Medical Journal of Bakırköy

Med J Bakirkoy 2025;21:62-69
DOI: 10.4274/BMJ.galenos.2024.2024.8-13

Research

The Impact of TRIMANO Adjustable Arm Holder on Proximal Humerus Fracture Management: Enhancing Surgery Duration, Surgical Efficiency, and Patient Outcomes

TRIMANO Ayarlanabilir Kol Tutucusunun Proksimal Humerus Kırığı Yönetimindeki Etkisi: Cerrahi Süre, Cerrahi Verimlilik ve Hasta Sonuçlarının İyileştirilmesi

Cumhur Deniz Davulcu[1], Muhammed Yusuf Afacan[1,2]

[1]İstanbul University-Cerrahpaşa, Cerrahpaşa Faculty of Medicine, Department of Orthopaedics and Traumatology, İstanbul, Türkiye
[2]İstanbul University-Cerrahpaşa, Cerrahpaşa, Institue of Graduate Studies, Department of Anatomy, İstanbul, Türkiye

ABSTRACT

Objective: This study investigates the impact of adjustable arm holders on ensuring stable fixation in the appropriate position and rotation during surgery, as well as on surgery duration and early postoperative functional outcomes in patients with proximal humerus fractures.

Methods: A retrospective evaluation was conducted on 34 patients with Neer 3-part or 4-part proximal humerus fractures. They were divided into two groups: eighteen patients without an adjustable arm holder and 16 patients with an adjustable arm holder TRIMANO FORTIS® (Arthrex, Maquet GmbH) during surgery. Surgery times were obtained from patient files, and functional outcomes were assessed postoperatively using joint range of motion and Constant-Murley scores.

Results: No significant difference in surgery duration was found based on the number of fracture parts (p=0.741). However, a significant difference was observed in postoperative Constant-Murley scores relative to the number of fracture parts (p=0.047), with 3-part fractures showing better functional recovery. The use of adjustable arm holders significantly reduced surgery time (p=0.003) and improved postoperative Constant-Murley scores (p=0.008). Increased surgery duration negatively impacted postoperative Constant-Murley scores (p=0.001). Regression analysis identified age, use of adjustable arm holders, and number of fracture parts as significant factors influencing postoperative Constant-Murley scores (p<0.0001), with age and number of fracture parts negatively affecting recovery, and the use of adjustable arm holders having a positive effect.

Conclusion: Adjustable arm holders significantly reduce surgery duration and improve postoperative functional outcomes in patients with Neer 3-part and 4-part proximal humerus fractures. Superior functional recovery was noted in patients with 3-part fractures compared to those with 4-part fractures.

Keywords: Arm, orthopedic equipment, patient positioning, humeral fractures, equipment design, operative time, outcome assessment, shoulder joint

ÖZ

Amaç: Bu çalışmada, ayarlanabilir kol tutucularının ameliyat sırasında uygun pozisyon ve rotasyonda stabil fiksasyon sağlamadaki etkisi, ameliyat süresi ve proksimal humerus kırığı olan hastalarda erken postoperatif fonksiyonel sonuçlar araştırılmıştır.

Gereç ve Yöntem: Neer 3 parçalı veya 4 parçalı proksimal humerus kırığı bulunan 34 hastanın retrospektif değerlendirmesi yapıldı. Hastalar, ameliyat sırasında ayarlanabilir kol tutucu TRIMANO FORTIS® (Arthrex, Maquet GmbH) kullanılmayan 18 hasta ve kullanılan 16 hasta olmak üzere iki gruba ayrıldı. Ameliyat süreleri hasta dosyalarından elde edildi ve fonksiyonel sonuçlar, postoperatif eklem hareket açıklığı ve Constant-Murley skorları ile değerlendirildi.

