

# Two versus three cannulated screws in pediatric Delbet type II femoral neck fractures: a retrospective comparative study

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## ABSTRACT

**BACKGROUND:** Pediatric femoral neck fractures are rare but carry a high risk of complications such as avascular necrosis (AVN), premature physeal closure, and coxa vara. Although stable internal fixation is essential, the optimal number of cannulated screws remains controversial. This study compares the clinical and radiological outcomes of two- versus three-screw fixation in a homogeneous cohort of Delbet type II fractures.

**METHODS:** Thirty-six children treated within three days of injury and followed for at least five years were retrospectively analyzed. All fractures were fixed using either two or three cannulated screws. Surgical variables included reduction quality, screw number, physeal penetration, screw-to-neck area ratio, and the presence of cortical comminution. Patients were stratified into two age groups (<10 and ≥10 years). Complications—AVN, premature physeal closure, and coxa vara—were assessed radiographically and classified using established criteria. Statistical comparisons were performed using appropriate parametric and nonparametric tests.

**RESULTS:** Older children (≥10 years) showed higher rates of total complications, AVN, and physeal closure; however, the differences were not statistically significant. Medial or posterior cortical comminution significantly increased complication rates. Physeal penetration markedly elevated the risk of premature physeal closure ( $p=0.045$ ). Reduction quality strongly correlated with outcomes, with unacceptable reductions associated with significantly higher rates of AVN and physeal closure. The number of screws did not significantly influence overall complications or specific adverse outcomes. The screw-to-neck area ratio showed a nonsignificant trend toward higher values in patients with complications.

**CONCLUSION:** Anatomical reduction and avoidance of physeal penetration are the primary determinants of postoperative outcomes in pediatric Delbet type II femoral neck fractures. When reduction is adequate and biological structures are preserved, the use of two or three screws yields comparable long-term results.

**Keywords:** Avascular necrosis; cannulated screws; complications; pediatric femoral neck fractures; surgical outcomes.

## INTRODUCTION

Pediatric femoral neck fractures account for approximately 1% of all childhood fractures; however, they are associated

with disproportionately high rates of complications, including avascular necrosis (AVN), premature physeal closure, coxa vara, and nonunion.<sup>[1,2]</sup> These injuries most commonly occur in active children aged 10–13 years following high-energy

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trauma and necessitate urgent anatomical reduction and stable internal fixation.<sup>[3]</sup>

Among the various technical factors influencing outcomes, the number and diameter of cannulated screws are critical determinants of both fixation stability and preservation of vascular integrity.<sup>[4]</sup> However, the optimal screw configuration remains controversial. While the use of three screws may theoretically provide greater mechanical stability, it has also been associated with increased risks of AVN and premature physeal closure.<sup>[5,6]</sup> In addition, the ratio between screw diameter and femoral neck width has been proposed as a factor influencing the likelihood of iatrogenic injury.<sup>[7,8]</sup>

Despite numerous studies, a clear consensus has not been established, largely due to heterogeneity in study populations, fracture classifications, and surgical techniques.<sup>[9]</sup> To reduce these confounding variables, the present study focuses exclusively on Delbet type II fractures and compares the long-term clinical and radiological outcomes of fixation using two versus three cannulated screws in a homogeneous pediatric cohort.

## MATERIALS AND METHODS

The following surgical parameters were evaluated: type of reduction, number of cannulated screws used, epiphyseal penetration by the screws, the screw-to-femoral neck width ratio (screw-to-bone ratio), and quality of reduction. All included fractures were Delbet type II (transcervical), ensuring sample homogeneity and comparable vascular risk profiles. The area of the femoral neck was calculated using the elliptical section formula ( $\pi \times \text{short axis [mm]} / 2 \times \text{long axis [mm]} / 2$ ), based on the narrowest diameters measured on anteroposterior (AP) and lateral hip radiographs. The total cross-sectional area of the screws was calculated as  $n \times \pi r^2$ , where  $n$  represents the number of screws and  $r$  the screw radius in millimeters. The screw-to-bone ratio was then derived to assess its potential association with postoperative complications. All radiographic measurements were performed by a single experienced observer. Reduction quality was graded according to Song's classification as anatomical, acceptable, or unacceptable.

Complications were defined as avascular necrosis, premature physeal closure, and coxa vara or coxa magna. For analytical purposes, a composite "total complication" variable was created to indicate the presence of any of these outcomes. Cases of nonunion were excluded from comparative analyses due to their low incidence and lack of statistical association. Complications were assessed using plain radiographs and magnetic resonance imaging (MRI). AVN was classified according to Ratliff criteria.<sup>[10]</sup>

To assess the potential influence of skeletal maturity on complication risk, patients were stratified into two age groups: <10 years and  $\geq 10$  years. This threshold was selected based on previous studies indicating that physeal vulnerability and vascular remodeling capacity differ substantially around this age in pediatric femoral neck fractures.<sup>[11]</sup> Demographic, surgical, and outcome parameters were compared between the two groups.

