ORIGINAL ARTICLE

In cases of humeral diaphyseal fractures, is lateral approach surgery without radial nerve exploration as effective and safe as conventional surgery?

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ABSTRACT

BACKGROUND: This study compares the efficacy and safety of lateral approach surgery with and without radial nerve dissection in treating humeral diaphyseal fractures. It assesses clinical, radiological, and complication outcomes, providing a description of the surgical methods and perioperative benefits.

METHODS: We retrospectively analyzed data from 71 patients admitted between May 2015 and December 2022 who underwent lateral approach surgery for humeral diaphyseal fractures. Group 1, consisting of 34 patients without radial nerve dissection, and Group 2, comprising 37 patients with radial nerve dissection, were compared. Parameters such as age, gender, fracture side (right/left), fracture type, follow-up time, surgical duration, blood loss, radiological and clinical evaluations (including Shoulder-Elbow range of motion [ROM] and Quick Disabilities of the Arm, Shoulder, and Hand score [Q-DASH]), and complications were examined. Surgical techniques and outcomes were documented.

RESULTS: Both groups exhibited comparable distributions in age, gender, fracture types, and follow-up times ($p>0.05$). Group 1 demonstrated significantly lower surgical duration and blood loss compared to Group 2 ($p<0.05$ for both). Clinical assessment revealed satisfactory shoulder and elbow ROM within functional limits for all patients, with no instances of infection. Q-DASH scores were similar between groups. Postoperative radial nerve palsy occurred in one patient in Group 1 and three patients in Group 2, with all cases resolving uneventfully during outpatient follow-ups. Radiological assessment confirmed uneventful union in all patients.

CONCLUSION: Lateral approach surgery without radial nerve dissection for humeral diaphyseal fractures offers comparable effectiveness and safety to conventional surgery, with potential perioperative advantages such as reduced operation time and blood loss.

Keywords: Humeral diaphyseal fracture; humerus lateral approach; radial nerve palsy; radial nerve dissection.

INTRODUCTION

Although conservative methods were previously common for humeral diaphyseal fractures, the adoption of surgical interventions is gradually increasing. This trend is driven by advancements in technology, specific fracture types, and patient expectations.[1,2] Among the various implant and approach options, plate-screw fixation has become the predominant treatment, often utilizing a lateral approach for its straightforward neurovascular access.[3,4]

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The primary concern with choosing the lateral approach is the risk of radial nerve dissection and subsequent radial nerve palsy. Some studies indicate that even dissection of the radial nerve can cause symptoms,[5] and the procedure's duration is extended by this dissection. Ongoing efforts are being made to either avoid radial nerve dissection altogether or to stabilize the fracture without interfering with the radial nerve pathway. Numerous studies have explored alternative approaches, such as anterior or anterolateral approaches, and different implant options like intramedullary nails, aiming to achieve this objective.[6-9]

In our clinic, based on the extensive experience of several surgeons, it has been observed that after initially dissecting the radial nerve, the fracture can be secured without further dissection during implant placement. Following intraoperative identification of the radial nerve's anatomical position in numerous suitable patients, successful fixation has been achieved without additional radial nerve dissection, consequently reducing surgical time.

This study aims to compare the outcomes of successful implant placement without radial nerve dissection in lateral approaches for humeral diaphyseal fracture surgery with conventional methods. Our focus is on clinical, radiological, and complication assessments. Additionally, we seek to provide a comprehensive description of the surgical technique, highlighting the perioperative benefits observed.

MATERIALS AND METHODS

We analyzed retrospective data from 71 patients admitted between May 2015 and December 2022 who underwent surgery using the lateral approach for humeral diaphyseal fractures. The ethics committee approved the study (Approval No: KAEK/202.09.287).

Inclusion and Exclusion Criteria

We considered fractures involving the middle third of the humerus, including those extending proximally but excluding the distal third, as humeral diaphyseal fractures. Eligible patients were 18 years or older, had no history of previous humeral surgery, preoperative radial nerve palsy, open fractures, pathological fractures, or other fractures in the same extremity, and presented with fractures deemed fresh within 21 days.

Patients who underwent surgery without radial nerve dissection were assigned to Group 1, while those with radial nerve dissection were placed in Group 2.

Following the routine diagnosis of patients admitted to the emergency department, stabilization was achieved using a long arm splint (U-slab). Surgical treatment preparations began in cases of unstable or segmental fractures where achieving proper alignment was challenging. While some surgeons opt for nerve dissection with a lateral approach, others achieve fixation without dissecting the nerve.

