ray, AO/OTA classification to X-ray/CT, Implant choice to X-ray/CT and Bland–Altman charts were used to evaluate reliability. ICC values below 0.50 are considered to indicate poor reliability; 0.50-0.75, medium reliability; 0.75-0.90, good reliability; and >0.90, excellent reliability. Calculated Probability (P-value) < 0.05 was considered to indicate statistically significant differences.

RESULTS

The median age was 79 (min-max, 30-100) and the female/male ratio was 49:31 (61.30%/38.70%). The results of the reproducibility analysis for intraobserver and interobserver consistency are given in Table 1 (intraobserver reliability in the first two columns and interobserver reliability in

Table 1. Intra/Inter-observer reproducibility study results in terms of AO/OTA classification and implant preference.

Observational analysis	Intra-observer compliance levels-ICC (%95 CI)		Inter-observer compliance levels-ICC (%95 CI)	p[a]
	Observer 1	Observer 2	Observer 1 / Observer 2	
AO/OTA classification to X-ray	0.958 (0,876-0,947)	0,957 (0,932-0,973)	0.939 (0,906-0,961)	<0.001
Implant preference to X-ray	0,958 (0,935-0,973)	0,932 (0,893-0,956)	0,928 (0,888-0,954)	<0.001
AO/OTA classification to X-ray/CT	0,935 (0,893-0,958)	0,990 (0,984-0,993)	0,913 (0,865-0,944)	<0.001
Implant preference to X-ray/CT	0.911 (0,861-0,943)	0.964 (0,943-0,977)	0.929 (0,890-0,955)	<0.001

a statistical significance of intra-observer and inter-observer reliability
The two columns on the left represent intra-observer reliability, and the right column represents interobserver reliability (Initial measurements are considered).
ICC: Intraclass Correlation Coefficient, CI: Confidence Interval
AO/OTA: Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association
CT: Computerized Tomography

the last column).

For Observer-1, the intra-observer ICC range was between 0.861 and 0.973 in all evaluations. For Observer-2, the intra-observer ICC range was between 0.893 and 0.993 in all evaluations. These data represented excellent consistency in terms of intra-observer evaluations for both observers (P<0.001). The interobserver ICC range was between 0.865 and 0.961 when the first evaluations were considered. These data represented excellent consistency in terms of interobserver evaluations (P<0.001).

According to AO/OTA on X-ray, 36.20% of the patients were 31A1, 53.70% were 31A2, and 10% were 31A3. On X-ray/CT, 26.20% of the patients were 31A1, 65% were 31A2, and 8.70% were 31A3. Significant differences were detected between the evaluations made according to x-ray or x-ray/CT for AO/OTA classification (P<0.001). The AO/OTA classification results of Observer-1 and Observer-2 according to the x-ray or x-ray/CT first evaluations are shown in Table 2 and Table 3.

Table 2. AO/OTA classification Observer 1 evaluation results according to X-ray or x-ray/CT

Observational analysis of the AO/OTA classification		According to X-ray/CT			p[a]
		31A1	31A2	31A3	
According to X-ray	31A1	19	10	0	<0.001
	31A2	2	41	0	
	31A3	0	1	7	

[a] Pearson Chi-square Test
AO/OTA: Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association
CT: Computerized Tomography

Table 3. AO/OTA classification Observer 2 evaluation results according to X-ray or x-ray/CT

Observational analysis of the AO/OTA classification		According to X-ray/CT			p[a]
		31A1	31A2	31A3	
According to X-ray	31A1	19	10	1	<0.001
	31A2	0	44	0	
	31A3	0	0	6	

[a] Pearson Chi-square Test
AO/OTA: Arbeitsgemeinschaft für Osteosynthesefragen/Orthopaedic Trauma Association
CT: Computerized Tomography

According to X-rays, implant preference was DHS in 36.20% of patients and IMN in 63.70% of patients. According to X-ray/CT, implant preference was DHS in 26.20% of patients and IMN in 73.70% of patients. A significant difference was detected between the evaluations made according to x-ray or x-ray/CT in terms of implant preference (P<0.001). The implant preference results of Observer-1 and Observer-2 according to the x-ray or x-ray/CT first evaluations are given in Table 4 and Table 5.

Table 4. Implant preference Observer 1 evaluation results according to X-ray or x-ray/CT

Observational analysis of the Implant preference		According to X-ray/CT		p[a]
		DHS	IMN	
According to X-ray	DHS	19	10	<0.001
	IMN	2	49	

[a] Pearson Chi-square Test
CT: Computerized Tomography
DHS: Dynamic Hip Screw
IMN: Intra-Medullary Nail

Table 5. Implant preference Observer 2 evaluation results according to X-ray or x-ray/CT

Observational analysis of the Implant preference		According to X-ray/CT		p[a]
		DHS	IMN	
According to X-ray	DHS	19	11	<0.001
	IMN	0	50	

[a] Pearson Chi-square Test
CT: Computerized Tomography
DHS: Dynamic Hip Screw
IMN: Intra-Medullary Nail

DISCUSSION

In our study, we evaluated the classification of proximal femur fractures according to AO/OTA main groups and the preference of implants to be used in the treatment interobserver and intraobserver. We found excellent interobserver and intraobserver consistency in terms of AO/OTA classification. In addition, we observed that the use of x-ray/CT caused a significant difference in the preference of implant to be used in the treatment of the proximal femur fracture, which was evaluated by the observers as AO/OTA 31A1 stable fracture pattern according to x-ray.

