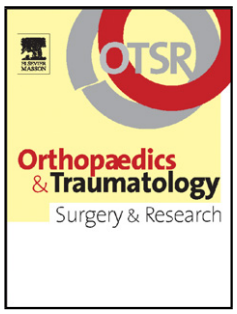

Title: Management of the floating shoulder: Does the glenopolar angle influence outcomes? A systematic review

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Review article

Management of the floating shoulder: Does the glenopolar angle influence outcomes? A systematic review.

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Abstract

Introduction: Currently there is no consensus on the optimal treatment of the "floating shoulder". We aim to perform a systematic review to determine outcomes in the management of this condition.

Materials and Methods: Studies related to the management of the "floating shoulder" were identified by a review of medline using platform Pubmed/Ovid, Scopus and Cochrane library data bases. Studies were included if they : (1) are published in the English language and (2) reported outcomes of at least 2 or more cases of floating shoulder injuries using at least one objective shoulder scoring system.. Exclusion criteria were (1) non-human and biomechanical studies and (2) studies with a clear selection bias. Three treatment groups were identified. Group 1 – non operative, Group 2 – fixation of clavicle only, and Group 3 – fixation of clavicle and scapula neck.

Results: Thirteen studies gave a population of 244 subjects of which 104 had non operative treatment, 98 had internal fixation of the clavicle only and 42 had fixation of both the clavicle and the scapula. There were no differences in the outcome scores among the 3 treatment arms as the patients with undisplaced or minimally displaced fractures had conservative treatment and those with displaced fractures were surgically stabilised. There was a positive correlation between the final glenopolar angle and the Constant score.

Conclusions: The review was unable to show a difference in outcomes among the 3 treatment groups. Any treatment modality that restores the glenopolar angle is likely to result in a good outcome.

Level of Evidence: Therapeutic Level IV

Keywords: Floating shoulder; conservative treatment; operative treatment; glenopolar angle; functional outcome scores

Introduction

The "floating shoulder" is an injury complex comprising a fracture of the clavicle and the surgical neck of the scapula [1]. It makes up to 0.10% of all trauma cases [1]. It was first described in the English literature by Herscovici et al in 1992 [1]. Fixation of the clavicle

was advocated in that study [1]. Associated injuries to the coracoclavicular and coracoacromial ligaments results in inferior and medial displacement of the scapular neck fracture and this had prompted others to advocate fixation of the scapular fracture as well [2,3]. Yet others have shown good outcomes with conservative treatment in a sling with figure of eight bandage and supervised aggressive physiotherapy after a few weeks [4]. Perhaps the latter treatment was reserved for undisplaced or minimally displaced fractures.

When managing the clavicle fracture in this injury either conservative or operative treatment will be acceptable as either treatment has been shown to give satisfactory results in isolated clavicle fractures [5]. However significantly displaced scapular neck fractures have resulted in poor outcomes in isolated scapular neck fractures [6,7]. The glenopolar angle, a surrogate measure of scapular neck fracture displacement was described by Bestard et al [8]. The glenopolar angle (GPA) is the angle subtended by a line joining the superior and inferior poles of the glenoid and the line joining the superior pole of the glenoid to the inferior most point of the scapula. A GPA of 30° to 45° is considered normal. Previous studies have shown a direct correlation between the glenopolar angle and clinical outcomes in isolated fractures of the scapular neck [6,7].

As there are multiple options for treating the floating shoulder in the literature, and apparently everyone of them giving equally good or bad outcomes, it is the purpose of the present study to conduct a systematic review of the literature on the management of this injury and to determine the outcomes with either operative or non-operative treatment. In the operative treatment category we looked at reports describing internal fixation of the clavicle alone as well as those describing surgical stabilisation of the clavicle and scapular neck fractures.

The aim of this review is to evaluate the following questions:

1. Is there a significant difference in the outcome among the three treatment modalities?
2. Is there a relationship between the glenopolar angle of the scapula and the final clinical outcome?

Materials and Methods

The authors searched Medline using platforms Pubmed/Ovid, Scopus and Cochrane data bases. The literature search was limited to studies between 1993 and 2015. The keywords utilised were "floating shoulder", "management", "glenopolar angle" and "clinical outcomes". The search was limited to publications in the English language. Case reports were excluded. To ensure completeness of the search, the bibliographies of the identified articles were scrutinized. The authors studied all the articles and decided on the relevance based on the inclusion and exclusion criteria.

