Original Article
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Intertrochanteric (Reverse Oblique) Fracture Subclassifications AO/OTA 31-A3 Have No Effect on Outcomes or Postoperative Complications

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Background: Reverse oblique intertrochanteric fractures (ROFs) are unstable extracapsular hip fractures that present a mechanical challenge. These fractures are classified as AO/Orthopaedic Trauma Association (OTA) 31-A3 according to the Trauma Association classification system and can further be subclassified into 3 subtypes based on their specific characteristics. The study aimed to evaluate and compare the radiographic and clinical outcomes of the 3 subtypes of ROFs.

Methods: A retrospective study was conducted at a single high-volume, tertiary center, where data were collected from electronic medical records of consecutive patients who underwent surgical fixation of AO/OTA 31-A3 fractures. Patients with less than 1-year follow-up, pathological fractures, and revision surgery were excluded. The subtypes of fractures were classified as 31-A3.1 (simple oblique), 31-A3.2 (simple transverse), and 31-A3.3 (wedge or multi-fragmentary). The operation was done using 4 different fixation methods, and radiological evaluation was performed at routine intervals.

Results: The final population consisted of 265 patients (60.8% women) with a mean age of 77.4 years (range, 50–100 years) and the mean follow-up time was 35 months (range, 12–116 months). The incidence of medical complications was similar across the groups. However, there was a trend toward a higher incidence of orthopedic complications and revision rates in the 31-A3.2 group, although this was not statistically significant ($p = 0.21$ and $p = 0.14$, respectively).

Conclusions: Based on the findings of this study, no significant differences were observed between the groups, indicating that the subclassifications of AO/OTA 31-A3 fractures do not have a significant impact on surgical outcomes or the occurrence of postoperative complications.

Keywords: *Trochanteric fractures, Fracture classification, Fracture fixation, Intramedullary, Subgrouping*

Hip fractures are increasing in incidence and represent a significant source of morbidity and mortality for elderly patients.[1,2] Early surgical intervention is strongly recommended for the majority of these patients to minimize the potential complications associated with prolonged immobilization and improve their overall outcomes.[3] Reverse oblique intertrochanteric fractures (ROFs) are unstable extracapsular hip fractures. These fractures are classified as AO/Orthopaedic Trauma Association (OTA) 31-A3, according to the Trauma Association classification system, and account for up to 20% of all intertrochanteric fractures.[4] These fractures can further be subclassified into 3 subtypes based on their specific characteristics. The first subtype, 31A3.1, is characterized by a simple oblique fracture. The second subtype, 31A3.2, consists of a simple transverse fracture and the third subtype, 31A3.3, is a wedge or multi-fragmentary fracture.[5]

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ROFs are technically challenging to manage due to fracture line direction, which makes them prone to displacement and rotational instability.[6] Recent studies support the use of cephalomedullary fixation for these fractures as the preferred method of fixation. The current evidence on the preferred nail length, however, is inconclusive.[7-9] Previous studies suggest that the incidence of implant failure in ROFs is high, compared to AO/OTA 31-A1 and A2 fractures. However, there is currently a paucity of evidence on the association between different subtypes and postoperative outcomes including complications and patient-reported outcomes.

The purpose of this study was to evaluate and compare the radiographic and clinical results of the 3 different subtypes of ROFs. Our hypothesis was that there would be no significant difference between the groups.

METHODS

The present study received approval from the Institutional Review Board of Tel Aviv Medical Center (No. 0481-20 TLV). Informed consent was waived because of the retrospective nature of the study and the analysis used anonymous clinical data.

This is a retrospective study that was conducted in a high-volume, academic, tertiary referral center. Data were collected from electronic medical records of consecutive patients who underwent closed reduction and internal fixation (CRIF) for AO/OTA 31-A3 fractures between June 2010 and May 2019. Data were extracted from electronic medical records of consecutive patients who underwent CRIF for AO/OTA 31-A3 fractures between the period of June 2010 and May 2019. Patient characteristics such as sex, age, and the American Society of Anesthesiologists (ASA) score[10] were documented.

ASA physical status classification system was used to assess the preoperative health of patients, with scores ranging from 1 (normal healthy patient) to 4 (patient with severe systemic disease that is a constant threat to life). Patients with pathological fractures, individuals who underwent revision surgery, and those with a follow-up duration of less than 1 year were excluded from the study.