Bulgular: İki grup arasında yaş, cinsiyet dağılımı, takip süresi ve Neer kırık parçalarının sayısı açısından karşılaştırılabilir bir fark bulunmadı. Kırık parçalarının sayısına göre ameliyat süresinde anlamlı bir fark bulunmadı (p=0,741). Ancak, postoperatif Constant-Murley skorlarında kırık

Address for Correspondence: Cumhur Deniz Davulcu, İstanbul University-Cerrahpaşa, Cerrahpaşa Faculty of Medicine, Department of Orthopaedics and Traumatology, İstanbul, Türkiye
E-mail: cumhurdeniz.davulcu@iuc.edu.tr **ORCID ID:** orcid.org/0000-0002-6444-5047

Cite as: Davulcu CD, Afacan MY. The impact of TRIMANO adjustable arm holder on proximal humerus fracture management: enhancing surgery duration, surgical efficiency, and patient outcomes. Med J Bakirkoy. 2025;21:62-69

Received: 26.08.2024
Accepted: 30.10.2024
Publication Date: 25.03.2025

parçalarının sayısına göre anlamlı bir fark gözlendi (p=0,047); 3 parçalı kırıklar daha iyi fonksiyonel iyileşme gösterdi. Ayarlanabilir kol tutucularının kullanımı ameliyat süresini anlamlı derecede azalttı (p=0,003) ve postoperatif Constant-Murley skorlarını iyileştirdi (p=0,008). Artan ameliyat süresi, postoperatif Constant-Murley skorlarını olumsuz yönde etkiledi (p=0,001). Regresyon analizi, yaş, ayarlanabilir kol tutucu kullanımı ve kırık parçalarının sayısının postoperatif Constant-Murley skorlarını etkileyen önemli faktörler olduğunu gösterdi (p<0,0001); yaş ve kırık parçalarının sayısı iyileşmeyi olumsuz etkilerken, ayarlanabilir kol tutucu kullanımı olumlu bir etkiye sahipti.

Sonuç: Ayarlanabilir kol tutucularının kullanımı, Neer 3 parçalı ve 4 parçalı proksimal humerus kırığı olan hastalarda ameliyat süresini anlamlı ölçüde kısaltmakta ve postoperatif fonksiyonel sonuçları iyileştirmektedir. Üç parçalı kırıklarda, 4 parçalı kırıklara kıyasla üstün fonksiyonel iyileşme gözlemlenmiştir. Proksimal humerus kırıklarında ayarlanabilir kol tutucularının cerrahi protokollere entegrasyonu, cerrahi verimliliği ve hasta sonuçlarını iyileştirerek hasta bakımına katkı sağlayabilir.

Anahtar Kelimeler: Kol, ortopedik ekipman, hasta pozisyonlama, humerus kırıkları, ekipman tasarımı, ameliyat süresi, sonuç değerlendirme, omuz eklemi

INTRODUCTION

Proximal humerus fractures, constituting approximately 5-6% of adult fractures (1,2), were first classified by Neer in 1970. This is the most commonly used classification in such fractures, constituting four parts: articular surface of the humeral head, greater tuberosity, lesser tuberosity, and shaft (3-5). While humeral shaft fractures typically undergo conservative treatment, surgery becomes a crucial consideration in cases of displaced fractures to decrease the risk of non-union (6). Plate osteosynthesis emerges as the preferred surgical method over intramedullary nailing for humeral shaft fractures extending proximally, since intramedullary nailing heightens the risk of shoulder impingement, limits shoulder mobility, and often necessitates the removal of metal implants (7,8).

In proximal humerus fracture surgery, ensuring the patient's optimal positioning is imperative to facilitate the most effective surgical approach. Nonetheless, this necessitates assistant surgeons to maintain the patient's arm in the desired position throughout the entirety of the procedure, which may oblige them to be positioned further from the surgical area (9). Ensuring stable fixation in the correct position and rotation is paramount in proximal humerus fracture surgery. Without the utilization of an adjustable arm holder, achieving fixation in the desired position poses considerable challenges. These devices keep the limb in the right position, with or without traction, freeing up the surgical assistant to focus on other tasks during the procedure (9). TRIMANO FORTIS® (Arthrex, Maquet GmbH) serves as an adjustable arm holder attached to any operative table, aiding in upper limb surgeries. It can be maneuvered using an accessible handle to position the patient's arm optimally for the procedure. With its three-joint mechanism, the TRIMANO enables easy adjustments of the limb across various positions, accommodating a wide range of surgical procedures (10). The arm holder ensures the surgical position remains steady, allowing the surgeon to position the limb optimally for the most effective approach to the surgical site.

