



Current trends in the treatment of supracondylar fractures of the humerus in children: Results of a survey of the members of European Paediatric Orthopaedic Society

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Abstract

Purpose: The purpose of this study was to evaluate the current trends in the treatment of supracondylar humerus fractures as well as the preferred post-operative follow-up protocol among members of the European Paediatric Orthopaedic Society.

Methods: The survey was composed by four main domains and 26 items: (1) surgeon information (3 items); (2) treatment (8 items); (3) post-operative treatment (3 items); and (4) factors influencing the outcome (12 items). All active members of European Paediatric Orthopaedic Society were invited by email to answer an electronic questionnaire.

Results: The survey was submitted to 397 European Paediatric Orthopaedic Society active members; 184 members answered (46.3%) the questionnaire. Among respondents, 64.1% declared >10 years of experience and 55.4% declared to treat >20 supracondylar humerus fractures per year. Closed reduction, percutaneous pinning, and supine position were the preferred treatment option for Gartland type II and III supracondylar humerus fractures by 79.9%, 95.5%, and 84.8% of respondents, respectively. Supracondylar humerus fractures are treated within 24 h from trauma by 33.2% of respondents. Pins are removed 4 weeks from index procedure by 58.2% of respondents. Fracture type (72.3%), surgeon experience, and (71.2%) are of “crucial importance” for expected outcome of supracondylar humerus fractures treatment.

Conclusion: Surgeon experience, type of fracture, treatment modality, and pins configuration were considered the main factors potentially influencing the outcome of supracondylar humerus fractures. European Paediatric Orthopaedic Society members agreed on the treatment modality of Gartland type II and III supracondylar humerus fractures, patient positioning, and timing of hardware removal. Other important issues such as timing of surgery, pins configuration, surgical approach, and post-operative protocol are still debated.

Level of evidence: level II.

Keywords: Supracondylar fracture, humerus, children, treatment, European Paediatric Orthopaedic Society survey

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Introduction

Supracondylar humerus fractures (SHFs) are the most prevalent injuries affecting the child's elbow, and represent the most common indication for surgery in children.¹ In particular, SHFs account for one-third of all fractures diagnosed in children younger than 8 years of age, and for up to one-fourth of all pediatric orthopedic surgical procedures.²

Despite the frequency of SHFs in children, today there are no consensual guidelines, and often the choice of the type of treatment and fixation, the positioning of the patient, the timing of surgery and hardware removal, the length of post-operative immobilization, as well as clinical and radiographic follow-up, and the need of post-operative physiotherapy (PT) are reported to the individual surgeon.^{3–7} In addition, the treatment of SHFs can be challenging even in the hands of experienced surgeons, and the rate of complications related to this type of injury is not negligible.²

The modified Gartland's classification is nowadays considered a useful guide for treatment of SHFs in children even though controversy still exists about the optimal approach for subtype IIA and IIB of SHFs.^{8–10} The difference between type IIA and IIB SHFs is related to the amount of rotation and translation of the distal fragment. In particular, type IIA SHFs are characterized by a displacement of 2–15 mm on the lateral or the anterior–posterior (AP) view and a 15°–20° retro-tilt on the lateral view with a partially intact posterior cortex, while type IIB SHFs, in addition to displacement and retro-tilt, also have a rotatory malalignment.^{11,12} Most type II SHFs fractures have been traditionally managed surgically. However, some authors agree that conservative treatment may be a valuable option in type IIA SHFs.^{11,12} The purpose of this study was to evaluate the current trends in the treatment of SHFs as well as the preferred post-operative follow-up protocol among members of the European Paediatric Orthopaedic Society (EPOS).

Material and methods

A web-based survey was designed by three EPOS members (V.P., G.T., and A.V.) and was distributed to all EPOS active members in October 2020, following EPOS Research & Scientific Committee and EPOS Board approval (see Appendix 1).

An email with a link to the survey, hosted by <https://forms.office.com>, was sent to 397 EPOS active members; moreover, at least one reminder email was sent to members not having responded to the questionnaire after the initial submission. The survey was composed by four main domains, for a total of 26 items: (1) surgeon information (3 items); (2) treatment (8 items); (3) post-operative treatment (3 items); and (4) factors influencing the outcome (12 items). In order to evaluate surgeons' experience, the respondents were asked to specify the number of years in

practice, number of SHFs treated per year, and the country of practice.

Concerning the treatment of SHFs, respondents were requested to specify their preferred treatment option for a given SHF, timing of surgery, patient positioning, and preferred surgical approach. The follow-up preferences were recorded in the post-operative treatment domain.

In the final section of the questionnaire (factors influencing the outcome), the respondents were asked to score each item from *zero* (least important) to *three* (most important): with *zero* figure corresponding to “not important at all,” *one* to “low importance,” *two* to “average importance,” and *three* to “crucial importance.” The questionnaire used for the survey is presented in Appendix 1 (see Appendix 1).

Statistical analysis

Responses were collected and entered into an Excel spreadsheet (Microsoft, Redmond, WA, USA). Statistical analysis was performed using the statistics package SPSS 27.0 (SPSS, Chicago, IL, USA). Data are expressed as numerical variables, frequencies and percentages, with the mean values and standard deviations. The threshold for statistical significance was set to a p-value less than 0.05.

Results

The survey was successfully submitted to 397 EPOS active members; 383 out of 397 EPOS members read the email (receivers; 96.5%), 214 clicked the link (readers; 53.9%), and 184 answered the questionnaire (respondents; 46.3%).