The surgery was performed within 48 hours of presentation. During surgery, the patients were positioned supine on a fracture table and operated under general or regional anesthesia. The method used for fixation was either the Expandable Proximal Femoral Nail (Fixion; HMB Medical Technologies), the Gamma 3 Proximal Femoral Nail (GPFN; Stryker), InterTAN nail (Smith & Nephew), and the TFN-Advanced Proximal Femoral Nailing System (TFNA; DePuy Synthes). The nails were inserted according to the standard protocol using the manufacturer's instructions.[11]

The operation was performed under fluoroscopic guidance using a C-arm with an image intensifier to verify fracture reduction and fixation. Data on the surgeons' experience, surgery duration, hemoglobin levels, intraoperative and postoperative complications, and other hospitalization characteristics were obtained from medical files. All radiographs were reviewed by a senior orthopedic surgeon (SF). Fractures were classified according to the proposed classification by AO/OTA, which characterizes ROFs as follows: AO/OTA 31-A3.1, simple oblique fracture; AO/OTA 31-A3.2, simple transverse fracture; and AO/OTA 31-A3.3, wedge fracture or multi-fragmentary fracture (Fig. 1).[12]

Postoperative management included early mobilization, full weight-bearing, and prophylactic treatment for thromboembolism. Patients were followed up routinely at our outpatient clinic at various intervals: 6 weeks, 3 months, 6 months, and 1 year postoperatively. Radiological evaluation of anteroposterior (AP) and axial films was

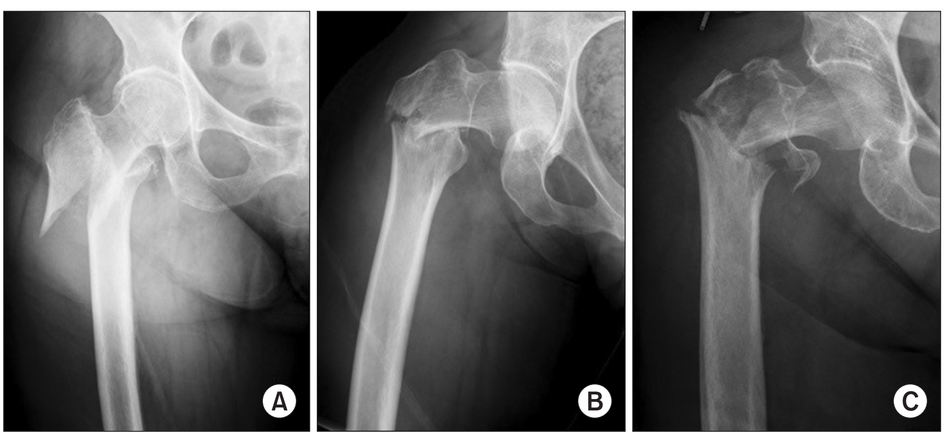

Fig. 1. AO/OTA subclassification of 31-A3 reverse oblique intertrochanteric fractures. (A) AO/OTA 31-A3.1: simple oblique fracture. (B) AO/OTA 31-A3.2: simple transverse fracture. (C) AO/OTA 31-A3.3: wedge fracture or multi-fragmentary fracture. OTA: Orthopaedic Trauma Association.

performed. Malunion was defined as more than 10° of varus or valgus compared to the unaffected hip and more than 10 mm of shortening. Nonunion was defined as either no callus or with callus that did not bridge the fracture site at least 15 weeks after the fracture.

Statistical Analysis

Statistical analysis was performed with IBM SPSS ver. 25 (IBM Corp.). Descriptive statistics were applied for patient characteristics. After continuous variables were tested for normality, means and standard deviations were calculated and compared by Student *t*-test. Frequencies and percentages were calculated for nominal variables and were compared between the groups by the chi-square test. One-way analysis of variance was used to assess differences in normally distributed variables between the 3 subgroup classifications, with post-hoc testing when the overall F-test was significant. Differences between study groups were considered statistically significant at $p < 0.05$.

RESULTS

Following exclusions, the final study population consisted of 265 patients (60.8% women), with 96 patients in the 31-A3.1 group, 57 in the 31-A3.2 group, and 112 in the 31-A3.3 group. The mean age was 77.4 years (range, 50–100 years). The mean age of patients in subclasses 31-A3.1, 31-A3.2, and 31-A3.3 was 82 ± 11 years, 80 ± 12 years, and 80 ± 13 years, respectively, with no significant difference between subgroups ($p = 0.37$). The mean follow-up time was 35 months (range, 12–116 months) with no significant difference between the groups ($p = 0.23$). The mean ASA scores were not significantly different between the groups ($p = 0.07$), indicating similar preoperative health status across groups (Table 1).

In terms of surgical technique, the only significant difference in screw placement was found in the middle position, with the 31-A3.2 group demonstrating a lower proportion of screws placed in the middle (43.9%), compared to the 31-A3.1 group (52.1%) and 31-A3.3 group (65.2%) ($p = 0.02$). No significant difference was found in tip apex distance (TAD) between the groups ($p = 0.30$) (Table 2).

