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Functional Outcome of Internal Fixation of Extra-Articular Scapular Fracture: A Systematic Review/ Meta-Analysis

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ABSTRACT

Background: Scapular fractures are a rare upper extremity injury brought on mostly by high-energy trauma. The bulk of these fractures are extra-articular. Un-displaced fractures can be successfully treated with conservative measures. However, displaced fractures do not produce excellent outcomes and require surgical intervention.

Objective: The aim of the current study was to perform a review of literatures and meta-analysis on the function results of treating extra-articular scapular fractures.

Material and methods: A meta-analysis study was conducted in the Orthopedics Surgery Department, Faculty of Medicine, Zagazig University. To find relevant literatures published between 2004 until 2019, a computerized search was conducted in the PubMed, MedLine, Cochrane Library (Cochrane Systematic Reviews and Cochrane Bone, Joint and Muscle Trauma Group), Embase, Science Direct, Scopus, CNKI, and Google Scholar are just a few of the databases that are available. A search included the single keyword or in combination: "extra-articular scapula fracture internal fixation". We searched for non-randomized clinical trials (CTs), as well as prospective and retrospective investigations, randomized CTs, and studies reviewing the functional results of extra-articular scapula fracture fixation.

Results: The results indicated that man DASH prior to procedure was 17.9, which decreased to 9.3 post operation, mean constant score was 77.6 pre-operation and increased to 89.1 post operation. As regard ROM mean for forward flexion was 151.4, mean abduction was 123.4, mean external rotation was 60.1 and mean internal rotation was 23.2.

Conclusion: Scapular body fractures treated with internal fixation have a high rate of success for union and shoulder function.

Keyword; Extra-articular scapular fracture, Internal fixation, Systematic review, Meta-analysis, Zagazeg University**.**

INTRODUCTION

About 0.5% of fractures are scapular fractures, and 62% to 98% of all scapular fractures are extra articular fractures [(1,2)]. Extra-articular scapular fractures frequently accompany both local and systemic injuries, and they typically result from high-energy trauma. The scapula is anatomically protected by the rib cage and the surrounding muscles, which explains why this phenomenon has an anatomical explanation and why extra-articular scapular fractures typically have a minor displacement [(3)].

It is debatable whether extra-articular scapular fractures should be operated on when anatomical deformity criteria are used. The signs are only more obvious in the presence potential problems, such as an open fracture or injury to the neurovasculature [(3)].

Extra-articular scapular fractures have traditionally not required surgery, however since Robert Judet's work [(4)], the methods and indications for internal fixation of these fractures have drawn growing interest [(5)]. Therefore, the purpose of this meta-analysis was to analyze earlier research on surgical treatment of extra-articular scapula fractures and assess its implications on patients' functional outcomes.

MATAERIAL AND METHODS

A meta-analysis study was conducted in the Orthopedics Surgery Department, Faculty of Medicine, Zagazig University. To find relevant literatures published between 2004 until 2019, a computerized search was conducted in the PubMed, MedLine, Cochrane Library (Cochrane Systematic Reviews and Cochrane Bone, Joint and Muscle Trauma Group), Embase, Science Direct, Scopus, CNKI, and Google Scholar are just a few of the databases that are available.

A search included the single keyword or in combination: "extra-articular scapula fracture internal fixation". We searched for non-randomized clinical trials (CTs), as well as prospective and retrospective investigations, randomized CTs, and studies reviewing the functional results of extra-articular scapula fracture fixation. Studies that fulfilled the next criteria were included in our systematic review: Extra-articular scapular fracture, skeletally mature patients, both sexes, minimum follow up period one year and radiological evaluation by X-RAY and CT scan. Exclusion criteria were intraarticular scapular fractures, brain trauma with a dismal prognosis, damage to the ipsilateral brachial plexus and follow up period <1 year.

Clinical outcomes data was operative time and post-operative data like DASH, ROM and constant score. The assessment was done using Cochrane Handbook Tool 5.1.0; the researchers were in charge to assess the methodological quality for each included study, in which the quality criteria were assessed.