We hypothesize that employing adjustable arm holders will streamline surgical procedures, yielding improved outcomes. In this way, we assume that the patients' postoperative clinical results will be better that the surgery time will be significantly shorter. Consequently, our objective is to assess the impact of adjustable arm holders on surgical duration and early postoperative functional outcomes in patients undergoing proximal humerus fracture surgery.

METHODS

This study was approved by the İstanbul University-Cerrahpaşa Clinical Research Ethics Committee (number: E-83045809-604.01-1004836, date: 07.06.2024). Informed consent was obtained from all individual participants included in the study. The study encompassed patients treated at our clinic for proximal humerus fractures with plate osteosynthesis between 2020 and 2022 who consented to participate in the research. Exclusions comprised patients who were unreachable, those who missing regular follow-up appointments, individuals with follow-up periods less than one year post-operation, those who refused to participate, those who underwent prior surgical procedures on the same upper extremity, and individuals with documented rotator cuff tears or other shoulder pathologies.

In this study, two groups were established based on the utilization of the adjustable arm holder TRIMANO FORTIS® (Arthrex, Maquet GmbH) during proximal humerus surgery. Figure 1 shows the components of the TRIMANO and Figure 2 demonstrates set-up and usage. Patients were evaluated retrospectively. A total of 34 patients meeting the inclusion criteria were included in our study. The group in which adjustable arm holders were used consisted of 16 people, while the group in which they were not used consisted of 18 people. The groups were determined randomly. We evaluated patients' gender, age, operation year, number of fracture parts according to Neer classification, operation duration, follow-up time, and postoperative Constant-Murley scores (11,12).

Arm holders were randomly used during operations, without specific patient selection criteria. Patients were

Figure 1. TRIMANO adjustable arm holder components. The TRIMANO adjustable arm holder is shown in its storage case. The image on the right displays the arm holder fully extended

Figure 2. TRIMANO adjustable arm holder setup and usage. The left image shows the TRIMANO adjustable arm holder attached to an operating table, ready for use. The middle and right images illustrate the arm holder in action, securing a patient's arm during surgery to provide stable positioning and facilitate surgical procedures

operated on without arm holders due to the limited availability of arm holders and the potential occurrence of simultaneous shoulder arthroscopic procedures in our hospital. All surgeries were conducted by the same surgeon. Fractures were classified using the Neer classification system, and the number of fracture parts was recorded independently by two different surgeons. This process was repeated twice, yielding consistent results. The same surgeons performed operations in both groups, employing the (anterior) deltopectoral approach for all patients. The operation durations were extracted from the patients' medical records. The patients' pain status, activity level, arm positioning, abduction strength, and shoulder range of motion were evaluated individually. Constant-Murley scores were recorded at a minimum of one year post-operation.