When examining the number of cases performed with each nail type by residents versus senior surgeons

Table 1. Patients Characteristics

Variable	AO/OTA			*p*-value
	31-A3.1 (n = 96)	31-A3. 2 (n = 57)	31-A3.3 (n = 112)	
Age (yr)	82 ± 11	80 ± 12	80 ± 13	0.38
Female sex	80 (83.3)	40 (70.2)	88 (78.6)	0.16
Right side	46 (47.9)	26 (45.6)	59 (52.7)	0.64
ASA score				0.07
1	8 (11.1)	4 (10.8)	12 (16.9)	
2	32 (44.4)	17 (45.9)	20 (28.2)	
3	32 (44.4)	12 (32.4)	38 (53.5)	
4	0	4 (10.8)	1 (8.7)	

Values are presented as mean ± standard deviation or number (%).
OTA: Orthopaedic Trauma Association, ASA; American Society of Anesthesiologists.

Table 2. Surgical Characteristics

Variable	AO/OTA			*p*-value
	31-A3.1 (n = 96)	31-A3. 2 (n = 57)	31-A3.3 (n = 112)	
Surgeon				
Resident	54 (56)	31 (54)	61 (54)	0.98
Senior	42 (44)	26 (46)	51 (46)	0.97
AP peg				
Inferior	47 (49.0)	35 (61.4)	65 (58)	0.07
Middle	46 (47.9)	21 (36.8)	43 (38.4)	0.76
Superior	2 (2.1)	1 (1.8)	4 (3.6)	0.78
Axial peg				
Anterior	16 (16.7)	9 (15.8)	13 (11.6)	0.47
Middle	50 (52.1)	25 (43.9)	73 (65.2)	0.02*
Posterior	30 (31.3)	23 (40.4)	26 (23.2)	0.07
TAD (mm)	21.6 ± 6.3	21.5 ± 6.9	22.1 ± 7.1	0.30
Nail length				
170 mm	0	1 (1.8)	2 (1.8)	0.12
180 mm	34 (35.4)	16 (8.1)	51 (45.9)	< 0.001*
200 mm	3 (3.1)	1 (1.8)	4 (3.6)	0.87
220 mm	9 (9.4)	11 (19.3)	20 (18)	0.29
235 mm	31 (32.3)	18 (31.6)	15 (13.5)	0.25
Long nail (> 235 mm)	19 (19.8)	10 (17.5)	20 (17.8)	0.95

Values are presented as number (%) or mean ± standard deviation.
OTA: Orthopaedic Trauma Association, AP: anteroposterior, TAD: tip apex distance.
*Statistically significant at $p < 0.05$.

Table 3. Surgical Outcomes

Variable	AO/OTA 31-A3.1 (n = 96)	AO/OTA 31-A3.2 (n = 57)	AO/OTA 31-A3.3 (n = 112)	*p*-value
Follow-up period (mo)	35 (12–116)	33 (12–79)	37 (12–105)	0.13
Medical complication*	24 (25)	14 (24.6)	23 (20.5)	0.71
Orthopedic complication	7 (7.3)	9 (15.8)	10 (8.9)	0.21
Infection	2 (2)	3 (5)	3 (3)	
Cut-out	3 (3)	2 (4)	4 (4)	
Malunion	1 (1)	3 (5)	2 (2)	
Nonunion	1 (1)	1 (2)	1 (1)	
Revision	6 (6.3)	9 (15.8)	10 (8.9)	0.14

Values are presented as median (range) or number (%).
OTA: Orthopaedic Trauma Association.
*Medical complications include pneumonia, pulmonary embolism, and urinary tract infections.

Table 4. Screw Location and PFN Characteristics in Cut-out Cases

AO/OTA	AP	Axial	Nail brand*	Nail length
31-A3.1	Inferior	Middle	Gamma	180 mm
	Middle	Anterior	Gamma	Long nail (> 235 mm)
	Inferior	Anterior	Gamma	180 mm
31-A3.2	Inferior	Anterior	Inflatable	220 mm
	Inferior	Posterior	Gamma	180 mm
31-A3.3	Inferior	Anterior	InterTAN	180 mm
	Inferior	Anterior	Gamma	180 mm
	Inferior	Posterior	Gamma	180 mm
	Inferior	Posterior	Inflatable	Long nail (> 235 mm)