Group 1 Surgical Technique

The patient was positioned in the beach chair position to ensure that the arm was under traction due to gravity. The acromion and the lateral condyle of the elbow were marked using a marker. The trajectory of the radial nerve[10] was determined by measuring the incision line between these points with a ruler (Fig. 1). Subsequently, the area devoid of the radial nerve was accessed. After navigating through the subcutaneous tissue and opening the muscle fascia, blunt dissection was used to separate muscle fibers to reach the bone. The skin and subcutaneous tissue were extended approximately 3-4 cm distally (toward the radial nerve trajectory area). The muscle fascia was opened, but no further dissection was performed. The bone was then openly reduced and temporarily fixed with Kirschner wires (Fig. 2).

In suitable cases, the fractures were stabilized with lag screws. Plates of appropriate sizes were prepared and positioned to bridge the fracture lines, a step that involved risks to the radial nerve. At this point, three double cortex screws sufficed to secure the plate extending distally from the fracture line.[11] Initially, the top of the bone had been carefully exposed bluntly using a periosteal elevator, which remained above the bone to ensure relaxation of the anterior, lateral, and posterior aspects of the bone. Although the radial nerve may

Figure 1. Determination of the radial nerve trace using a ruler for measurement.

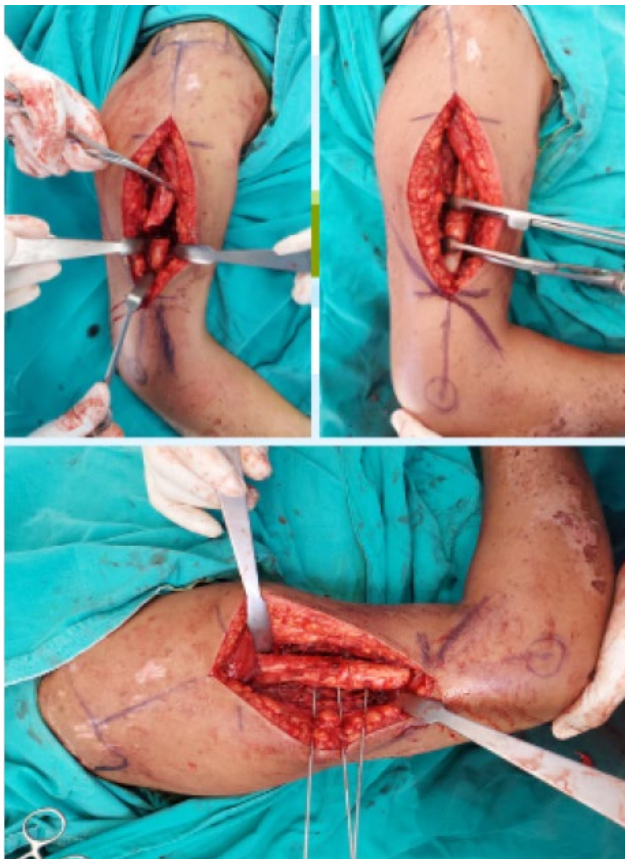

Figure 2. Reduction and temporary fixation of the fracture.

sometimes have been visible, attention was primarily focused on the bone with retractors (Fig. 3).

The plate was positioned distally from the fracture line, containing three screw holes. A plate hole was then drilled into the most accessible proximal and distal parts, and the double cortex screws were inserted. Initially, the plate should not be compressed with these first two screws. After ensuring that the distal soft tissues were not trapped under the plate, the screws were tightened, bringing the plate into contact with the bone. The proximal screws were then secured, followed by the placement of the most distal screws. The second stage, where there was a risk to the radial nerve, occurred during the completion of these distal screws. To safeguard the radial nerve, the tissue surrounding the bone was meticulously cleared, and a retractor was placed under the distal end screw (S retractor-plate hole technique) (Fig. 4).

Preference was given to using locked screws for all screw placements. Once fracture fixation was confirmed, a final check was performed to ensure no muscle or soft tissue was trapped under the plate. Closure of surgical layers followed, concluding the procedure.