Statistical Analysis

Within the scope of the study, the number of samples was calculated using power analysis. As a result of the power analysis performed with G*Power (version 3.1.9.6) in the 2-group study, the reliability was 95%, the effect size was 1.25, and the power value was 0.90. In this context, the minimum number of samples was calculated as 32. Accordingly, since it was deemed appropriate to conduct the study by taking at least 16 samples from each group, a minimum of 16 patients for each group was included in the study. In this study, a series of statistical analyses were performed to determine the factors affecting the results of surgical interventions performed with or without adjustable arm holders. Data analysis was performed using international business machines corporation Statistical Package for the Social Sciences statistics 24 software. Data analysis: the dataset consists of a total of 34 patients, including various demographic and clinical characteristics. These data include patients' surgery times, follow-up periods, fracture classifications according to Neer, use of adjustable arm holders, and postoperative Constant-Murley scores. Descriptive statistics: first, descriptive statistics (mean, standard deviation, minimum, maximum and median values) were calculated for variables such as the patients' surgery year, age, gender, fracture classification and use of adjustable arm holders. Correlation analysis: the relationships between the patient's surgery time, follow-up time, and postoperative Constant-Murley score were evaluated using the Pearson correlation coefficient (r). Statistical significance levels (p-values) and r are reported. The effect of categorical variables such as gender, number of fracture parts, and use of adjustable arm holder on patients' outcomes and surgery duration was analyzed with the Mann-Whitney U test. Chi-square test: the effect of the use of adjustable arm holders on the distribution of the number of fracture parts was examined with the chi-square test. Regression analysis: multiple linear regression analysis was performed for factors thought to be effective on the postoperative Constant-Murley score (age, use of adjustable arm holders, and number of fracture parts). In the analysis, the effects of independent variables on the dependent variable are reported along with unstandardized and standardized coefficients, t-statistics and p-values.

RESULTS

Considering the surgery year of the 34 patients participating in the study, the p-value obtained as a result of the chi-square test, was calculated as 0.278. This result shows that there is no statistically significant difference between the use of adjustable arm holders based on the year of surgery

(detailed in Table 1). There was no statistically significant difference in age between the groups (p>0.05). The p-value of the chi-square test for gender distribution is 0.968, indicating that there is no statistically significant difference between the groups in terms of gender. The p-value obtained as a result of the chi-square test for this variable is 1.000, which indicates that 3-and 4-part fractures, have a similar distribution in the groups with and without adjustable arm holders. The age, gender distribution, follow-up period, and the number of Neer fracture fragments of the patients are similar in both groups (detailed in Table 1 and Table 2). Operation duration in minutes, follow-up times in years, and postoperative Constant-Murley scores are detailed in Table 1. The average surgery time is 105.29 minutes, and the standard deviation is 15.02 minutes. The average follow-up period was 1.82 years. Constant-Murley scores obtained after surgery vary between 70 and 100. The mean score was calculated as 86.26. These results show that postoperative patients generally achieved high functional gains and had a good recovery process (Table 1).

There is no statistically significant difference in surgery times and postoperative Constant-Murley scores between male and female patients. There is no statistically significant difference in surgery time according to the number of fracture parts (detailed in Table 3). There is a statistically significant difference between postoperative Constant-Murley scores according to the number of fracture parts (p=0.047). It indicates that patients with 3-part fractures show higher functional recovery than those with 4-part fractures. The average surgery duration of patients without an adjustable arm holder was determined as 112.22 minutes, and the duration for patients with an adjustable arm holder was determined as 97.50 minutes. The use of adjustable arm holders significantly reduces the surgery time (p=0.003). The postoperative mean Constant-Murley score, of patients without an adjustable arm holder, was determined as 82.89, with a standard deviation of 7.35 and a median of 82. For the patients studied, the mean is 90.06, the standard deviation is 6.86, and the median is 91. The use of adjustable arm holders significantly improves

Table 1. The demographic, clinical, and surgical characteristics of the patients included in the study

		n	%	T-	%	T+	%	Min	Max	X	SD	M
OY 2020	*p=0.278	2	5.9	2	11.1	0	0.0					
OY 2021		24	70.6	11	61.1	13	81.3					
OY 2022		8	23.5	5	27.8	3	18.8					
Age Total Group		34						31	70	50.68	10.44	50
Age T-	**p=0.769	18	52.9					31	69	50.11	10.31	49
Age T+		16	47.1					32	70	51.31	10.88	51
Male	*p=0.968	19	55.9	10	55.6	9	56.3					
Female		15	44.1	8	44.4	7	43.8					
Neer 3-part	*p=1,000	17	50.0	9	50.0	8	50.0					
Neer 4-part		17	50.0	9	50.0	8	50.0					
TRIMANO	-	18	52.9									
	+	16	47.1									
Operation duration in minutes								85	145	105.29	15.02	100
Follow-up time in years								1	3	1.82	0.52	2
Postoperative Constant-Murley score								70	100	86.26	7.90	86