PFN: Proximal Femoral Nail, OTA: Orthopaedic Trauma Association, AP: anteroposterior.
*Gamma: Gamma 3 Proximal Femoral Nail (GPFN, Stryker), Inflatable: Expandable Proximal Femoral Nail (Fixion; HMB Medical Technologies), InterTAN: InterTAN nail (Smith & Nephew).

within the subgroup classifications, significant differences emerged for certain implants. For the 31-A3.1 group, senior surgeons performed a greater proportion of cases with inflatable nails compared to residents (80.0% vs. 20.0%, $p = 0.051$). For the 31-A3.3 group, residents used Gamma nails in more cases than seniors (62.9% vs. 37.1%, $p = 0.02$); however, seniors utilized inflatable nails more frequently than residents (75.0% vs. 25.0%, $p = 0.02$). No other statistically significant differences were found between residents and seniors in the utilization of nail types across the subgroups. The incidence of medical complications did not differ between groups ($p = 0.71$). However, there was a trend toward a higher incidence of orthopedic complications in the 31-A3.2 group (15.8%) compared to the other groups (7.3% for 31-A3.1 and 8.9% for 31-A3.3), although this was not statistically significant ($p = 0.21$). There was also a trend toward a higher revision rate in the 31-A3.2 group (15.8%) compared to the other groups (6.3% for 31-A3.1 and 8.9% for 31-A3.3); however, this was also not statistically significant ($p = 0.14$) (Table 3).

In the 31A3.1 group, there were 7 cases of orthopedic complications. These occurred in 5 patients who received GPFN (3 with 180-mm nails and 2 with long nails), 1 patient treated with InterTAN 180 mm, and 1 patient treated with a 220-mm Inflatable nail. In the 31A3.2 group, there were 9 cases of orthopedic complications. Three cases were observed in patients treated with GPFN (2 with 180-mm nails and 1 with a long nail), 3 cases in patients treated with TFNA (2 with 235-mm nails and 1 with a long nail), 1 case in a patient treated with InterTAN 180mm, and 2 cases in patients treated with the Inflatable 220-mm nail.

Lastly, in the 31A3.3 group, there were 10 cases of orthopedic complications. Five patients were treated with GPFN 180 mm, 2 patients with TFNA 235 mm, 1 patient with InterTAN 180 mm, and 2 patients with Inflatable nails (1 with 220 mm and 1 with a long nail) (Table 4).

DISCUSSION

The aim of this study was to compare the clinical and radiological outcomes of 3 different subtypes of ROFs. The study's main finding is that there was no significant difference in surgical outcomes and postoperative complications between the groups. Cut-out was identified as the most common complication in all 3 groups.

Cut-out is a well-recognized and significant perioperative complication that can occur after internal fixation of intertrochanteric fractures. Its prevalence has been reported to range from 1.9% to 3.2%.[13] Cut-out typically occurs due to the collapse of the neck-shaft angle into the varus, leading to the extrusion of the screw from the femoral head.[14,15] In this study, the overall cut-out rate for the entire cohort was 3%, which is in agreement with rates previously reported.[16] The cut-out rate was 3% for the 31-A3.1 group and 4% for the 31-A3.2 and 31-A3.3 groups.

However, no significant statistical difference was found in the cut-out rate among the 3 subtypes. Several authors have attempted to identify predictors of cut-out to mitigate the risk of developing this complication, evaluating and proposing numerous patient- and operation-related factors as potential risk factors.[13)]

Bojan et al.[17)] proposed that the pattern of the fracture has a significant correlation with the development of cut-outs. They observed a cut-out rate of 6.5% in 31-A3.3 fractures, which is higher compared to the overall rate of 1% for all intertrochanteric fractures. Similarly, Haidukewych et al.[4)] reported a high cut-out rate of 12.7% in 47 ROF type 31-A3.1 and A3.3 fractures, regardless of the type of internal fixation devices used. In contrast, our study demonstrated a lower cut-out rate, which may be attributed to the fact that the study cohort underwent surgical treatment using lag screws rather than helical blades. Stern et al.[18)] demonstrated significantly higher cut-out rates when helical blades were used compared to lag screw fixation for low-energy peritrochanteric femur fractures in elderly patients.