Ethical Consideration:

The protocol for this study was approved and registered by both the Institutional Review Board [IRB] and the Local Ethics Committee at Zagazig University's Faculty of Medicine.

Statistical Analysis: Review Manager (RevMan5.4) software provided by Cochrane collaboration was used

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in our statistical analysis. In continuous data, mean difference (MD) was employed, whereas in dichotomous data, odds ratio (OR) was used. As for statistical significance, a P-value of 0.05 or below was judged acceptable. Additionally, a 95% confidence interval (CI) was applied.

RESULTS

The first search criteria found 307 articles, of which 88 were disregarded. Of these, 53 studies were published before 2004, 22 lacked an English translation, 9 lacked a complete text manuscript, and 5 solely reported on patients under the age of 18 years old.

An additional 192 studies were disqualified for having the wrong topic, and 32 were disqualified for having separate data sets that included intra-articular outcome data. The final data analysis included 15 manuscripts, which are listed in **Figure 1**.

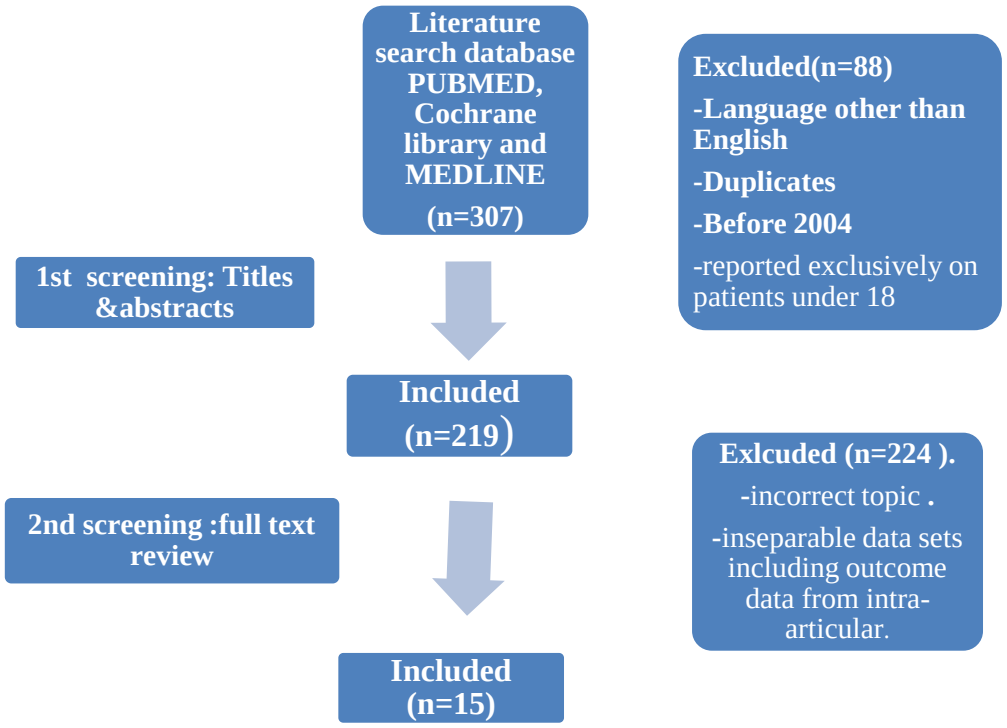

Figure (1): Flow Diagram (PRISMA chart of included studies).

In total, outcomes of 338 patients were reported. These patients had a mean adjusted age of 41.7 years (range 34-48.8) and a mean adjusted follow up time of 38.8 months, 253 were males and 85 females,138 were in right side and 125 in left side, as regard site of fracture mentioned in some studies were mainly in body (n.202), neck in (n.84) as shown **Table 1**.

Table (1): Summary of patients' demographics.