Inclusion criteria were early surgical fixation (within three days of injury), internal fixation using two or three cannulated screws, a minimum follow-up of five years, and complete clinical and radiological data. Patients with metabolic bone disorders, pathological or open fractures, or neuromuscular conditions were excluded.

## Statistical Analysis

Continuous variables were expressed as mean  $\pm$  standard deviation (SD) or median (interquartile range [IQR]), as appropriate, and categorical variables as frequencies. Normality was assessed using the Shapiro–Wilk test. Between-group comparisons were performed using t-test, Mann–Whitney U test, or Fisher's exact test, as appropriate. Statistical significance was defined as  $p < 0.05$ .

## Ethics Approval

This study was approved by the Ondokuz Mayıs University Clinical Research Ethics Committee (Date: 23.11.2023, Decision no: 2023/382) and conducted in accordance with the ethical principles of the 1964 Declaration of Helsinki and its subsequent amendments. Written informed consent was obtained from all participants or their legal guardians.

**Table 1.** Demographic and injury characteristics

Characteristic	n (%) or Mean $\pm$ SD
Sex	
Female	10 (27.8)
Male	26 (72.2)
Age (years)	9.2 $\pm$ 3.4
<10 years	14 (38.9)
$\geq 10$ years	22 (61.1)
Follow-up time (months)	108.5 $\pm$ 64.8
Bone healing time (weeks)	11.8 $\pm$ 2.3
Mechanism of injury	
Traffic accident	17 (47.2)
Fall	13 (36.1)
Sports injury	6 (16.7)
Initial displacement*	
Type I	6 (16.7)
Type II	20 (55.6)
Type III	10 (27.7)
Medial or posterior cortex	
Comminuted	13 (36.1)
Without comminution	23 (63.9)

Continuous variables are presented as mean $\pm$ standard deviation (SD); categorical variables as number (%). \*Initial displacement was classified according to the Song and Wang system. SD: Standard deviation; AP: Anteroposterior.

## RESULTS

A total of 36 pediatric patients with femoral neck fractures were included. Demographic and injury characteristics are presented in Table 1, and treatment-related parameters in Table 2. Complication rates were not significantly associated with sex, mechanism of injury, initial displacement, or reduction method (open versus closed reduction) ( $p>0.05$ ). (Table 3).

When stratified by age, 14 patients (38.9%) were younger than 10 years and 22 (61.1%) were aged  $\geq 10$  years. The overall complication rate was lower in the younger group compared with the older group (28.6% vs. 50.0%), although this difference did not reach statistical significance ( $p=0.21$ ) (Table 3). Similarly, rates of avascular necrosis (14.3% vs. 31.8%) and premature physeal closure (14.3% vs. 36.4%) were higher in older patients, but these differences were not statistically significant ( $p>0.05$ ).

Fractures with medial or posterior cortical comminution demonstrated higher complication rates compared with those without comminution (Table 3). Similarly, physeal penetration by fixation screws was associated with an increased risk of premature physeal closure and overall complications ( $p=0.045$ ) (Table 3). Physeal penetration associated with premature physeal closure ( $p=0.045$ ) was a significant predictor of postoperative outcomes. Unacceptable reductions were associated with a markedly higher incidence of avascular necrosis and premature physeal closure compared with anatomical or acceptable reductions ( $p=0.034$  and  $p=0.045$ , respectively).

In contrast, the number of screws used for fixation did not significantly influence complication rates. Although the three-screw group demonstrated a higher complication rate than the two-screw group (53.3% vs. 42.9%), the difference was not statistically significant ( $p=0.47$ ) (Table 3). Similarly, no significant association was observed between screw number and specific complications, including avascular necrosis, premature physeal closure, or coxa vara ( $p>0.05$ ). No cases of coxa magna were observed. When stratified by age, patients aged  $\geq 10$  years demonstrated higher overall complication rates

**Table 2.** Treatment-related characteristics

Characteristic	n (%)
Fixation method	
Two cannulated screws	21 (58.3)
Three cannulated screws	15 (41.7)
Physeal penetration	
Yes	19 (52.8)
No	17 (47.2)
Type of reduction	
Open reduction	7 (19.4)
Closed reduction	29 (80.6)
Reduction quality (Song classification)	
Anatomical	12 (33.3)
Acceptable	20 (55.6)
Unacceptable	4 (11.1)

compared with those  $<10$  years (50.0% vs. 28.6%), including higher incidences of AVN (31.8% vs. 14.3%) and premature physeal closure (36.4% vs. 14.3%). However, these differences did not reach statistical significance. This trend may reflect reduced remodeling capacity and increased mechanical stress in older children, as skeletal maturity progresses and the vascular adaptability of the femoral head declines.

