

# DO THE CHANGES OF SCAPULOTHORACIC ANGLE AFFECT WINGED SCAPULA DEVELOPMENT AND FUNCTIONAL SCORES DURING CLAVICLE FRACTURE TREATMENT?

## AS ALTERAÇÕES DO ÂNGULO ESCAPULOTORÁCICO AFETAM O DESENVOLVIMENTO DE ESCÁPULA ALADA E ESCORES FUNCIONAIS DURANTE O TRATAMENTO DE FRATURA DE CLAVÍCULA?

MEHMET RAUF KOÇ<sup>1,2</sup> , İSMAIL HAKKI KORUCU<sup>3,4</sup> , MEHMET YUCENS<sup>5,6</sup> , ALI ÇAĞDAŞ YÖRÜKOĞLU<sup>5,6</sup> , ALI SALLI<sup>7,8</sup> , ŞEVKET YALÇIN<sup>9,10</sup> , OĞUZHAN PEKINCE<sup>11,12</sup> , MUSTAFA ÖZER<sup>3,4</sup> 

1. El Cerrahisi Kliniği, Tepecik Eğitim ve Araştırma Hastanesi, İzmir, Türkiye.
2. Clinic of Hand Surgery, Tepecik Training and Research Hospital, İzmir, Turkey.
3. Ortopedi ve Travmatoloji Kliniği, Tıp Fakültesi, Necmettin Erbakan Üniversitesi, Konya, Türkiye.
4. Orthopedics and Traumatology Clinic, Meram Faculty of Medicine, Necmettin Erbakan University, Konya, Turkey.
5. Ortopedi ve Travmatoloji Kliniği, Pamukkale Üniversitesi Tıp Fakültesi, Denizli, Türkiye.
6. Orthopedics and Traumatology Clinic, Pamukkale University Faculty of Medicine, Denizli, Turkey.
7. Tedavi ve Rehabilitasyon, Fuar Hastanesi, Afyon, Türkiye.
8. Physiotherapy and Rehabilitation, Fuar Hospital, Afyon, Turkey.
9. Fizik Tedavi ve Rehabilitasyon, Pendik Medipol Üniversitesi Hastanesi, İstanbul, Türkiye.
10. Physical Therapy and Rehabilitation, Pendik Medipol University Hospital, İstanbul, Turkey.
11. Ortopedi ve Travmatoloji Kliniği, Konya Şehir Hastanesi, Konya, Türkiye.
12. Orthopedics and Traumatology Clinic, Konya City Hospital, Konya, Turkey.

### ABSTRACT

**Introduction:** To compare surgical and conservative management of midshaft clavicle fractures according with scapulothoracic joint angle change, considering clinical, functional, and radiological outcomes. **Methods:** A total of 95 midshaft clavicle fracture patients aged between 18-70 years with a minimum follow-up duration of 12 months were included in this study. Patients were treated either conservatively (Group 1) or surgically (Group 2). Plane deformities, scapulothoracic joint angle, shortness and isokinetic muscle strength were measured. Shoulder Pain, Disability Index (SPADI) and Short Form-36 (SF36) were assessed. **Results:** Scapulothoracic joint angles were higher in the conservative treatment group than in surgery group ( $p=0.036$ ). Consequently, winged scapula was seen more commonly in the conservative treatment group than in the surgery group ( $p=0.001$ ). Surgical treatment was associated with significantly better SF-36 physical scores and with SPADI pain and disability scores. However, the two groups did not differ in terms of isokinetic muscle strength. Negative anteroposterior plane deformity ( $p<0.001$ ) and negative axial plane deformity ( $p=0.004$ ) were more frequent in the conservative treatment group. Clavicle shortness was more common in the conservative treatment group. **Conclusions:** According to our findings scapulothoracic joint angle changes were seen in the conservative treatment group more than in the surgery group. Consequently, winged scapula was seen more commonly in the conservative treatment group than in the surgery group ( $p=0.001$ ). **Level of Evidence III; Retrospective comparative study.**