Eligible studies included original articles published in peer reviewed journals in the English language that featured 2 or more cases of floating shoulder injuries managed with either operative or non-operative treatment and elaborated functional outcomes using at least one validated objective shoulder scoring system. The additional inclusion criteria consisted of studies that mentioned the exact values of the outcome scores for each patient or the average for the cohort included rather than mere mention of good or poor results. The studies that included the glenopolar angle in the analysis of clinical outcomes were separated for further scrutiny.

We excluded review articles and non-human and biomechanical studies.

Review procedure and data extraction

The data extracted from each study included (1) first author, (2) year of study, (3) the number of patients in a particular treatment group, (4) the average age of the patients, (5) male: female ratio (6) the mechanism of injury and (7) the clinical outcomes. The study design eg. prospective, retrospective, randomised controlled or others and the quality of the study were also determined. The data on number of patients in a specific treatment modality and their respective outcome scores were pooled and compiled into three groups: non-operative treatment (Group 1); internal fixation of the clavicle alone (Group II) and internal fixation of the clavicle and scapula (Group III). All scapular neck fractures were stabilised with reconstruction plates and screws. The approach was posterior between the infraspinatus and teres minor. The respective outcome scores mentioned for each individual patient were noted from all included studies. In cases where the study had only mentioned an average score for a particular treatment group and no individual scores were available, all such patients were assumed to have that average score. For each available scoring system, the average score was calculated for the total number of patients falling into a particular treatment group and was graded accordingly.

The Constant score [9] was graded as excellent (86-100 points), good (71-85 points), moderate (56-70 points) or poor (0-55 points). The Herscovici score [1] was graded excellent (13-16 points), good (9-12 points), fair (5-8 points) and poor (4 points or less). The Rowe score [10] was graded excellent (90-100 points), good (70-89 points), fair (40-69 points) and poor (39 points or less). The UCLA score [10] was designated as excellent/good if $\geq$ than 27 points and fair/poor if < than 27 points.

For the second aim of the study the overall association between the final glenopolar angle and the clinical outcome was studied by using Pearson's correlation coefficient and linear regression.

Quality assessment (Table 1)

The methodological quality of the individual studies was evaluated by the 2 authors. Disagreements if any were resolved by consensus. To assess the methodological quality we used a standardised set of ten criteria based on modified questions formulated from pre-existing quality assessment tools and previously published systematic reviews [11]. An article received 1 point when a criteria was met. Zero points were given if the criteria was not met or if information concerning that criteria was not mentioned in the article. Articles could obtain a minimum score of 0 and a maximum of 10 points. We considered articles to be of high methodological quality if the total score was 7 points or higher.

Results

Search results (Figure 1)

The literature search of various databases provided 407 results. After adjusting for duplicate studies and after applying eligibility criteria 33 studies remained. After screening the titles and abstracts of these studies, 16 studies could not fulfil the inclusion criteria and hence were excluded.

The full texts of the remaining 17 studies were retrieved and studied in detail. In view of a clear selection bias and possible influence of associated injuries on treatment selection and functional outcome 4 studies were excluded leaving 13 studies for this systematic review.

Quality assessment

As per the abovementioned methodological quality assessment criteria 8 [3,2,4, 12-16] of the 13 studies were considered as high quality studies while the remaining 5 studies were considered as low quality studies.

Overview of included studies (Table 2)

Out of 13 studies, 8 studies were retrospective [3,2,4,17-19,12,16] and 2 studies prospective [14-15]. The nature of the study was unclear in 3 series. 2 studies were randomised control trials [14-15]. Only 3 studies had Institutional Review Board approval.

A total of 244 patients was presented in the 13 studies. The average age was 39.6years. The male/female ratio was approximately 4:1. The majority of the injuries were incurred in road traffic accidents, falls from heights or other high energy trauma. 104 patients had conservative treatment with a sling or figure of eight bandage followed by physiotherapy. 98 individuals had internal fixation of the clavicle. 42 patients had internal fixation of the clavicle and scapular neck fractures.

Outcomes of treatment

Tables 3, 4 and 5 outline the clinical outcomes among the 3 modalities of treatment. Most of the studies utilised the Constant score. The average Constant score for all patients from all studies in the conservative treatment group (Group I) was 77.9 (Good), for the group with internal fixation of the clavicle only (Group II) was 78.4 (Good) and the group (Group III) with fixation of both scapula and clavicle 71 (Good). The average Rowe score for Group I was 85.7 (Good), 88 (Good) for Group II and 86.5 (Good) for Group 3. The average Herscovici score for all studies was 14.1 (Excellent) for Group I and 13.9 (Excellent) for Group II where this score was utilised.