*Chi-square test, **Mann-Whitney U test, OY: Operation year, T-: Trimano not used, T+: Trimano used, n: Total number, Min: Minimum, Max: Maximum, X: Mean, SD: Standard deviation, M: Median

Table 2. Distribution of Neer classification types with and without adjustable arm holder

		Adjustable arm holder				Chi-square test
		TRIMANO -		TRIMANO +		
		n	%	n	%	p-value
Neer classification	**Neer 3-part**	9	52.9	8	47.1	1.000
	Neer 4-part	9	52.9	8	47.1	

-: Not used, +: Used, n: Total number

Table 3: Comparison of operation duration, follow-up times, and postoperative constant scores by gender, Neer classification, and use of adjustable arm holder

	Gender						Mann-Whitney U test	NEER classification						Mann-Whitney U test	Adjustable arm holder						Mann-Whitney U test
	Male			Female				NEER 3-part			NEER 4-part				TRIMANO -			TRIMANO +			
	X	SD	M	X	SD	M	p-value	X	SD	M	X	SD	M	p-value	X	SD	M	X	SD	M	p-value
Operation duration in minutes	104.74	14.95	100	106.00	15.61	105	0.726	104.41	14.88	100	106.18	15.57	100	0.741	112.22	15.92	108	97.50	9.31	95	0.003
Follow-up times in year	1.84	0.50	2	1.80	0.56	2	0.794	1.88	0.49	2	1.76	0.56	2	0.489	1.83	0.62	2	1.81	0.40	2	1.000
Postoperative constant scores	86.37	7.58	86	86.13	8.55	84	0.972	89.24	8.07	92	83.29	6.70	84	0.047	82.89	7.35	82	90.06	6.86	91	0.008

SD: Standard deviation, X: Mean, M: Median

postoperative Constant-Murley scores (p=0.008) (detailed in Table 3).

A moderate negative correlation with r=-0.532 was determined between the patient's surgery time and the postoperative Constant-Murley score. This relationship is statistically significant with a value of p=0.001. This result shows that as the surgery duration increases, the postoperative Constant-Murley score decreases, meaning that prolonging the surgery duration may negatively affect functional results (Table 4).

The constant value in the regression analysis model was calculated as 119,456, and this value is statistically significant (t=23,436, p<0.0001). This is the mean value of the postoperative Constant-Murley score expected when each of the independent variables is zero. The effect of the age variable on the postoperative Constant-Murley score is negative (-0.516). The standardized coefficient (-0.682) shows that age reduces the postoperative Constant-Murley score, meaning that as age increases, the level of postoperative functional recovery decreases. This coefficient is statistically significant (t=-7,779, p<0.0001). The use of an adjustable arm holder has a positive effect on the postoperative Constant-Murley score (7,794). The standardized coefficient (0.500) indicates that this variable has a significantly positive effect on the score. The contribution of this variable is also statistically significant (t=5,923, p<0.0001). The effect of the number of fracture parts variable on the postoperative Constant-Murley score is negative (-3.056). The standardized coefficient (-0.196) indicates that more fracture fragments reduce the postoperative functional recovery score. This effect is statistically significant (t=-2,243, p=0.032). The R^2 value of the model was calculated as 0.787. This indicates that the model explains 78.7% of the variance in the dependent variable, meaning the model is highly effective. The f-statistic testing the overall significance of the model is 36,961, and this value is statistically significant (p<0.0001). This regression model clearly reveals that the factors affecting the postoperative Constant-Murley score are age, use of adjustable arm holders, and the number of fracture parts. While age and the number of fracture parts have a negative effect on postoperative recovery, the use of an adjustable arm holder has a positive effect (Table 5).