**Keywords:** Clavicle. Fracture, bone. Radiology. Scapula.

### RESUMO

**Introdução:** Comparar o manejo cirúrgico e conservador das fraturas da diáfise da clavícula conforme alteração do ângulo escapulotorácico, considerando resultados clínicos, funcionais e radiológicos. **Métodos:** Um total de 95 pacientes com fratura do terço médio da clavícula com idade entre 18-70 anos, com um tempo mínimo de seguimento de 12 meses, foram incluídos neste estudo. Os pacientes foram tratados conservadoramente (Grupo 1) ou cirurgicamente (Grupo 2). Deformidades planas, ângulo escapulotorácico, encurtamento e força muscular isocinética foram medidos. O Índice de Dor e Incapacidade do Ombro (SPADI) e a Short Form-36 (SF36) foram avaliados. **Resultados:** Os ângulos da articulação escapulotorácica foram maiores no grupo de tratamento conservador do que no grupo de cirurgia ( $p=0,036$ ). Conseqüentemente, a escápula alada foi vista mais comumente no grupo de tratamento conservador do que no grupo de cirurgia ( $p=0,001$ ). O tratamento cirúrgico foi associado a escores físicos SF-36 significativamente melhores e escores SPADI de dor e incapacidade. No entanto, os dois grupos não diferiram em termos de força muscular isocinética. A deformidade no plano anteroposterior negativo ( $p<0,001$ ) e a deformidade no plano axial negativo ( $p=0,004$ ) foram mais frequentes no grupo de tratamento conservador. O encurtamento da clavícula foi mais comum no grupo de tratamento conservador. **Conclusões:** De acordo com nossos achados, as alterações do ângulo escapulotorácico foram mais observadas no grupo de tratamento conservador do que no grupo de cirurgia. Conseqüentemente, a escápula alada foi vista mais comumente no grupo de tratamento conservador do que no grupo de cirurgia ( $p=0,001$ ). **Nível de Evidência III; Estudo comparativo retrospectivo.**

**Descritores:** Clavícula. Fratura óssea. Radiologia. Escápula.

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The study was conducted at Necmettin Erbakan University, Meram Medical Facility, Orthopedic and Traumatology Clinical. Correspondence: Mehmet Yucens, Orthopedics and Traumatology Clinic, Pamukkale University Faculty of Medicine, Denizli, Turkey, [aflyucens@yahoo.com](mailto:aflyucens@yahoo.com)

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## INTRODUCTION

Clavicle fractures constitute 2.6 to 4 percentage of all fractures,<sup>1</sup> and nearly 70% of these lesions occur at the mid-shaft region.<sup>2,3</sup> In midshaft clavicle fractures, displacement is either present at the time of initial insult or develop later.

Clavicle fractures can be treated either conservatively or surgically. Both treatments have high risk of malunion.<sup>4</sup> Despite the controversy surrounding the negative outcomes of clavicular malunion other than the cosmetic effect,<sup>4</sup> many studies have also reported loss of power, easy fatigability, numbness, or paresthesia of the arm in patients with clavicular malunion.<sup>4</sup>

Although clavicle shaft fractures have been traditionally managed conservatively in the past, recently surgery has also become a viable therapeutic option for these lesions depending on developing implant technology.<sup>5,6</sup> Currently the most commonly preferred surgical method is plate fixation, followed by elastic nails or intramedullary screws. The choice of treatment depends on several factors including the pre-fracture functional status, occupation involving heavy duty work, aesthetic concerns, and co-existent systemic conditions of the patient that may hamper surgery.

In this study, our aim was to compare surgical and conservative management of midshaft clavicle fractures for scapulo-thoracic angle change, clinical, functional, and radiological outcomes.

## METHODS

### Patients

A total of 95 midshaft clavicle fracture patients aged between 18 and 70 years were included in this study. They were treated either conservatively (Group 1) or surgically (Group 2), between March 2012 and March 2015 and follow-up lasted a minimum 12 months. The patients who were operated after initial conservative treatment, needed a revision surgery, had bilateral clavicle fractures, removal of implants, presence of congenital pseudo-arthritis, history of or needed scapular surgery were excluded. The study protocol was approved by the local ethics committee. Conservative and surgical treatment groups were compared by means of scapulo-thoracic angle changes, clinical, radiological, and functional outcomes. Indications for surgical treatment were as follows: displacement > 2 cm, shortening > 2 cm, fragmentation > 3 fragments, segmental fracture, open fracture, fracture threatening the surrounding soft tissue integrity, significant clinical deformity, scapular malposition as identified in the initial examination, poly-trauma requiring early functional restoration in the arm and weight bearing activity in the upper extremity, and willingness of the patient for rapid functional recovery. Other patients were managed conservatively.