Group 2 Surgical Technique

Initially, the trajectory of the radial nerve was identified, and the nerve was carefully explored and protected through dissection. Subsequently, standard reduction principles were

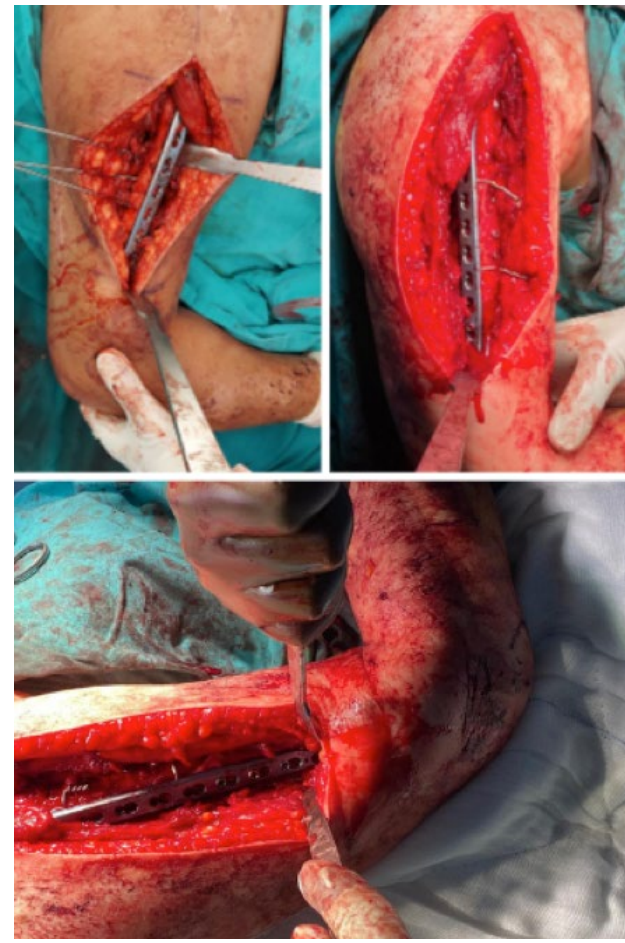

Figure 3. Perioperative images of radial nerve tracing area retraction.

applied, followed by surgical fixation. A total of six locking screws, with three screws inserted into each fracture line, were routinely utilized for fixation.

Data Collection

Demographic Data: We recorded the age, gender, fracture side, fracture type, and duration of follow-up for patients included in the study.

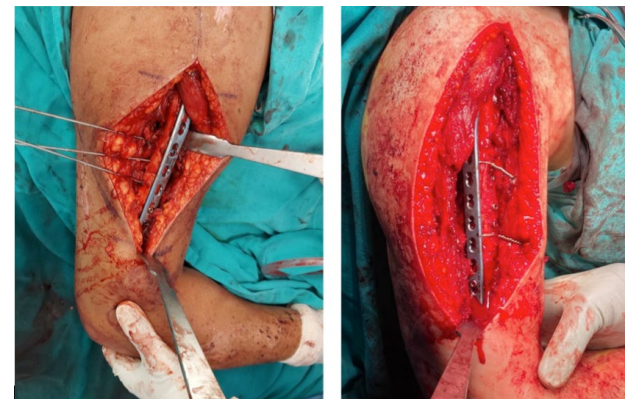

Figure 4. Fixation of the distal screws using the S retractor-plate hole technique, without dissecting the radial nerve (perioperative views from two different patients).

Clinical Data: We extracted surgical time (from incision to wound closure) and perioperative bleeding volume from anesthesia records. We routinely conducted preoperative and postoperative neurovascular examinations. Postoperatively, we implemented early mobilization protocols for the shoulder and elbow joints. We employed shoulder and elbow range of motion (ROM) assessments and the Quick Disabilities of the Arm, Shoulder, and Hand (Q-DASH) scoring system for clinical evaluation. We ensured follow-up periods of at least six months.

Radiological Data: Regular outpatient follow-ups included two-way X-rays for radiological assessment.

Complication Data: We monitored postoperative recovery of the radial nerve and documented incidents of wound complications, infections, and fracture nonunions.

Statistical Analysis

Statistical analysis was conducted using IBM SPSS (Statistical Package for the Social Sciences) Statistics 26 (IBM, Chicago, IL, USA). Descriptive statistics including means, standard deviations, medians, frequencies, ratios, and ranges, were calculated, and data distribution was assessed using the Shapiro-Wilk test. The Student's t-test was employed to compare data distributions between the two groups. A significance level of $p<0.05$ was adopted for all analyses.