## DISCUSSION

The findings of the present study are largely consistent with previous literature; however, some differences warrant further consideration. Our results partially differ from those of Dai et al.<sup>[11]</sup> who reported a stronger association between physeal penetration and complications in patients younger than 10 years. In contrast, the present study demonstrated a higher, although not statistically significant, tendency toward complications in older children. This discrepancy may be explained by methodological differences, as Dai et al.<sup>[11]</sup> included a heterogeneous cohort of Delbet types I–IV. In contrast,

**Table 3.** Univariate analysis of factors associated with postoperative complications

Variable	AVN	Premature physeal closure	Coxa vara	Any complication
Age ( $<10$ vs $\geq 10$ years)	0.261	0.194	0.473	0.211
Initial displacement (Song and Wang classification)	0.740	0.680	0.720	0.830
Cortical comminution (medial/posterior cortex)	0.110	0.037*	0.290	0.045*
Reduction method (open vs closed)	0.960	0.820	0.440	0.610
Physeal penetration (yes vs no)	0.320	0.045*	0.550	0.040*
Reduction quality (Song classification)	0.034*	0.045*	0.060	0.029*
Screw configuration (two vs three screws)	0.410	0.480	0.270	0.470

Values represent p values obtained from Fisher's exact test. AVN: Avascular necrosis. \* Statistically significant ( $p<0.05$ ).

our study was restricted to type II fractures treated within three days of injury, resulting in a more homogeneous population with early surgical fixation.

In our series, patients aged  $\geq 10$  years exhibited higher overall complication rates, including increased incidences of AVN and premature physeal closure; however these differences did not reach statistical significance. This trend may reflect reduced remodeling capacity and increased mechanical vulnerability associated with advancing skeletal maturity.

Similarly, İnan et al.<sup>[12]</sup> reported a nonsignificant increase in AVN risk with age, supporting the concept that biological maturity may adversely influence outcomes. Palocaren et al.<sup>[13]</sup> also emphasized that younger children possess greater potential for femoral head remodeling and vascular adaptation, which may contribute to lower deformity rates and improved long-term functional outcomes.

Medial or posterior cortical comminution was significantly associated with premature physeal closure and overall complications ( $p=0.03$  and  $p=0.04$ , respectively). Loss of postero-medial support compromises both mechanical stability and femoral head perfusion, predisposing to varus deformity and early physeal injury. These findings are consistent with prior biomechanical studies highlighting the importance of cortical integrity in maintaining blood flow and load distribution across the femoral neck.<sup>[14]</sup>

Physeal penetration by fixation screws was also associated with an increased risk of premature physeal closure and overall complications ( $p=0.045$ ). This relationship has been widely reported in the literature, as transphyseal fixation may disrupt the vascular network and growth plate architecture.<sup>[8,15]</sup> Bali et al.<sup>[14]</sup> similarly concluded that the occurrence of AVN is more closely related to vascular compromise than to fixation type, supporting the notion that biological factors may play a more dominant role than mechanical variables in determining complication risk. Hughes and Beaty further emphasized that, although stable fixation is essential, preservation of the physis should remain a key principle in the management of skeletally immature patients.<sup>[15]</sup>

Reduction quality emerged as a critical prognostic factor. Unacceptable reductions were strongly associated with AVN and premature physeal closure  $p=0.034$  and  $p=0.045$ . Anatomical alignment facilitates revascularization and reduces intracapsular pressure, whereas residual displacement may compromise perfusion despite otherwise stable fixation.<sup>[16]</sup>

In contrast, the number of screws did not significantly influence complication rates. Although patients treated with three screws demonstrated a higher overall complication rate than those treated with two screws (53.3% vs. 42.9%), this difference was not statistically significant. Previous investigations have reported conflicting findings: Lim et al.<sup>[7]</sup> suggested that increased screw density may elevate the risk of avascular necrosis, whereas Li et al.<sup>[17]</sup> reported an overall AVN rate

of 24.3% in a cohort of 115 pediatric femoral neck fractures, identifying older age and delayed fixation as significant risk factors. However, the present findings indicate that, when anatomical reduction is achieved and physeal penetration is avoided, the number of screws alone is unlikely to substantially affect postoperative outcomes. Comparable bone healing times between the two- and three-screw groups ( $11.5\pm 1.9$  vs.  $12.3\pm 2.4$  weeks) further support the notion that both configurations can provide adequate stability when properly executed.