All studies with single treatment arms [3-4,17,20,13,16] had Excellent / Good clinically validated outcome scores.

Van Noort et al [18] had “good” Constant score for patients in Group I and II. Yadav et al [14] showed “excellent” Herscovici score for both these groups. Egol et al [2] had equally

good ASES scores for their Group I and III. Oh et al [21] had 3 treatment aims with Rowe scores falling in the "good" category in all 3. Labler at al [19] also had 3 arms. The outcomes were in the "excellent" Constant score category for Group I, "moderate" in Group II and "excellent" in Group III. Kim et al [12] had a "moderate" Constant score for Group I, "good" for Group II and "poor" for Group III the latter group only having 1 patient. Lin et al [15] had "moderate" Constant scores for Group I and II and "good" for Group III.

GPA and outcome score (Figure 2)

Two studies [13,12] allowed an analysis of a correlation or otherwise between the GPA of the scapula and a validated clinical outcome score- Constant Score.

There was a significant correlation between GPA and the Constant score ($p<0.001$, $r=0.700$) [12-13]. Linear regression including main effect of GPA and interaction between GPA and study showed that there was no significant interaction ($p<0.357$). It means that the 2 regression lines generated by 2 different studies did not differ significantly. The overall regression line will be: mean (Constant score) = 35.02 + 1.27* GPA. That means for every 1 unit increase in GPA towards normal the mean Constant score will increase by 1.27 units (95% CI: 0.786 – 1.754).

Discussion

This systematic review will clarify some confusion that prevails on the optimal treatment for the floating shoulder which although rare places shoulder function and ultimately the function of the entire upper limb at risk if inadequately managed. Fortunately 8 of the 13 studies included were of high quality. However only 2 were randomised controlled trials comparing 2 and 3 modalities of treatment respectively. By pooling the data from the various series we hope to arrive at some guide on management of this complex injury. The studies only looked

at fractures of the clavicle with in addition a fracture of the scapular neck. No studies have looked at associated soft tissue injuries sustained by the shoulder girdle in addition to the fractures in this injury complex. Injuries to the coraco clavicular and coracoacromial ligaments have been assessed indirectly in this review, by the displacement of the scapula neck fracture using the GPA which we also correlated with clinical outcome scores. Injuries to the rotator cuff and shoulder girdle musculature in addition to injuries to the branches of the brachial plexus [2] have been indirectly assessed by the outcome scores.

This review confirms that the floating shoulder results from a high energy trauma. Males in the fourth and fifth decades of life are the usual victims. The most frequent modality of treatment is conservative with a sling or figure of eight bandage. Fixation of the clavicle fracture is the most frequent surgical procedure. This systematic review found no significant differences in the functional outcomes among the 3 modalities of treatment. Analysis of 2 series [13,12] where the GPA was analysed in detail revealed a correlation between the final GPA and clinical outcome.

Non operative treatment

Conservative management has the merits of its non-invasive nature, reducing morbidity and avoiding the risks of neurovascular and soft tissue injury. A non-operative approach however may lead to non-union [2] or malunion and associated rotator cuff dysfunction that may lead to abduction weakness. The only series with a purely non operative approach [4] had good to excellent results. However the majority of the fractures in that series were minimally displaced or undisplaced. Van Noort et al [18] also obtained a good Constant score for their conservatively treated patients, the majority of whom, 22 out of 28 had minimal displacement of the glenoid neck fracture. Labler et al [19] also reported good to excellent results with

conservative treatment of patients with minimal or no displacement. Paihes et al [22] whose series was not included in our review also treated minimally displaced fractures conservatively and had good Simple Shoulder Test scores, Oxford Shoulder Scores and DASH scores. Minimally displaced or undisplaced fractures may thus be amenable to a non-operative approach.