Author	Number of cases	Age	M\F	Follow up\mn	Side of fracture	Site of fracture
Jaikish et a.l [6]	12	42	10\2	33	Right (n.4), left (n.8)	
Vidovic et al. [7]	14	42	13\1	44	Right (n.8), left (n.6)	Body (n.14)
Mannambeth et al. [8]	11	45	8\3	15.6	Right (n.7), left (n.4)	
Mohd Asihin et al. [6]	10	43	7\3		ND	Body (n.7), neck (n.3)
Hu et al. [9]	16	45.6	14\2		Right (n.9), left (n.7)	
Tatro et al. [1]	37	45.4	29\8	93.6	ND	Body (n.36), neck (n.1)
Fandridis et al. [10]	6	34	6\0	28	ND	
Yuan et al. [11]	72	37.5	44\28	60.3	Right (n.40), left (n.32)	Body
Porcellini et al. [12]	6	48.8	5\1	49.8	Right (n.2), left (n.4)	
Ao et al. [13]	22	38	12\10	19.5	ND	
Schroder et al. [2]	61	44	49\12	33	Right (n.27), left (n.34)	Neck
Lin et al. [14]	13	38.7	6\7	24	Right (n.8), left (n.5)	
Jones et al. [15]	31	42.6	27\4		Right (n.18), left (n.13)	Body (n.12), neck (n.19)
Cole et al. [16]	5	44	3\2	39	Right (n.4), left (n.1)	
Bartoníček et al. [5]	22	35	20\2	26.1	Right (n.11), left (n.11)	

Mechanism of injury was mostly traffic accident in 266, fall in 47, sports in 1, bruising in 2, direct hit in 3, others in 4. Mean duration from injury to operation was 99.4 hours (range 5-336), and mean operative time was 123.7 minutes as shown **Table 2**.

Table (2): Mechanism of injury, duration from injury to operation and operative time.

Author	Mechanism of injury	Duration from injury to operation\h	Operative time\min
Jaikish et al.[6]	Traffic accident (n.8), fall (n.2)	72	ND
Vidovic et al.[7]	Traffic accident (n.8), fall (n.6)	ND	ND
Mannambeth et al.[8]	Traffic accident (n8), fall (n.3)	ND	ND
Mohd Asihin et al.[6]	Traffic accident (n.10)	ND	ND
Hu et al.[9]	Traffic accident (n.8), fall (n.6), bruising (n.2)	8.1	103
Tatro et al.[1]	Traffic accident (n.34), fall (n.7), other (n.2)	336	188
Fandridis et al.[10]	Traffic accident (n.5), fall (n.1)	216	ND
Yuan et al.[11]	Traffic accident (n.68), fall (n.4)	48	ND
Porcellini et al.[12]	Traffic accident (n.5), fall (n.1)	ND	ND
Ao et al.[13]	Traffic accident (n.15), fall (n.4), direct hit (n.3)	ND	80
Schroder et al.[2]	Traffic accident (n.58), fall (n.3)	11	ND
Lin et al.[14]	Traffic accident (n9), fall (n.4)	5	ND
Jones et al.[15]	Traffic accident (n.22), fall (n.7), sports (n.1), others (n.2)	ND	ND
Cole et al.[16]	Traffic accident (n.4), fall (n.1)	ND	ND
Bartoníček et al.[5]	Traffic accident (n.19), fall (n.3)	ND	ND

Table 3 showed that mean angulation pre was 24.34 which decreased post-operation to 1.75 on the other hand GPA was 25.32 pre-operation and increased to 36.6 post operation.

Table (3): Angulations and GPA pre and post operation.

Author	Angulation pre	Angulation post	GPA pre	GPA post
Jaikish et al. [6]	ND	ND	ND	ND
Vidovic et al.[7]	ND	ND	ND	ND
Mannambeth et al.[8]	35.8	3.5	34.6	35.8
Mohd Asihin et al.[6]	ND	ND	ND	ND
Hu et al.[9]	ND	ND	ND	ND
Tatro et al.[1]	ND	ND	ND	ND
Fandridis et al.[10]	11.3	ND	26.6	38.1
Yuan et al.[11]	ND	ND	ND	ND
Porcellini et al.[12]	ND	ND	ND	ND
Ao et al.[13]	ND	ND	ND	ND
Schroder et al.[2]	34.4	ND	ND	ND
Lin et al.[14]	ND	ND	15.08	35.5
Jones et al.[15]	27.8	ND	ND	ND
Cole et al.[16]	12.4	0	25	37
Bartoníček et al.[5]	ND	ND	ND	ND

Table 4 showed that man DASH pre operation was 17.9 which decreased to 9.3 post-operation, mean constant score was 77.6 pre-operation and increased to 89.1 post-operation. As regard ROM mean for forward flexion was 151.4, mean abduction was 123.4, mean external rotation was 60.1 and mean internal rotation was 23.2.