### Treatments

In patients with indication for surgery, an incision over the fracture line was made while the patient was in beach-chair position and the bone was exposed; if present, the butterfly fragment was fixed, followed by the temporary fixation of the main fragments by bone clamp. Then an appropriately curved plate was positioned superiorly with an adequate number of holes, and was fixed to the bone using screws in accordance with AO principles. A simple shoulder strap was prescribed to each patient postoperatively. Shoulder mobility, adherence to exercise, and potential complications were assessed at each routine follow-up visit. Nine months after surgery Shoulder Pain and Disability Index (SPADI) and Short Form-36 (SF36), were performed, and radiological assessments and isokinetic tests were done.

### Radiological assessments

Anteroposterior (AP) plane deformity was estimated using the two lines passing from the medullary midline to medial or lateral

fragments of the clavicle on AP radiographs. The angle between these two lines was AP plane deformity. Angling towards inferior or superior directions were considered negative or positive, respectively. Axial plane deformity was estimated using the two lines passing from the medullary midline to medial or lateral fragments of the clavicle on axial CT/MRI sections (Figure 1). The angle between these two lines was the axial plane deformity. Angling towards the anterior or posterior directions were considered negative or positive, respectively. The lines pass through the long axis of the fragments in the respective planes. The scapulo-thoracic angle was estimated using axial CT/MRI images and was defined as the angular difference on two sides formed by the intersection of the lines crossing the body of both scapulae and the tangential of the single line passing through the peak points of the ribs in both thoracic cages (Figure 2). If the scapulo-thoracic (ST) angle on the fracture side was greater than the non-fracture side, then this value was taken as a positive value, and vice versa. Presence of shortening was identified through the measurement of the line between the midline passing through the medial tip and the midline passing through the middle point of the fragments on AP radiographs. Since 20 mm is considered a critical threshold for the decision for surgery, fractures were stratified based on shortening as follows: 0 mm, < 20 mm, and  $\geq$  20 mm.

### Functional assessments

Health-related quality of life was assessed using SF-36 scores.<sup>7,8</sup> SF-36 is divided into physical and mental sub-scales, with higher scores indicating better quality of life. The shoulder pain and disability were evaluated with SPADI scores,<sup>9</sup> which range between 0 and 100, with increasing scores reflecting more severe symptoms. The isokinetic muscle power of the shoulder during internal and external rotation was evaluated using a Biodex Sys3Pro (USA) Test and Exercise System (Figure 3). In order to minimize the effect of daytime fatigue on muscular power, the assessments took place between 10 and 12 a.m. Prior to the test, sub-maximal exercise of 5-minute duration was performed for warming the upper extremity with isokinetic ergometer. Then, patients sat in the seat with the hip and knees flexed at 90 degrees and the trunk was stabilized using

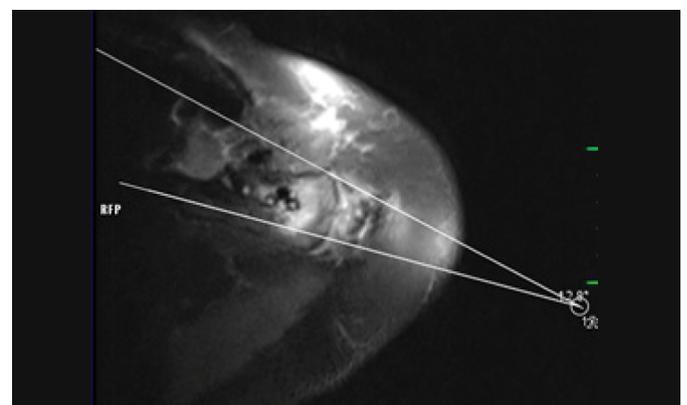


Figure 1. Axial plane deformity measurement.