Post hoc power analysis was performed in this study. For an effect size of 0.8 and an α error probability of 0.05, the power of the study was found to be 0.95 for 34 patients in Group 1 and 37 patients in Group 2.

RESULTS

Among the 71 patients included in the study, 34 were classified as Group 1 and 37 as Group 2. The mean age was 48.64±19.72 in Group 1, compared to 45.43±16.73 in Group 2. The female-to-male ratio was 0.61 in Group 1 and 0.94 in Group 2. In terms of fracture side, the right-to-left ratio was 2.77 in Group 1 and 1.05 in Group 2. According to the AO classification (AO 12), Group 1 comprised 10 patients with A1 fractures, 9 with A2 fractures, 3 with A3 fractures, 1 with B1 fracture, 2 with B2 fractures, 7 with C1 fractures, and 2 with C2 fractures. Group 2 included 10 patients with A1 fractures, 6 with A2 fractures, 12 with A3 fractures, 2 with B1 fractures, 3 with B2 fractures, 1 with a B3 fracture, 1 with a C1 fracture, 1 with a C2 fracture, and 1 with a C3 fracture. The mean follow-up time was 36.17±21.69 months for Group 1 and 42.86±24.03 months for Group 2. Both groups showed similar distributions in terms of age, gender, fracture type, and follow-up time ($p>0.05$). However, there was a difference in fracture side distribution between the groups ($p<0.05$). Since the fracture side did not impact the study's aim, its statistical significance was not considered (Table 1).

The mean surgical time for Group 1 was 50±12.38 minutes, compared to 67.32±10.81 minutes for Group 2, showing a statistically significant difference in the operation duration between the two groups ($p=0.0002$), with Group 1 demonstrating a shorter surgical time. Additionally, the mean amount of bleeding in Group 1 was 52.97±12.66 ml, while in Group 2, it averaged 75.58±16.54 ml. Group 1 experienced significantly less bleeding ($p=0.0002$) (Table 1).

Figure 5. Preoperative and postoperative radiological images.

The clinical Q-DASH score at the last follow-up was 87.79±7.09 in Group 1 and 86.35±11.58 in Group 2. Both groups exhibited similar Q-DASH scoring distributions ($p>0.05$). In the final clinical assessment, full functional shoulder and elbow range of motion was successfully achieved in all patients, with no instances of infection noted. Postoperative radial nerve palsy occurred in 1 patient in Group 1 and 3 in Group 2; all recovered uneventfully during outpatient clinic follow-ups. At the last radiological evaluation, all patients demonstrated uneventful union (Fig. 5).

DISCUSSION

The study yielded several key findings. Firstly, surgical time and bleeding volume were reduced in the group that did not undergo radial nerve dissection. Secondly, clinical scores in the non-dissection group were comparable to those of the dissection group, with similar risks of radial nerve palsy.

Table 1. Patients' demographic data and monitored parameters

	Non-radial Nerve Dissection (Group 1) n=34	Radial Nerve Dissection (Group 2) n=37	p value*
Age			
Avg±SD	48.64±19.72	45.43±16.73	0.463
Min-Max (Median)	19-82 (35)	18-72 (40)	
Gender			
Female	13	18	0.383
Male	21	19	
Fracture Side			
Right	25	19	0.027*
Left	9	18	
Fracture Type (AO 12)			
A1	10	10	0.455
A2	9	6	
A3	3	12	
B1	1	2	
B2	2	3	
B3	0	1	
C1	7	1	
C2	2	1	
C3	0	1	
Follow-up Period (months)			
Avg±SD	36.17±21.69	42.86±24.03	0.221
Min-Max (Median)	6-82 (44)	6-96 (63)	
Surgical Duration			
Avg±SD	50±12.38 min	67.32±10.81 min	0.0002*
Min-Max (Median)	35-75 (35)	50-90 (55)	
Bleeding Amount			
Avg±SD	52.97±12.66 ml	75.58±16.54 ml	0.0002*
Min-Max (Median)	30-80 (40)	50-100 (80)	
Postoperative Radial Nerve Palsy			
Yes	1 patient (2%)	3 patients (8%)	0.343
No	33 patients (98%)	34 patients (92%)	
Quick DASH Score			
Avg±SD	87.79±7.09	86.35±11.58	0.525
Min-Max (Median)	70-100 (85)	70-100	(80)

*The p-value <0.05 is considered statistically significant for a 95% confidence interval.