Moreover, the position of the lag screw within the femoral head has been identified as an important factor in the occurrence of cut-outs. The optimal placement of the lag screw in the femoral neck has been extensively discussed, with many authors recommending a central-posterior position in the lateral view and a central-inferior position in the AP view projection. A study conducted by De Bruijn et al.[19)] investigated predictors of screw cut-out and found that the central-central, anterior-inferior, and central-inferior positions significantly contributed to protecting the screw from cutting out. In our study, out of the 9 cases of cut-outs, the AP position of the screw was inferior in 8 cases. Regarding the axial location, 3 cases were posterior, 5 were anterior, and 1 was in the middle position. These findings suggest that in this study cohort, the specific location of the screw did not appear to be a critical factor in the risk of cut-outs. While our data showed a higher relative proportion of cut-outs with inferior versus middle lag screw positioning on AP views, the overall number of cut-out events was small at 9 total cases. This low absolute count makes drawing definitive conclusions about position challenging. The 5.4% cut-out rate with inferior placement could represent a chance finding rather than a true increase in risk. At our institution, surgeons prioritize central or inferior screw positioning during preoperative planning and intraoperatively for these fracture patterns. This practice preference over many years likely minimized the utilization of superior positioning, which may have aggravated the apparent difference between inferior and middle locations. Bone quality also plays a key role, with osteoporosis increasing the risk of cut-out despite optimal position. Considering the complex interplay of surgical factors and bone health, our results should be interpreted with caution. Further research with larger cohorts is warranted to clarify the relationship between AP lag screw position and cut-out risk in specific unstable intertrochanteric fracture subclasses.

Additionally, the TAD, which indicates the position and depth of a screw within the femoral neck and head, has been identified as another significant prognostic factor for cut-out occurrences. Goffin et al.[20)] suggested that a TAD greater than 25 mm cannot be considered as a reliable predictor of lag screw cut-out. In our study cohort, the average TAD was 21.78 ± 6.7, which may explain the absence of observed differences between the cohorts regarding this complication.

The overall revision rate in this study for the entire cohort was 9%. No significant difference was observed in the revision rates between different implant designs for each ROF group. Previous studies investigating different implant designs for ROFs have also reported no significant difference in the overall rate of complications and revisions between the TFNA nail and the GPFN.[9)] Additionally, a previous study with a small sample size (n = 40) reported a revision rate of 27.5% for GPFN in the treatment of ROFs.[21)] We believe that such a relatively high rate may be in part attributed to the limited sample size. Bonnaire et al.[22)] similarly reported a revision rate of 7.5% in unstable trochanteric fractures managed with GPFN. The lower revision rate in their study could be due to the inclusion of AO/OTA 31-A2 fractures as unstable fractures.

Previous studies have recommended the use of long nails for the treatment of ROFs.[3,23)] However, the results of our study contradict these findings and suggest that for ROFs, long nails do not offer any advantage over short nails. Conversely, Okcu et al.[8)] found a significant difference in the overall complication rate for the treatment of ROFs between long nails (> 34 cm) and standard nails (24 cm). In contrast, a biomechanical analysis conducted by Blum et al.[7)] suggested there is no benefit associated with using long nails for the treatment of unstable trochanteric fractures. The current evidence on this topic is inconclusive, highlighting the need for further detailed investigation.

The AO/OTA classification aims to guide the treatment of intertrochanteric fractures by differentiating stable versus unstable patterns. However, prior studies have demonstrated only moderate interobserver agreement on 31-A3 subgroups, with Kappa generally in the fair range.[24,25)]

Despite attempts to refine the system, variability in radiographic interpretation remains. While we used an experienced surgeon reader, fracture classification reliability was a limitation without multiple blinded observers. However, the AO/OTA schema remains the predominant approach used in the literature despite reliability concerns. Further refinement is still needed to improve reliability and enable optimal communication between surgeons when managing these challenging trochanteric fractures.

The current study has several limitations. First, it employed a retrospective design, which may limit the ability to establish causal relationships. Additionally, the sample sizes of the 3 groups were unequal, with the 31-A3.2 group being almost half the size, potentially introducing bias into the findings. Second, although the different types of proximal femoral nails did not appear to have an impact on cut-out rates, it is important to note that the study included 4 different implants and various nail lengths, which may confound results. Another limitation of this study is the use of just a single reader to classify all radiographs into AO/OTA 31A3 fracture subgroups. Having 2 blinded, independent readers would have enabled the calculation of inter- and intra-rater reliability statistics to quantify consistency in the fracture classifications. With only 1 reader, there is potential for subjectivity and bias in the subclassification of these complex patterns. While an experienced, fellowship-trained orthopedic trauma surgeon served as the reader, variability between clinicians in interpreting fracture morphology is well-documented. Lastly, surgical experience is a factor that could have influenced results, as surgeries were performed by both residents and senior surgeons. However, the overall level of surgical experience did not differ between the groups, thus minimizing the potential bias.

The subclassification of AO/OTA 31-A3 fractures did not have any effect on postoperative complications or revision rates following surgical fixation for reverse oblique fractures. Future high quality prospective studies are warranted to better understand whether this classification system offers any information on prognostication.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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