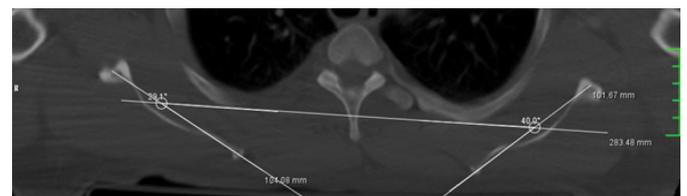


Figure 2. Scapulo-thoracic angle measurement.



**Figure 3.** Isokinetic muscle power analyzes.

stabilizer bands. The elbow was placed in the elbow attachment of the device with the shoulder abducted at 90 degrees and elbow flexed at 90 degrees. The height of the dynamometer was adjusted according the axial center of the shoulder rotation. A correction factor was used for the gravity. Patients were provided information on the nature of the test and the exercise, and were asked to push and pull the effort arm as forcefully and quickly as possible. Initially exercise using three different angular velocities were performed in the concentric-concentric mode at 60 degrees/sec, 120 degrees/sec, and 180 degrees/sec (with three submaximal movements for warming up before the exercise). This was followed by three internal and external rotation movements at maximal force. For 90-degree ROM distance, the long axis of the forearm was at right angle to the ground surface at the start and fully parallel at the finish of the exercise during internal rotation, and during external rotation, the long axis was switched from a position fully parallel to the horizontal line to a position at right angle. Between each angular velocity, the intact side (control side) was allowed to rest for 2 minutes. For both upper extremities, peak torque/bw (maximal muscular power/weight in kg) corrected for weight was estimated. The percent deficit between the intact site and the fractured site was used for study analyses.

### Statistical analysis

Statistical Package for Social Sciences version 16.0 (SPSS ver. 16.0) was used for the statistical analysis of data. Normality of continuous variables was tested with Kolmogorov-Smirnov test. Continuous variables were compared using Student's "t" test for independent samples or Mann-Whitney "U" test depending on the normality of distribution. Categorical variables were compared using Chi-square or Fisher's Exact test, where appropriate. A p value <0.05 was considered indication of statistical significance.

### RESULTS

In this study groups did not differ with regard to age, gender, fracture side, presence of additional trauma, occupation or AO classification of the fracture as demographic and clinical characteristics. However, trauma type distribution was significantly different in the two groups. About half of conservatively treated patients had fallen simply, and all patients who underwent surgery were injured with a high-energy trauma (Table 1).

In our study we found that scapulo-thoracic angle changes were statistically higher in conservative treatment group than in surgery group (p=0.036). Winged scapula was more common in the conservative treatment group (p=0.001) (Table 2). Negative AP plane deformity (p<0.001) and negative axial plane deformity (p=0.004)

**Table 1.** Demographic and clinical characteristics of the groups.

	Group I Conservative treatment (n=60)	Group II Surgical treatment (n=35)	p
Age, y (mean SD)	33.1 12.8	35.3 12.8	0.409
Male gender	43 (71.7%)	26 (74.3%)	0.782
Right sided fracture	28 (46.7%)	14 (40.0%)	0.528
<b>Additional trauma</b>			
Scapula	4 (6.7%)	3 (8.6%)	0.461
Humerus	1 (1.7%)	1 (2.9%)	
Scapula plus humerus	0 (0%)	1 (2.9%)	
Rib	8 (13.3%)	5 (14.3%)	
<b>Type of trauma</b>			
Traffic accident (in vehicle)	14 (23.3%) <sup>a</sup>	18 (51.4%)	0.002
Traffic accident (outside of vehicle)	16 (26.7%)	11 (31.4%)	
Fall	27 (45.0%) <sup>a</sup>	4 (11.4%)	
Assault	2 (3.3%)	2 (5.7%)	
Simple trauma	1 (1.7%)	0 (0%)	
<b>Occupation</b>			
Heavy work	10 (16.7%)	10 (28.6%)	0.196
Light work	35 (58.3%)	14 (40.0%)	
Not working	15 (25.0%)	11 (31.4%)	
<b>AO classification</b>			
B1	40 (66.7%)	20 (57.1%)	0.353
B2-B3	20 (33.3%)	15 (42.9%)	