Thirdly, no significant differences were observed in radiological outcomes. Fourthly, complications such as infection and nonunion were absent in both groups.

Successful fixation was achieved without extensive dissection of the radial nerve, relying only on the exposure of the nerve to compression forces and ensuring it was not interposed between the implant and the bone. The reliability of this approach was highlighted by its comparison with the dissection group.

The radial nerve is a significant concern due to its vulnerability to preoperative or perioperative damage in humeral fractures. Transient radial nerve palsy occurs in approximately 1 out of every 5 patients in lateral approaches and 1 out of every 9 patients in posterior approaches due to the surgical

approach and dissection.[12] Tang et al. examined the anatomical position of the radial nerve in a cadaver study and found it intersected approximately 27.96±5.27 units from the total distance between the acromion and the lateral condyle of the humerus.[13] Numerous cadaver studies have mapped the anatomical trajectory of the radial nerve and identified various anatomical markers.[10,14] Theoretically, there is adequate safe space for surgery to be performed without radial nerve dissection, thereby avoiding radial nerve injury. In our study, the incidence of radial nerve palsy was 2% in Group 1 compared to 8% in Group 2.

Several studies in the literature focus on protecting the radial nerve. Considering the anatomical location of the radial nerve in the posterior approach, bridge plating was employed as a bypass technique.[6] While this technique appears useful, achieving fracture reduction presents challenges. It is clear that a dramatic situation arises when radial nerve palsy, developing perioperatively, is detected in the postoperative period.

Another study proposed positioning the plate laterally, akin to an external fixator, but only under the skin.[7] This technique does not provide anatomical reduction or compression of the fracture, and addressing perioperative radial nerve damage with this method could lead to dramatic outcomes.

Despite the difficulties associated with intramedullary nailing due to potential radial nerve damage, antero-posterior or intramedullary distal locking techniques have been developed to minimize the risk.[15] However, shoulder irritation and rotator cuff damage caused by antegrade nails may cause discomfort for the patient.[16]

Safe dissection emerges as the most reliable method for protecting the radial nerve, which is at significant risk when using a fixator.[17] In this study, the radial nerve was safeguarded without actual dissection; instead, it was exposed only to severe compression, resulting in fewer complications compared to dissection. In our study, only one patient in the group that did not undergo radial nerve dissection experienced compression exposure, and recovery occurred within 10 days.

Examining its anatomical structure, the radial nerve travels obliquely from the posterior midline of the humerus to reach laterally. For diaphyseal fractures, the most ideal surgical approach is posterior and distal, typically via the lateral and anterior approaches. With minimally invasive plate osteosynthesis (MIPO) and bridge plating often favored in the anterior approach, its distal part may be at significant risk.[9] In the lateral approach, since the fracture line and the plate are completely central, it can be argued that any developing radial nerve injury is always due to dissection. Thus, in this technique (Group 1), it can be maintained that the injury is always caused by compression. In the anterior approach of the humerus, the musculocutaneous nerve and main arteries are also at risk.[9] In light of all this data, the most secure area of the humeral diaphysis, and the farthest from the neurovascular structures, can be identified as the lateral aspect.

Radial nerve dissection consistently resulted in prolonged surgical times for all patients. Additionally, these extended surgeries often led to excessive bleeding. Avoiding radial nerve dissection can save both surgical time and reduce bleeding volume, which is particularly critical in cases involving multiple traumas or patients in poor condition for surgery.[18]

Although this study provides technical insights, mastering the technique requires surgeons to first observe open dissections and understand the positioning of the radial nerve perioperatively.

The clinical significance of this study is underscored by many surgeons' goals to shorten operative incisions and reduce operative times. Avoiding radial nerve dissection appears to be the most effective method to achieve these objectives in humeral diaphysis fractures. We believe that this can be safely accomplished through the approaches demonstrated in this study.

The study has certain limitations. Firstly, prospective and randomized studies with larger sample sizes are needed to further validate these findings. Due to its retrospective nature, the study was limited to clinical nerve examinations only. Future prospective studies should consider including laboratory tests, such such as Electromyography (EMG), in the early postoperative period to assess neuropraxia in comparison to standard methods. Additionally, it is crucial to establish the maximum limits for measuring the distance from the fracture to the elbow joint for more precise evaluations.