The screw-to-neck area ratio was higher in patients who developed complications (21.9% vs. 17.5%;  $p=0.092$ ). Although this difference did not reach statistical significance, it suggests that the geometric occupancy of the femoral neck may play a relatively minor role compared with biological and technical factors, such as physeal preservation and reduction quality. In line with the findings of Wang et al.,<sup>[18]</sup> these results indicate that achieving adequate stability while minimizing vascular compromise remains essential for optimizing outcomes.

This study has several limitations. Its retrospective design and relatively small sample size limit the power to detect rare complications and may introduce selection bias. The number of screws was determined by the operating surgeon, resulting in potential heterogeneity in fixation technique. Additionally, radiographic measurements were performed by a single observer without interobserver validation, which may affect reproducibility. Despite these limitations, the inclusion of a pediatric cohort with a minimum follow-up of five years strengthens the reliability of long-term outcomes, including premature physeal closure and leg length discrepancy.

## CONCLUSION

The present study suggests that, in pediatric femoral neck fractures, anatomical reduction and preservation of physeal integrity are more critical determinants of outcome than the number or configuration of screws. Older age may be associated with a modest increase in complication risk, underscoring the importance of meticulous reduction and preservation of physeal integrity during fixation.

**Ethics Committee Approval:** This study was approved by the Ondokuz Mayıs University Clinical Research Ethics Committee (Date: 23.11.2023, Decision No: 2023/382).

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## ORIJİNAL ÇALIŞMA - ÖZ

## Delbet tip II pediatrik femur boyun kırıklarında iki ve üç kanüllü vida kullanımının karşılaştırılması: Retrospektif karşılaştırmalı bir çalışma

**AMAÇ:** Pediatrik femur boyun kırıkları nadirdir; ancak avasküler nekroz (AVN), erken fiz kapanması ve koksa vara gibi komplikasyon riski yüksektir. Stabil internal fiksasyon gerekli olmakla birlikte, optimum kanüllü vida sayısı hâlen tartışmalıdır. Bu çalışma, homojen bir Delbet tip II kırık kohortunda iki ve üç vidalı fiksasyonun klinik ve radyolojik sonuçlarını karşılaştırmayı amaçlamaktadır.

**GEREÇ VE YÖNTEM:** Yaralanmadan sonraki üç gün içinde tedavi edilen ve en az beş yıl takip edilen otuz altı çocuk retrospektif olarak analiz edildi. Tüm kırıklar iki veya üç kanüllü vida kullanılarak tespit edildi. Cerrahi değişkenler arasında redüksiyon kalitesi, vida sayısı, fiz penetrasyonu, vida-boyun alan oranı ve kortikal parçalanma varlığı yer aldı. Hastalar iki yaş grubuna (<10 ve ≥10 yaş) ayrıldı. Komplikasyonlar (AVN, erken fiz kapanması ve koksa vara) radyografik olarak değerlendirildi ve belirlenmiş kriterlere göre sınıflandırıldı. İstatistiksel karşılaştırmalar uygun parametrik ve parametrik olmayan testler kullanılarak yapıldı.

**BULGULAR:** Daha büyük çocuklarda (≥10 yaş) toplam komplikasyon, AVN ve fiz kapanması oranları daha yüksek bulundu; ancak farklar istatistiksel olarak anlamlı değildi. Medial veya posterior kortikal parçalanma komplikasyon oranlarını anlamlı ölçüde artırdı. Fiz penetrasyonu, erken fiz kapanması riskini belirgin şekilde artırdı (p=0.045). Redüksiyon kalitesi sonuçlarla güçlü korelasyon gösterdi; kabul edilemez redüksiyonlar anlamlı derecede daha yüksek AVN ve erken fiz kapanması oranları ile ilişkiliydi. Vida sayısı, genel komplikasyon oranlarını veya spesifik olumsuz sonuçları anlamlı olarak etkilemedi. Vida-boyun alan oranı, komplikasyon gelişen hastalarda daha yüksek değerlere eğilim gösterdi; ancak bu fark istatistiksel olarak anlamlı değildi.

**SONUÇ:** Pediatrik Delbet tip II femur boyun kırıklarında postoperatif sonuçların temel belirleyicileri anatomik redüksiyonun sağlanması ve fiz penetrasyonundan kaçınılmasıdır. Redüksiyonun yeterli olduğu ve biyolojik yapıların korunduğu durumlarda, iki veya üç vida kullanımı benzer uzun dönem sonuçlar vermektedir.

**Anahtar sözcükler:** Avasküler nekroz; cerrahi sonuçlar; kanüllü vida; komplikasyonlar; pediatrik femur boyun kırıkları.

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