Operative treatment

Surgical treatment of the floating shoulder restores immediate stability thereby fascilitating early mobilisation and an improved outcome [1,17]. Reduction and fixation of the clavicle also reduces the risks of non-union, decompresses the brachial plexus and restores the length tension relationship of the thoraco humeral and thoraco scapular musculature [1]. If the coracoclavicular ligaments are intact, indirect reduction of the scapular neck fracture may also be achieved [20] with overall improved clinical outcomes. Rickli et al [17] had excellent Constant scores with fixation of the clavicle only as did Hashiguchi et al [20] with good to excellent UCLA scores. They both believed in indirect reduction of the scapular neck with stabilisation of the clavicle. Similarly Gilde et al [16] reported excellent Herscovici scores with fixation of the clavicle alone in 13 patients where the scapular neck fracture did not have significant displacement. A similar observation was made by Izadpanah et al [13] where "Good" Constant scores were reported with clavicle stabilisation with minimally displaced scapular neck fractures. Yadav et al [14] also achieved good outcomes with stabilisation of the clavicle as it improved the GPA to near normal. Van Noort et al [18] reported poor outcomes with stabilisation of the clavicle alone if caudal displacement of the scapular neck fracture was present. Lin et al [15] also found good results with stabilisation of the clavicle as it restored the glenoid fracture and the GPA. Thus stabilisation of the clavicle alone would suffice if the scapular neck fracture is undisplaced or reduced if displaced.

Stabilisation of both the fractures also provides immediate stability for early mobilisation. However it increases surgical time, increased blood loss, increased soft tissue trauma and postoperative pain from double incisions. Egol et al [2] reported external rotation weakness that was attributed to teres minor takedown in 6 of his 7 patients and to the axillary nerve injury that occurred in 2 patients. Leung and Lam [3] had good and excellent Rowes scores with stabilisation of both bones in 14 of their 15 patients. Lin et al [15] had good DASH and Constant scores in their stabilisation of both fractures and they attributed this to a better restoration of the GPA. Labler et al [19] also made a similar observation when severely displaced fractures were stabilised. We conclude that stabilisation of both bones may be indicated for significant displacement.

This systematic review found that fractures of the clavicle and scapula that were undisplaced or minimally displaced were treated in the majority of cases conservatively. Operative stabilisation was undertaken for significant displacement of either or both of the 2 bones. If fracture stabilisation of the clavicle restores the anatomy of the scapula neck, the latter was treated non operatively. Otherwise surgery was carried out for the latter injury. This may account for the similarity in outcome scores amongst the 3 treatment arms.

The importance of restoring the scapular neck fracture is confirmed in the second part of the review. Figure 2 revealed a significantly positive correlation ($P < 0.001$) between the glenopolar angle and the Constant score. Izadpanah et al [13] found an excellent correlation between the final GPA angle and the Constant score. All their cases had stabilisation of the clavicle with minimal displacement of the scapular neck fracture. Kim et al [12] found that the Constant score of the shoulders with a GPA above 30 was better than that in the patients with a GPA below 30 degrees ($P<0.05$).

Van Noort et al [18] reported on 28 conservatively treated patients and 7 with stabilisation the clavicle and acromio clavicular joint. 6 of their conservatively treated patients had a caudal dislocation of the glenoid. The Constant score was 42 as opposed to 85 in the remaining 22 patients with no caudal dislocation. Similarly 5 of the 7 operatively treated patient demonstrated caudal dislocation of the glenoid and had a mean Constant score of 62 as opposed to a score of 85 in the 2 with no caudal dislocation. Lin et al [15] also showed a progressive increase in the Constant score with increase in the final glenopolar angle towards normal values with the conservative group (GPA 25.2, Constant score 62.3); fixation of clavicle group (GPA 28.2; Constant score 65.5) and fixation of clavicle and scapular group (GPA: 35.5; Constant score: 76.6). Thus restoration of the GPA appears from the systematic review to be important in the final outcomes in floating shoulder injuries. A previous study on isolated fractures of the scapula has also shown the importance of restoring the GPA for optimum shoulder function [6]. Surgery may therefore be important if the GPA is outside the normal range in a floating shoulder.

Study limitations

The strengths of this systematic review include the complete inclusion of all studies on the subject. This is the only systematic review on the subject in the literature. The weaknesses include the non-uniform pattern of the studies and the inclusion of non-randomised and retrospective studies. Also only publications in English were included for this review.

Conclusion

The floating shoulder results from a major traumatic incident. The systematic review indicates no clear superiority of any one treatment modality as treatment was tailored to whether the fractures were undisplaced (non-operative) or displaced (operative). The stabilisation of the clavicle seems to be the most frequently conducted surgical procedure. The importance of restoring normal anatomy of the scapular neck fracture becomes clear as treatment seem to be directed according to whether the scapular neck fracture is displaced or otherwise. It is clear that the final GPA plays a major role in the final clinical outcome.