Accurate classification of proximal femur fractures is important in preoperative planning and affects patient positioning and implant preference. Fung et al. showed that interobserver reproducibility is better than EVJE classification systems in their study, in which they used the AO/OTA classification evaluated by x-ray.[7] It is known that the AO classification has poor reproducibility when subgroups are considered[8]. Better results are obtained when only the main fracture groups (A1, A2, A3) are considered.[15–17] In our study, we used AO/OTA main groups, which can be the primary guide for selecting implants to be used in the treatment and increase reproducibility.

Intertrochanteric femur fracture stability is defined in the AO/OTA and EVJE classification systems.[6] Segmental and unstable intertrochanteric femur fractures are 31-A2/31-A3 in the AO/OTA system and Type IV - Type V in the EVJE System. Preferring the implant suitable for stability in intertrochanteric femur fractures is one of the main factors affecting the success of the treatment. A failure rate of less than 7% is faced when suitable implants are preferred for unstable fractures.[18,19] For this reason, it is important to use a reliable tool (i.e. that has higher reproducibility) to evaluate the stability of intertrochanteric femur fractures. Van Embden et al. showed low consistency between observers regarding stability in their study, including intertrochanteric femur fractures with x-ray.[8] Isida et al. found that 3DCT had better intra-observer and inter-observer and x-ray outcomes than conventional x-rays for fracture stability evaluation and implant preference along with interobserver reproducibility. Using plain X-rays, it is difficult to evaluate the posterior fracture line of the intertrochanteric space.[11] It is also the second important component for the stability of intertrochanteric femur fractures in the posteromedial fragment.[20] The integrity or restoration of the posteromedial hinge prevents varus displacements and retroversion of the proximal fragment.[2] When the sections were examined, the posteromedial fragment could be evaluated more clearly than x-ray. Although 31A1 stable fracture pattern was identified in 36.20% of the patients on X-ray, this rate was 26.20% when CT was added to the evaluation. Considering the importance of stability in the preference of the appropriate implant for maintaining the reduction, we believe that CT evaluation and x-ray will benefit the 31A1 fracture pattern. CT scans are used to analyze complex fractures, detect intra-articular fragments, and associated articular surface fractures, and define fracture patterns better in surgical planning. In 1987, Konishi et al. first published their study describing 3D tomography observations for fracture typing and configuration analysis.[21] In the following years, Alexandre et al. showed that Computed Tomography provides an additional contribution compared to x-ray in analyzing fracture lines more precisely and detecting lateral wall fractures in patients with trochanteric fractures.[22] The accompanying lateral wall pattern in intertrochanteric femur fractures affects fracture stability and the treatment preference of the surgeon. Some studies suggest using intramedullary implants for stability, especially in patients with lateral wall fractures accompanying intertrochanteric femur fractures.[23] Again, Hecht et al. showed that CT provides better and more predictable fixation results in unstable intertrochanteric femur fractures after preoperative use.[24] In the present study, DHS, which was preferred to apply to stable fracture patterns, was preferred in 36.20% of patients compared to x-ray, and it was preferred in 26.20% compared to x-ray/CT. We think the CT evaluation and x-ray will be less critical in the treatment of imp-

lant preference in groups other than 31A1 because implant preference is for intramedullary fixation in the 31A2 and 31A3 groups with unstable fracture patterns.

The study had a single-center observational design. One of the study's limitations was the lack of homogeneity in the distribution of fracture patterns. Although pelvis AP, hip AP, and hip lateral standard radiographs could not be obtained in every patient, at least one pelvis AP image was included in the standard evaluation of each patient. While preoperative evaluation is essential in stability evaluation and implant preference, our study was conducted only on radiographic data. A randomized prospective clinical study to be planned considering the results of the present study will contribute to the literature.

In conclusion, the purpose of the present study was that CT would increase our understanding of hip fractures, not to suggest its routine use in such fractures. Preoperative CT scans may provide diagnostic benefits for implant preference, especially in intertrochanteric femur fractures evaluated as stable (31A1) according to x-ray results.

Ethics approval

The Marmara University Faculty of Health Sciences Ethics Committee for Non-Invasive Clinical Studies approved the study (Approval date and number: 30.12.2020/80).

Conflict of Interest

No conflict of interest was declared by the authors.

Financial Disclosure

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Informed consent

Informed consent was obtained from all individual participants included in the study.

Contribution

The authors contributed equally at all stages of the study

Kaynaklar

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