**Table 2.** Scapulothoracic angle changes.

Scapulothoracic angle changes	< 0	= 0	> 0	p
	Mean sd (Med, min, maks)	Mean sd (Med, min, maks)	Mean sd (Med, min, maks)	
SF36 PCS	44,77 7,52 <sup>a</sup>	51,23 7,83 <sup>b</sup>	46,15 9,31	0,018*
Wing scapulae	0 (%0) <sup>a</sup>	1 (%2,1) <sup>a</sup>	14 (%73,7) <sup>b</sup>	<0,001*

were more frequent in the conservative treatment group and shortness, either <20 mm (p<0.001) or ≥20 mm (p=0.024), was more common in the conservative treatment group.

Surgical treatment group was associated with significantly better SF-36 physical scores and SPADI pain, disability and total scores (Table 3). However, the two groups did not differ in terms of isokinetic muscle strength. Axial plane deformity of clavicle and scapulo-thoracic joint pain were statistically significant. Fracture skin irritation and level difference between shoulders were higher in patients who were treated conservatively. The highest SPADI pain score in surgical treatment group were found in patients who had skin scar. SPADI pain score was relevant in the patient who had skin irritation in conservative treatment group.

### DISCUSSION

According to our study winged scapula and higher scapulo-thoracic angle are more common in conservative treatment group. Shortening is higher in conservative treatment group. And increased scapulo-thoracic angle causes winged scapulae. Further winged scapulae can cause loss of power and acromioclavicular joint arthrosis. The results of our study suggest that improved radiological and functional outcomes may be obtained using a surgical approach for the management of midshaft clavicle fractures, which is increasingly preferred in recent years.<sup>10</sup> Also, to our knowledge, this study is the first of its kind to directly measure the impairment in the integrity of the scapulo-thoracic joint as well as representing one of the

**Table 3.** Comparison of functional and radiological outcomes.

	<b>Group I Conservative treatment (n=60)</b>	<b>Group II Surgical treatment (n=35)</b>	<b>p</b>
<b>SF-36</b>			
Physical score	47.5 7.6	52.6 8.0	0.003
Mental score	52.0 5.0	50.0 10.2	0.868
<b>SPADI</b>			
Pain score	31.9 17.6	27.0 25.4	0.018
Disability score	31.1 17.1	24.8 24.4	0.003
Total score	31.1 15.4	26.0 24.5	0.005
Winged scapula	18 (30.0%)	1 (2.9%)	0.001
<b>AP plane deformity</b>			
<0 degrees	50 (83.3%)	2 (5.7%)*	<0.001
0 degrees	6 (10.0%)	33 (94.3%)*	
>0 degrees	4 (6.7%)	0 (0%)	
<b>Axial plane deformity</b>			
<0 degrees	16 (26.7%)	1 (2.9%)*	0.043
0 degrees	41 (68.3%)	34 (97.1%)*	
>0 degrees	3 (5.0%)	0 (0%)	
<b>Scapulothoracic angle difference</b>			
<0 degrees	8 (16.7%)	2 (6.9%)	0.021
0 degrees	24 (50.0%)	24 (82.8%)*	
>0 degrees	16 (33.3%)	3 (10.3%)*	

few studies that involved a combined assessment of isokinetic measurements, shoulder scoring, and functional outcomes.

Until now, several studies have compared the outcomes of surgical and conservative management of clavicle fractures with controversial results. On the other hand, many reports have pointed out to an increased incidence of permanent shoulder dysfunction in adult patients with midshaft clavicle fractures treated conservatively, leading to the suggestions that surgery may represent a better option for preventing delayed complications and symptoms in displaced or irreducible fractures.<sup>11-15</sup> In a meta-analysis by Xu, J. et al.,<sup>16</sup> superior results have been identified with surgery than with conservative treatment, with plate fixation being associated with lower rates of non-union, complications, and symptomatic malunion. Again, in another meta-analysis by Wang X.H. et al. involving DASH, Constant Shoulder Score, complications, and sub-group (neurological symptoms, and complications other than non-union or symptomatic malunion) assessments, the authors have concluded that surgery may be a superior option for midshaft clavicle fractures.<sup>17</sup> However, these authors have not recommended the routine use of surgery as a primary option. In a 2015 study by Van der Ven Denise, J.C. et al., patients treated either surgically or conservatively were assessed using union, DASH shoulder scoring, Constant-Murley score, VAS pain scale, chronic complaints, as well as a questionnaire assessing patient satisfaction; it was found that patients in the surgical treatment group had less pain and higher function scores six weeks after surgery, although in the long term, i.e. after 24 weeks, there were no significant differences between the two methods in terms of functional outcomes.<sup>18</sup> In our study we found that there is less pain in surgery group than in conservative group similarly and pain in surgery group further occurs from the scar tissue in surgery area. Because of this we suggest surgeons