Table (4): Summary of DASH, ROM and constant score.

Author	DASH pre	DASH post	ROM	Constant score pre	Constant score post
Jaikish et al. [6]	ND	ND	Forward flexion (n.140), abduction (n.136), external rotation (n.34)	ND	80
Vidovic et al. [7]	ND	ND	ND	ND	93.4
Mannambeth et al. [8]	11.4	6.5	ND	ND	ND
Mohd Asihin et al. [6]	ND	19.3	Forward flexion (n.157), abduction (n.114), external rotation (n.60),	ND	ND
Hu et al. [9]	9.5	4.2	ND	82.9	95.8
Tatro et al. [1]	ND	8.9	Forward flexion (n.145.9), abduction (n.113.2), external rotation (n.57)	ND	ND
Fandridis et al. [10]	ND	ND	Forward flexion (n.166), abduction (n.120), external rotation (n.81), internal rotation (n.5)	ND	93.8
Yuan et al. [11]	11.1	5	ND	73.5	88.5
Porcellini et al. [12]	ND	10.1	Forward flexion (n.146.6), abduction (n.148.3), external rotation (n.61.6), internal rotation (n.7)	ND	75.8
Ao et al. [13]	ND	5.5	ND	ND	91.8
Schroder et al. [2]	ND	12.1	Forward flexion (n.154), abduction (n.106), external rotation (n.66)	ND	ND
Lin et al. [14]	ND	ND	ND	ND	ND
Jones et al. [15]	ND	ND	Forward flexion (n.152.6), abduction (n.146.2), external rotation (n.50.8), internal rotation (n.57.8)	76.57	ND
Cole et al. [16]	39.2	12.2	Forward flexion (n.149.6), abduction (n.104.6), external rotation (n.61.2)	ND	ND
Bartoníček et al. [5]	ND	ND	ND	ND	94.3

Table 5 showed that some studies mentioned the number of patients that can returns to normal activity was 135; mean time to union was 11.15 weeks. Up to 42 complications were founded in all included studies.

Table (5): Number of patient's returns to normal activity and mean time to union/wks.

Author	Number of patients returned to normal activity	Complications	Time to union\wks
Jaikish et al. [6]	12	0	ND
Vidovic et al. [7]	ND	4	ND
Mannambeth et al. [8]	10	0	ND
Mohd Asihin et al. [6]	8	0	ND
Hu et al. [9]	ND	2	ND
Tatro et al. [1]	34	8	ND
Fandridis et al. [10]	ND	5	ND
Yuan et al. [11]	ND	12	12.3
Porcellini et al. [12]	ND	1	ND
Ao et al. [13]	ND	7	ND
Schroder et al. [2]	36	0	ND
Lin et al. [14]	ND	0	10
Jones et al. [15]	31	1	ND
Cole et al [16]	4	0	ND
Bartoníček et al. [5]	ND	2	ND

Table 6 showed that complications were founded in all included studies in form of Pain in 10 cases, infraspinatus muscle hypotrophy in 4 cases, implant removal in 6 cases, hematoma in 2 cases, Heterotopic ossification in 1 case, Infection in 2 cases, Delayed union in 1 case, shoulder manipulation under anesthesia in 8 cases, screw removal due to possible intra-articular involvement in 1 case, Traumatic arthritis in 1 cases, Vascular nerve injury in 4 cases, scapular refracture in 1 case, removal of exostoses in 1 caseplate-related prominence and total removal in 7 cases, atrophy of the infraspinatus muscle in 1 case, insufficient reduction of the inferior angle in 1 case.

Table (6): Summary of complications type.