DISCUSSION

In our investigation, we examined the impact of the TRIMANO adjustable arm holder on managing proximal humerus fractures, with a focus on surgical duration, efficiency, and patient outcomes. Our results revealed a notable reduction in surgery time in the group utilizing

Table 4. Correlation analysis of operation duration, follow-up times, and postoperative constant scores

Correlation analysis		Operation duration in minutes	Follow-up times in year	Postoperative Constant-Murley scores
Operation duration in minutes	**r**	1.000	0.239	**-0.532**
	p-value		0.173	**0.001**
Follow-up times in year	**r**		1.000	0.041
	p-value			0.817
Postoperative constant scores	**r**			1.000
	p-value			

r: Pearson correlation coefficient

Table 5. Regression analysis for predicting postoperative constant scores

Regression analysis	Unstandardized coefficients		Standardized coefficients	t	p-value	R^2	F
	B	SE	Beta				
Constant-Murley*	119.456	5.097		23.436	**<0.0001**	0.787	36.961
Age	-0.516	0.066	-0.682	-7.779	**<0.0001**		
Adjustable arm holder	7.794	1.316	0.500	5.923	**<0.0001**		
Neer classification number of fracture parts	-3.056	1.363	-0.196	-2.243	**0.032**		

Dependent variable=Postoperative constant score, Method=Stepwise
*The constant value in the model is calculated as 119,456, which is statistically significant (t=23,436, p<0.0001). This value represents the expected mean postoperative Constant-Murley score when all independent variables are zero

adjustable arm holders, coupled with an improvement in postoperative Constant-Murley scores, indicating the potential benefits of employing this device in enhancing both surgical efficiency and patient recovery. Moreover, our findings underscore the adverse effect of prolonged surgery time on functional outcomes, while also demonstrating superior functional recovery in patients with 3-part fractures compared to those with 4-part fractures.

Adjustable extremity holders play a crucial role in orthopedic surgery by providing enhanced stability and facilitating improved surgical access. In the absence of such holders, assistant surgeons are tasked with positioning and maintaining stability throughout the procedure. However, utilizing adjustable holders eliminates the need for constant manual adjustment, resulting in reduced vibration and allowing surgeons to approach the surgical site with greater precision and ease. Numerous authors have demonstrated the impact of adjustable extremity holders on surgery duration, consistently noting a decrease in operating theater time with their utilization (9,10,13,14). Kim et al. (15) conducted a study examining the effect of intraoperative limb positioning on both-column acetabular fractures, yielding satisfactory radiological and clinical outcomes following the implementation of intraoperative traction with a limb positioner. Washburn et al. (16) detailed a technique for managing acute ankle traumas using a combination of a previously placed calcaneus external fixation pin and the TRIMANO (Arthrex, Naples, FL,) external positioning arm to apply skeletal traction during both arthroscopic and open definitive fixation procedures. Schulz-Drost et al. (17) reported that in the stabilization of flail chest injuries employing minimally invasive techniques aimed at addressing the core instability, if posterior and lateral approaches were deemed necessary, patients were positioned in a lateral decubitus posture. During this positioning, the ipsilateral arm was kept mobile using a TRIMANO three-dimensional (3D) Support Arm® (MAQUET Holding B.V. and Co. KG, Rastatt, Germany). In Böhringer et al. (18) study on intraoperative 3D imaging in plate osteosynthesis of proximal humerus fractures, the patient's arm was positioned freely with the assistance of a support arm (Arthrex TRIMANO®). Alkhani et al. (13) examined the transaxillary approach in the treatment of thoracic outlet syndrome by using the TRIMANO Arthrex arm as an assistive device. Their findings suggest that employing the TRIMANO Arthrex arm is both safe and beneficial in positioning and managing patients undergoing transaxillary first rib resection. Notably, its use reduces the requirement for surgical assistants and enhances surgeon comfort by ensuring stable exposure throughout the procedure. Ashour et al. (10) presented a case of elbow trauma requiring orthopedic and vascular repair, highlighting the TRIMANO device's usefulness in upper limb