Disclosure of Interest

The authors declare that they have no competing interest.

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Table 1. Criteria used for methodological quality assessment

	Criteria	**Response**

1	Objective is clearly documented	The aims and objectives of the study should be stated in the "introduction" part and should be relevant with the existing literature.
2	Inclusion of consecutive patients with mention of the study period	The authors mention: "consecutive patients" or "all patients during period from … to …" or "all patients fulfilling the inclusion criteria".
3	Inclusion and exclusion criteria	Should be clearly stated.
4	Inclusion of patients	The number of eligible patients or the patients that agreed to participate (i.e. gave consent) should be reported
5	Prospective collection of data. Data were collected according to a protocol defined prior to the start of the study	Study type must be mentioned in terms of: "prospective", "retrospective", "randomized" or "follow-up" study
6	Outcome measures	The association between the treatment modality (operative or non-operative) for floating shoulder and functional outcome with or without radiological outcome should be mentioned. At least one objective scoring system (Constant score, Herscovici score, Rowe score, UCLA score, DASH score etc.) with or without radiological assessment should be used.
7	Unbiased allocation of treatment method	There should not be a selection bias while allocating a specific treatment for the specific set of patients; the associated injuries must not have affected the outcome or else the treatments should have been randomly allocated to avoid bias.
8	Accurate determinant measures (valid and reliable)?	For studies where the outcome measures are shown to be valid and reliable and exact value of the outcome scores is mentioned, the question should be answered adequate.
9	Loss to follow-up	The amount of patients lost to follow up was reported and less than 20%
10	Adequate statistical analyses	To be judged adequate if the relationship between given treatment modality and functional outcome is reported.

Table 2: Patient Demographics

		No	Age (Years)	M/F	Mechanism	Group I	Group II	Group III	Follow-up (months)
1	Leung & Lam (1993) [3]	15	31	15/0	RTA / Fall			15	25
2	Rikli et al (1995) [17]	12	38	10/2	RTA / Hang gliding		12		72
3	Edwards et al (2000) [4]	20	40		RTA / Gunshot	20			28
4	Van Noort et al (2001) [18]	35	43	30/5	RTA	28	7		35/35
5	Egol et al (2001) [2]	19	36.5	14/5	RTA	12		7	53/36
6	Oh et al (2002) [21]	13	42	10/2	RTA / Fall	3	5	5	12/12/12
7	Hashiguchi et al (2003) [20]	5	38.6	5/0	RTA / Fall		5		57.4
8	Labler et al (2004) [19]	17	36	16/1	RTA / Fall	8	7	2	92.7/69.4/47
9	Kim KC et al (2008) [12]	16	53	10/6	High energy trauma	7	8	1	32/32/32
10	Izadpanah et al (2012) [13]	16	35.2	13/3	High energy trauma		16		35.7
11	Yadav et al (2013) [14]	25	35	20/5	RTA / Fall	13	12		24/24
12	Lin TL et al (2015) [15]	39	42.3	23/16	RTA / Fall	13	13	13	24/24/24
13	Gilde et al (2015) [16]	13	46	10/3	RTA		13		16

Table 3: Group I – Outcome scores with conservative treatment

	Patient Numbers	Herscovici Score (average)	Constant Score (average)	Rowe Score (average)	ASES Score (average)
Edwards et al [4]	20	15.3	96.4	94.5	
Yadav et al [14]	13	13			
Lin TL et al [15]	13		62.3		

Van Noort et al [18]	28		76		
Labler et al [19]	8		90		
Kim KC et al [12]	7		64.7		
Oh et al [21]	3			77	
Egol et al [2]	12				80.2
Average		14.1	77.9	85.7	80.2

Table 4: Group II – Outcome scores with fixation of clavicle alone

	Patient Numbers	**Herscovici Score (average)**	**Constant Score (average)**	**UCLA Score (average)**	**Rowe Score (average)**
Rikli et al [17]	12		96		
Hashiguchi et al [20]	5			34	
Yadav et al [14]	12	15			
Lin TL et al [15]	13		65.5		
Kim K C et al [12]	8		77.4		
Van Noort et al [18]	7		71		
Oh et al [21]	5				88
Labler et al [19]	7		66		
Gilde et al [16]	13	12.9			
Izadpanah et al [13]	16		85.3		
Average		13.9	78.4	34	88