Author	Pain	Infraspinatus muscle hypotrophy	Implant removal	Hematoma	Heterotopic ossification	Infection
Jaikish et al. [6]	ND	ND	ND	ND	ND	ND
Vidovic et al. [7]	ND	4	ND	ND	ND	ND
Mannambeth et al. [8]	ND	ND	ND	ND	ND	ND
Mohd Asihin et al. [6]	ND	ND	ND	ND	ND	ND
Hu et al. [9]	2	ND	3	ND	ND	ND
Tatro et al. [1]	ND	ND	3	ND	ND	ND
Fandridis et al. [10]	5	ND	ND	ND	ND	ND
Yuan et al. [11]	2	ND	ND	2	1	1
Porcellini et al. [12]	ND	ND	ND	ND	ND	1
Ao et al. [13]	ND	ND	ND	ND	ND	ND
Schroder et al. [2]	ND	ND	ND	ND	ND	ND
Lin et al. [14]	ND	ND	ND	ND	ND	ND
Jones et al. [15]	1	ND	ND	ND	ND	ND
Cole et al. [16]	ND	ND	ND	ND	ND	ND
Bartoníček et al. [5]	ND	ND	ND	ND	ND	ND

DISCUSSION

Regarding the patients' demographics of the included studies, we found that 338 patients' results in total were reported. The mean adjusted age of these individuals was of 41.7 years (range 34-48.8) and a mean adjusted follow up time of 38.8 months, 253 were male and 85 females.

All of the studies reported that the majority of the injured cases were men. The longest follow-up was reported by **Tatro *et al.*** [1] with mean follow up of 93.6 months followed by **Yuan *et al.*** [11] with a 60.3 month mean follow-up.

The study by **Jaikish *et al.*** [6] was to evaluate the results of displaced extra-articular scapula fractures treated with open reduction and internal fixation. Ten male and 2 female patients with displaced scapular body and neck fractures were enrolled in the study with 42 years old on average and a 33-month follow-up.

Also, **Vidović *et al.*** [7] with patients who had scapular fractures in order to describe a surgical approach and report on patient-based functional results and complications after open reduction and internal fixation. There were 14 patients in the research. The study included 1 female and 13 male, with a mean age of 42 years (range 26–75 years).

Regarding the Mechanism of injury we found that it was mostly traffic accident in 266, fall in 47, sports in 1, bruising in 2, direct hit in 3, others in 4.

Regarding the operative data of the studies, we found that mean duration from injury to operation was 99.4 hours (range 5-336) as reported by 7 studies, and mean operative time was 123.7 minutes as reported by 3 studies.

The longest duration from injury to operation was reported by **Tatro *et al.*** [1] as they reported that it was 336 hours, this study also reported the longest operative time 188 minutes of the extra-articular scapular fractures treated with open reduction and internal fixation (ORIF). The least operative time of 80 minutes was reported by **Ao *et al.*** [13].

Regarding the outcome measures, (Angulation and GPA pre and post operation) our results showed that the mean angulation pre was 24.34 which decreased post operation to 1.75 on the other hand GPA was 25.32 pre operation and increased to 36.6 post operation.

The study by **Mannambeth *et al.*** [8] stated that radiographically, their research revealed that the mean scapular neck angulation might be corrected with a considerable improvement ($P<0.001$), However, post-

operatively, there was no discernible change in the glenopolar angle.

While, the study by **Lin *et al.*** [14] reported that the glenopolar angle significantly improved after surgery.

However, the study by **Cole *et al.*** [16] reported that there was a notable improvement in mean scapular neck angulation correction (P=0.011), and glenopolar angle (P=0.001) post-operatively.

Regarding the DASH, ROM and constant score, our results showed that the mean DASH pre operation was 17.9 which decreased to 9.3 post-operation, mean constant score was 77.6 pre-operation and increased to 89.1 post operation. As regard ROM mean for forward flexion was 151.4, mean abduction was 123.4, mean external rotation was 60.1 and mean internal rotation was 23.2.