plastic surgery. They recommend its adoption to streamline procedures, reduce staffing needs, and enhance training opportunities. Herzberg and Field (19) studied the use of a mechanical forearm holder during elbow arthroscopy in the lateral decubitus position. They discovered that this technique offers a simple and reproducible method to maintain elbow joint position without requiring an assistant, facilitating effective elbow arthroscopy. Gentile et al. (14) recommended utilizing the TRIMANO FortisTM arm in ankle arthroscopy. Their findings indicate that the TRIMANO arm enables rapid, one-handed manipulation of distraction during the procedure, streamlining ankle arthroscopy. Assiotis et al. (9) outlined a surgical technique that adapts the use of the TRIMANO FORTIS® dynamic pneumatic limb positioner (Arthrex, Maquet GmbH) for open and arthroscopic procedures involving the elbow, proximal forearm, midshaft, and distal humerus, and they reported that this approach provided simplicity, reproducibility, and improved surgical efficiency. Dongqiang et al. (20) proved that the TRIMANO universal robotic arm, when used with contact shoulder arthroscopy, significantly aids surgical procedures and clinical teaching. They also showed that its potential for integration with remote medicine and other disciplines (21) streamlines shoulder arthroscopy practices and enhance teaching platforms (20).

In our literature review, we did not come across any previous studies comparing patients who had arm holders during surgery with those who did not. This makes our study unique, as we analyzed surgery duration and functional outcomes in both groups for the first time in the literature.

Study Limitations

One limitation of our study may lie in the follow-up time, as we had recently introduced this device. Consequently, we focused on analyzing short-term outcomes. However, in the future, we plan to conduct a follow-up study to evaluate the long-term outcomes of the same patient groups.

CONCLUSION

In conclusion, our investigation into the impact of the TRIMANO adjustable arm holder on managing proximal humerus fractures reveals significant contributions to surgical efficiency, patient outcomes, and overall clinical practice. Consistent with the literature, our study confirms the efficacy of adjustable extremity holders in reducing surgery time, enhancing postoperative functional scores, and improving patient recovery. Importantly, our findings emphasize the detrimental effects of prolonged surgery time on functional outcomes, underscoring the importance of efficient surgical techniques. Furthermore, our study contributes to the existing body of knowledge by highlighting the superior functional recovery observed in patients with 3-part fractures compared to those with 4-part fractures. This evidence also underscores the power of the Neer classification system in predicting functional outcomes and guiding clinical decision-making in the management of proximal humerus fractures. Overall, our results support the widespread adoption of adjustable extremity holders, such as the TRIMANO device, as valuable tools in orthopedic surgery, offering tangible benefits in terms of surgical efficiency, patient recovery, and ultimately, improved clinical outcomes.

ETHICS

Ethics Committee Approval: This study was approved by the İstanbul University-Cerrahpaşa Clinical Research Ethics Committee (number: E-83045809-604.01-1004836, date: 07.06.2024).

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

FOOTNOTES

Authorship Contributions

Surgical and Medical Practices: C.D.D., M.Y.A., Concept: C.D.D., M.Y.A., Design: C.D.D., M.Y.A., Data Collection or Processing: C.D.D., M.Y.A., Analysis or Interpretation: C.D.D., M.Y.A., Literature Search: C.D.D., M.Y.A., Writing: C.D.D., M.Y.A.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study received no financial support.