Table 5: Group III – Outcome scores with fixation of clavicle and scapular

	Patient Numbers	Constant Score	Rowe Score	ASES
Lin TL et al [15]	13	76.6		
Leung & Lam [3]	15		84	
Labler et al [19]	2	93		
Egol et al [2]	7			88.7
Kim K C et al [12]	1	43.4		
Oh et al [21]	5		89	
Average		71	86.5	88.7

Figure 1

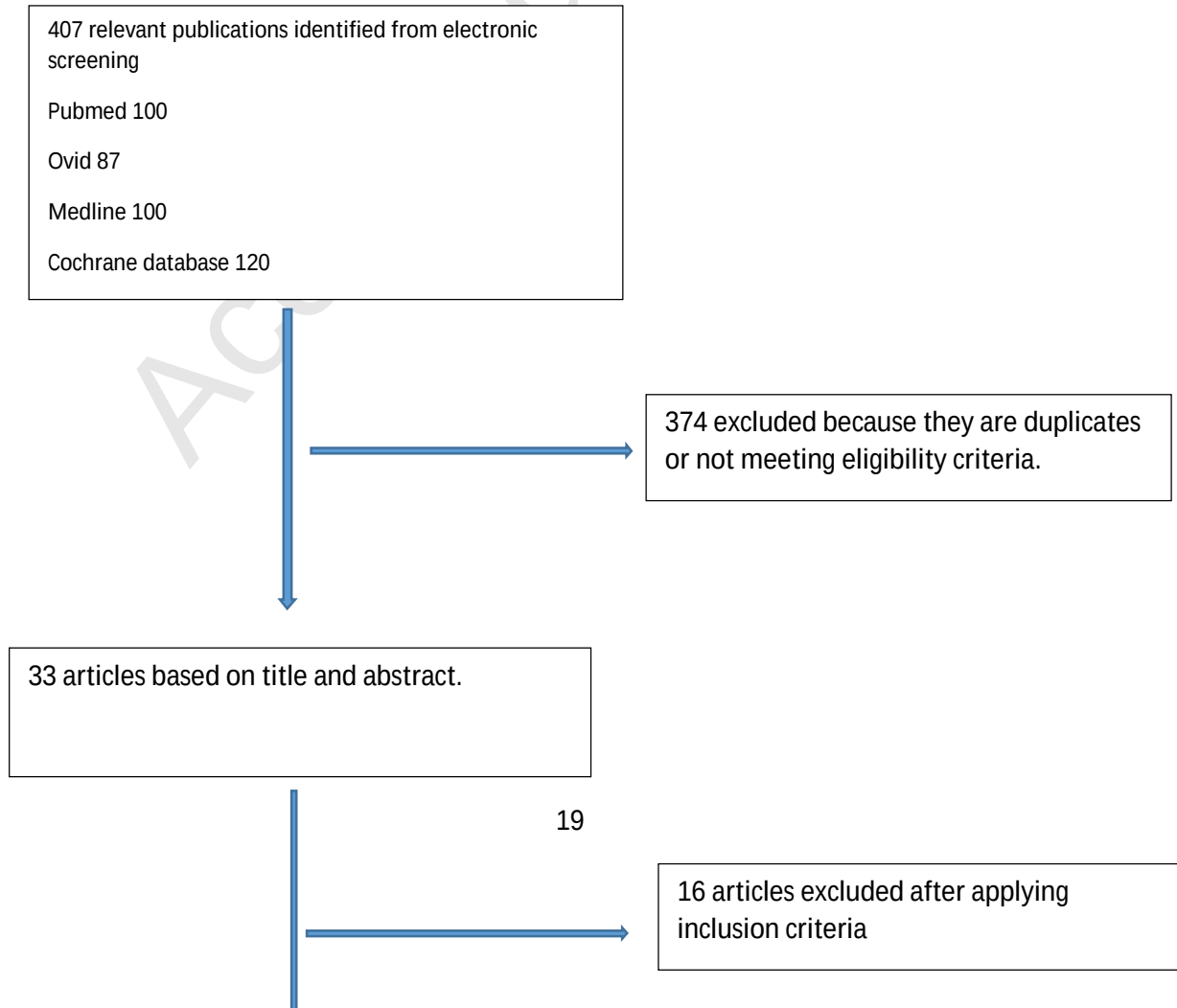

Figure 2 : The relationship between the Glenopolar angle (GPA) and the Constant score