to employ subskin suture for minimize the scar tissue. In another study involving midshaft clavicle fractures with a follow up duration of more than 10 years,<sup>19</sup> 77% of the patients were treated conservatively with successful outcome, and the authors concluded that surgery should only be considered in patients with neurovascular problems or skin compromise. Furthermore, they also suggested that three out of four patients will undergo unnecessary surgery if surgical management is universally performed in all patients with displaced fractures. Altamimi SA et al. found better Constant scores and DASH scores in addition to improved patient satisfaction with surgery than with conservative management at 1 year.<sup>20</sup> Ban, I. et al., on the other hand, proposed that conservative management of midshaft clavicle fractures may represent a better therapeutic option on the basis of insufficient supportive evidence for surgery and also on the basis of the risk of overtreatment.<sup>21</sup>

Parry, J. A. et al. examined the outcomes with conservative and surgical treatments using Quick DASH Score, Constant Shoulder Score, and treatment satisfaction in a group of adolescents, and found excellent QuickDASH and Constant Shoulder Scores in both groups.<sup>22</sup> Better shoulder positioning and patient satisfaction were found in displaced midshaft clavicle fractures performed within 6 weeks following the injury in the study by George DM et al.<sup>23</sup> They suggested that early surgical management may be particularly appropriate for younger individuals, in subjects working in occupations requiring physical activity in the upper extremities, as well as in physically active individuals rather than the elderly or sedentary subjects.

In our study, shortening was more marked after conservative treatment. Stegeman SA et al. reported slight over protraction and lateral rotation as well as reduced back tilt in abduction in patients developing shortening after conservative management; also, during anteflexion, slight increase in winging in scapular orientation, slight increase in lateral rotation, and mildly reduced back-tilt were observed in the fracture side.<sup>24</sup> Despite these findings, Constant-Murley and DASH scores were excellent. Thus, it was concluded that negative impact of shortening may be minimal, obviating the need for surgery to achieve adequate bone length.

In the current study, better results were obtained with surgery in terms of AP plane deformity, axial plane, deformity, alteration in the scapula-thoracic angle, and wing-scapula development. Since surgery allows reconstruction of the anatomical structure, we may assume that the natural position is restored with regard to 3-dimensional angulation and scapular dyskinesia (winging) after surgery. Furthermore, SPADI scores (pain, disability, total) and SF36 physical scores exhibited a similar change after surgery, which yielded better results than conservative management with respect to these measures. As expected, wound site problems would occur at a higher rate with surgery. On the other hand, conservative management would be more likely to be associated with asymmetry and skin irritation due to impaired shoulder position, leading to a potential worsening in the physical scores after conservative therapy. This may explain the better functional and satisfaction outcomes with surgery than with conservative management in our patient group. Nevertheless, the choice of treatment should be determined based on a number of factors including the general status of the patient, fracture type, bone condition, and the expertise and knowledge level of the surgeon. In conclusion, both conservative and surgical approaches may be used for the management of midshaft clavicle fractures. However, our results suggest better outcomes with surgery with respect to both radiological and functional assessments.

**AUTHORS' CONTRIBUTION:** Each author contributed individually and significantly to the development of the manuscript. MRK, IHK and MÖ were the main contributors in the drafting of the manuscript. MRK, IHK and OP made the surgery, ŞY, AS and MRK followed patients and gathered clinical data. MY and AÇY evaluated the data of the statistical analysis. MRK and MY performed the literature search, review of the manuscript and contributed to the intellectual concept of the study.

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