REFERENCES

1. Pencle F, Varacallo MA. Proximal humerus fracture. [Updated 2023 Aug 4]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK470346/
2. Court-Brown CM, Caesar B. Epidemiology of adult fractures: a review. Injury. 2006;37:691-7.
3. Neer CS 2nd. Displaced proximal humeral fractures. I. Classification and evaluation. J Bone Joint Surg Am. 1970;52:1077-89.
4. Carofino BC, Leopold SS. Classifications in brief: the Neer classification for proximal humerus fractures. Clin Orthop Relat Res. 2013;471:39-43.
5. Marmor MT, Agel J, Dumpe J, Kellam JF, Marecek GS, Meinberg E, et al. Erratum: comparison of the Neer classification to the 2018 update of the orthopedic trauma association/AO fracture classification for classifying proximal humerus fractures: erratum. OTA Int. 2025;8:e379.

6. van de Wall BJM, Ochen Y, Beeres FJP, Babst R, Link BC, Heng M, et al. Conservative vs. operative treatment for humeral shaft fractures: a meta-analysis and systematic review of randomized clinical trials and observational studies. J shoulder Elb Surg. 2020;29:1493-504.
7. Maes V, Putzeys G. One-year follow-up after treatment of proximal and/or middle one-third humeral shaft fractures with a helical plate: healing rates, complications and functional outcome measures. BMC Musculoskelet Disord. 2021;22:890.
8. Kurup H, Hossain M, Andrew JG. Dynamic compression plating versus locked intramedullary nailing for humeral shaft fractures in adults. Cochrane Database Syst Rev. 2011:CD005959.
9. Assiotis A, Rumian A, Yeoh C, Uppal HS. Approaching the humerus, elbow, and proximal forearm using the trimano arm holder. Cureus. 2024;16:e58833.
10. Ashour T, Chadwick S, Wong J, Choukairi F. TRIMANO-A helping hand for upper limb surgery. JPRAS Open. 2023.
11. Constant CR, Murley AH. A clinical method of functional assessment of the shoulder. Clin Orthop Relat Res. 1987;214:160-4.
12. Constant CR, Gerber C, Emery RJH, Søjbjerg JO, Gohlke F, Boileau P. A review of the Constant score: modifications and guidelines for its use. J shoulder Elb Surg. 2008;17:355-61.
13. Alkhani M, Arsicot M, Oliny A, Millon A, Della Schiava N, Bordet M. Thoracic outlet syndrome: single-center experience on the transaxillary approach with the aid of the TRIMANO arthrex arm. J Vasc Surg Cases Innov Tech. 2024;10:101400.
14. Gentile M, Blickenstaff B, Peluso R, Lamba C, Fravel W. One-step distraction technique using Trimano FortisTM arm in ankle arthroscopy. Foot and Ankle Surg Tech Reports Cases. 2022;2:100111.
15. Kim JW, Oh CW, Park KH, Hong WK, Yoon SH, Lee GS, et al. Application of an intraoperative limb positioner for adjustable traction in both-column fractures of the acetabulum: a technical note with clinical outcome. J Clin Med. 2023;12:1682.
16. Washburn FJ, Umbel BD, Martin KD. Use of the external fixator calcaneus pin: using the TRIMANO to its full potential. Arthrosc Tech. 2022;11:e669-73.
17. Schulz-Drost S, Grupp S, Pachowsky M, Oppel P, Krinner S, Mauerer A, et al. Stabilization of flail chest injuries: minimized approach techniques to treat the core of instability. Eur J Trauma Emerg Surg. 2017;43:169-78.
18. Böhringer A, Cintean R, Eickhoff A, Gebhard F, Schütze K. Intraoperative 3D imaging in plate osteosynthesis of proximal humerus fractures. Arch Orthop Trauma Surg. 2023;143:4993-5000.
19. Herzberg G, Field LD. Use of a mechanical forearm holder during elbow arthroscopy in lateral decubitus position. Arthrosc Tech. 2024;102991.
20. Dongqiang G, Haoran G, Lei C, Wei L. Application of trimano universal manipulator in clinical and teaching of shoulder arthroscopy. J Musculoskelet Disord Treat. 2023;9.
21. He J, Baxter SL, Xu J, Xu J, Zhou X, Zhang K. The practical implementation of artificial intelligence technologies in medicine. Nat Med. 2019;25:30-6.