The study by **Mannambeth *et al.*** [8] reported that the mean DASH score was 11.4 (range 0-51.6), which improved to 6.5 (range 0-34.2) if one patient with an ipsilateral upper Neurologic damage to a limb was disregarded. A 37-year-old male patient with a low DASH score was the driver in a high-speed car accident that caused him to fracture his leg. He also had several metacarpal fractures, a fracture of the lateral clavicle, and an accompanying ipsilateral segmental fracture of the humerus. Additionally, he suffered brachial plexus damage. The remaining eight patients all went back to their prior jobs after their injuries.

Furthermore, **Hu *et al.*** [9] reported that at three months following surgery, the Y-type locking plate group displayed higher CSF ratings compared to the straight reconstructive locking plate group (82.9±3.5 vs. 79.3±4.4, P=0.01) and lower DASH scores (9.5±2.5 vs. 12.7±3.9, P=0.008). There were no differences at 6 and 12 months.

Regarding the number of patient's returns to normal activity and mean time to union/weeks, some studies mentioned the number of patients that can returns to normal activity was 135; mean time to union was 11.15 weeks.

The study by **Jaikish *et al.*** [6] stated that out of 12 treated instances, 4 patients saw outstanding results, 7 patients saw decent results, and 1 patient saw a fair result. All of the patients returned to their old line of work and were able to carry out their daily tasks without any trouble.

Also, **Mannambeth *et al.*** [8] stated that at the time of the last follow-up, all fractures had healed. In addition **Mohd *et al.*** [17] reported that all patients achieved radiological union at time of assessment.

In addition, **Cole *et al.*** [16] indicated that all 5 patients, who had undergone surgery, had shown high levels of satisfaction with their overall outcome at the most recent follow-up and said they would choose to undergo the procedure again in the same situation. Concerning their injured shoulder, none of the patients reported any pain. Four out of the 5 patients were able to seamlessly go back to their prior jobs and pastimes.

Regarding complications, we found that 42 complications were founded in all included studies in form of pain in 10 cases, infraspinatus muscle hypotrophy in 4 cases, implant removal in 6 cases, hematoma in 2 cases, Heterotopic ossification in 1 case, Infection in 2 cases, Delayed union in 1 case, 8 instances of shoulder manipulation under anesthesia, 1 instance of screw removal due to potential intra-articular involvement arthritis because to trauma in 1 cases, Vascular nerve injury in 4 cases, scapular refracture in 1 case, removal of exostoses in 1 case plate-related prominence and total removal in 7 cases. In one example, the infraspinatus muscle atrophy was present, while in another, the inferior angle's reduction was insufficient.

The study by **Jaikish *et al.*** [6] due to a delayed infection and a restriction in shoulder movement in our series, 1 patient had a fair outcome. The patient who received a fair outcome had diabetes and after 8 weeks experienced a delayed infection. He had treatment with intravenous antibiotics, which also cleared up the infection.

Also, **Mannambeth *et al.*** [8] reported that none of the patients suffered postoperative neurovascular damage, superficial or deep infections, or both. After 4 months, 2 patients underwent elective clavicle hook plate removal; however, no patient needed to have their scapular implant removed.

Yuan *et al.* [11] found that the cohort treated with rings saw 12 complications in 6 patients while the cohort not treated with rings saw 18 clinical issues in 15 patients. In terms of the incidence of refracture, vascular nerve injury, traumatic arthritis, impingement pain, scapular spine fracture, unexplained pain, infection, stiff shoulder secondary to SBF, hematoma, nonunion, and heterotopic ossification at final follow-up, there were no statistically significant differences between the two groups. Aseptic loosening (also known as instability) and mal-union were significantly different between the two groups (P<0.05 for both comparisons).

In addition, **Cole *et al.*** [16] revealed that at the latest follow-up, 1 patient blamed a lower back ailment connected to spine fractures, which also happened at the time of his scapula fracture, for his incapacity to resume his job as a truck driver. He had some residual loss of mobility, stiffness, weakness, and fatigability even though his shoulder function had improved. A second patient, who denied experiencing any symptoms, had radiographic signs of ectopic bone growth around the site of the osteotomy.

CONCLUSION

Internal fixation provides excellent results regarding union and shoulder function with a low complication rate for extra-articular scapular fractures with substantial displacement. One can anticipate a positive functional outcome and a return to the level of physical activity they had before the accident with this mode of treatment.

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