CONCLUSION

Our study suggests that the fixation of humeral diaphyseal fractures using the lateral approach without radial nerve dissection is both effective and safe. By comparing outcomes between patients who underwent this approach and those who underwent conventional surgery, we observed similar clinical and radiological results, with no significant differences in complication rates. Notably, the lateral approach without radial nerve dissection resulted in shorter operation times and reduced bleeding, offering potential perioperative benefits. These findings support the feasibility and reproducibility of this technique, highlighting its potential as a viable alternative in the surgical management of humeral diaphyseal fractures. Further research, including prospective studies and larger sample sizes, is necessary to validate these findings and refine surgical techniques in this area.

Ethics Committee Approval: This study was approved by the Basaksehir Çam and Sakura City Hospital Ethics Committee (Date: 16.09.2022, Decision No: 2022.09.287).

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Authorship Contributions: Concept: N.D., C.Ö.H., H.B., C.E.; Design: N.D., C.Ö.H., H.B., C.E.; Supervision: N.D., C.Ö.H., H.B., C.E.; Resource: N.D., C.Ö.H., H.B., C.E.; Materials: N.D., C.Ö.H., C.E.; Data collection and/or processing:

N.D., C.Ö.H., C.E.; Analysis and/or interpretation: N.D., H.B., C.E.; Literature search: N.D., H.B., C.E.; Writing: N.D., H.B., C.E.; Critical review: N.D., H.B., C.E.

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ORİJİNAL ÇALIŞMA - *ÖZ*

Humerus diyafiz kırıklarında radial sinir diseksiyonu yapılmadan lateral yaklaşım cerrahisi konvansiyonel cerrahi kadar etkili ve güvenli midir?

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AMAÇ: Bu çalışma humerus diyafiz kırıklarının tedavisinde radiyal sinir diseksiyonu ile birlikte ve olmadan lateral yaklaşımlı cerrahinin etkinliğini ve güvenliğini karşılaştırmaktadır. Cerrahi yöntemlerin ve perioperatif faydaların ayrıntılı bir açıklamasının yanı sıra klinik, radyolojik ve komplikasyon sonuçları değerlendirildi.

GEREÇ VE YÖNTEM: Mayıs 2015 ile Aralık 2022 tarihleri arasında başvuran ve humerus diyafiz kırığı nedeniyle lateral yaklaşımla cerrahi uygulanan 71 hastanın verileri retrospektif olarak analiz edildi. Radiyal sinir diseksiyonu yapılmayan 34 hasta Grup 1'i, radiyal sinir diseksiyonu yapılan 37 hasta Grup 2'yi oluşturdu. Yaş, cinsiyet, kırık tarafı (sağ/sol), kırık tipi, takip süresi, ameliyat süresi, kanama miktarını içeren parametreler, radyolojik ve klinik değerlendirmeler (Omuz-Dirsek hareket açıklığı [ROM] ve Quick Disabilities of the Arm, Shoulder, and Hand score [Q-DASH]) ve komplikasyonlar incelendi. Cerrahi teknikler ve çözümler belgelendi.

BULGULAR: Her iki grup da yaş, cinsiyet, kırık tipleri ve takip süresi açısından benzer dağılımlar gösterdi. ($p>0.05$) Grup 1'de, Grup 2'ye kıyasla anlamlı derecede daha düşük cerrahi süre ve kanama miktarı görüldü. (her ikisi için de $p<0,05$) Klinik değerlendirmede, enfeksiyon vakası olmaksızın, tüm hastalarda fonksiyonel sınırlar dahilinde tatmin edici omuz ve dirsek hareket açıklığı ortaya çıktı. Q-DASH skorları gruplar arasında benzerdi. Ameliyat sonrası radial sinir felci Grup 1'de 1, Grup 2'de 3 hastada gelişti ve olguların tamamı ayaktan takiplerde sorunsuz bir şekilde iyileşti. Radyolojik değerlendirmede tüm hastalarda sorunsuz kaynama görüldü.

SONUÇ: Humerus diyafiz kırıklarında radial sinir diseksiyonu yapılmadan lateral yaklaşım, ameliyat süresi ve kanamanın azalması gibi potansiyel perioperatif avantajlarla birlikte geleneksel cerrahiyle kıyaslanabilir etkinlik ve güvenlik göstermektedir.

Anahtar sözcükler: Humerus diafiz kırığı, humerus lateral yaklaşımı, radial sinir felci, radial sinir diseksiyonu

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