Demographics

According to the number of years in practice (YiP), respondents divided into three groups: Group 1: less than 5 years of practice (n=35; 19.0%), Group 2: between 6 and 10 years of practice (n=31; 16.8%), and Group 3: more than 10 years of practice (n=118; 64.1%).

According to the number of SHFs treated per year (SHFpY), the responders were divided into four groups: Group A: less than 10 SHFs/year (n=34; 19%), Group B: between 11 and 20 SHFs/year (n: 48; 26.1%), Group C: between 21 and 30 SHFs/year (n: 51; 27.7%), and Group D: 31 or more SHFs/year (n: 51; 27.7%). Overall, 79.3% (n=146) of the respondents practice Pediatric Orthopedic Surgery in Europe, Israel, and Turkey, 7.1% in Asia (n=13), 4.9% in Africa (n=9), 8.2% in North and South America (n=15), and 0.5% in Oceania (n=1).

Treatment options

Concerning the treatment modality of Gartland II SHFs, 79.9% of the respondents (n=147) preferred “closed reduction and percutaneous pinning” while the 15.2%

Table 1. Gartland's type II and III treatment preferences.

According to Gartland's classification, which of the following treatments do you usually perform for type II?			
Close reduction and casting	Close reduction and percutaneous pinning	Open reduction and percutaneous pinning	Other procedures
28 (15.2)	147 (79.9)	1 (0.5)	8 (4.3)
<i>Answers according years of practice (p=0.97)</i>			
0–5 years (8); 6–10 years (4); >10 years (16)	0–5 years (26); 6–10 years (27); >10 years (94)	0–5 years (1); 6–10 years (0); >10 years (0)	0–5 years (0); 6–10 years (0); >10 years (8)
<i>Answers according SHFs per year (p=0.86)</i>			
0–10 (5); 11–20 (8); 21–30 (8); >30 (7)	0–10 (28); 11–20 (36); 21–30 (42); >30 (41)	0–10 (0); 11–20 (1); 21–30 (0); >30 (1)	0–10 (1); 11–20 (3); 21–30 (1); >30 (3)
According to Gartland's classification, which of the following treatments do you usually perform for type III?			
Close reduction and casting	Close reduction and percutaneous pinning	Open reduction and percutaneous pinning	Other procedures
<i>Answers according years of practice (p=0.33)</i>			
0 (0.0)	175 (95.1)	7 (3.8)	2 (1.1)
0–5 years (0); 6–10 years (0); >10 years (0)	0–5 years (32); 6–10 years (31); >10 years (112)	0–5 years (3); 6–10 years (0); >10 years (4)	0–5 years (0); 6–10 years (0); >10 years (2)
<i>Answers according SHFs per year (p=0.52)</i>			
0–10 (0); 11–20 (0); 21–30 (0); >30 (0)	0–10 (33); 11–20 (44); 21–30 (60); >30 (48)	0–10 (1); 11–20 (3); 21–30 (0); >30 (3)	0–10 (0); 11–20 (1); 21–30 (1); >30 (0)

SHFs: supracondylar humerus fractures.

answered “closed reduction and casting” (n=28) (YiP: p=0.97; SHFpY: p=0.86) (Table 1).

Concerning the treatment modality of Gartland III SHFs, 95.5% (n=175) of the respondents selected “closed reduction and percutaneous pinning” as preferred treatment option (YiP: p=0.33; SHFpY: p=0.52) (Table 1); 33.2% (n=61), 26.1% (n=48), and 20.1% (n=37) designated of “within 24h,” “within 12h,” and “within 6h” as the best timing for the surgical management of neurovascularly intact SHFs (YiP: p=0.82; SHFpY: p=0.31) (Table 2). The 59.2% of respondents (n=109) perform surgery before midnight while they postpone it to the following morning if SHFs are admitted after midnight; however, 20.7% of respondents (n=38) do surgery at any time of the night shift while 20.1% of participants (n=37) delay surgical treatment of SHFs to the following morning (YiP: p=0.64; SHFpY: p=0.98). When surgery is postponed, 71.1% of respondents splint the patient, while 26.6% attempt to realign the fracture before splinting (YiP: p=0.06; SHFpY: p=0.86).

If surgical treatment is required, patients are placed in supine position by 84.4% of respondents (n=156) while prone positioning of the patient is preferred by 6% of respondents (n=11) (YiP: p=0.3; SHFpY: p=0.15); 9.2% of respondents use both positions indifferently (n=17). If open reduction is needed, 40.8% (n=75), 25.5% (n=47), and 14.7% (n=27) perform a lateral, anterior, and posterior approach, respectively (YiP: p=0.61; SHFpY: p=0.001) (Table 3).

Displaced SHFs requiring surgery are stabilized by two crossed pins in 33.7% of cases (n=62), by two divergent lateral pins in 23.9% of cases (n=44), by three lateral pins in 11.4% of cases (n=21), and by one medial pin and two

lateral pins in 15.8% of cases (n=29) (YiP: p=0.6; SHFpY: p=0.4) (Table 1).

Post-operative protocol and follow-up

The survey recorded a maximum of four post-operative AP and lateral elbow radiographs during follow-up period (range=1–4); in particular, 64.13% (n=118) of the respondent perform AP and lateral elbow radiographs once, 29.9% (n=55) twice, 5.4% (n=10) three times, and 0.5% (n=1) four times during follow-up (YiP: p>0.05; SHFpY: p>0.05) (Figure 1). The first set of radiographs is performed at 1 week post-operative in 46.2% (n=85) of cases, while the second radiographic check is performed at 2 and 3 weeks post-operative by 15.2% (n=28) and 14.1% (n=26) of respondents, respectively. Two percent (n=4) perform a third radiographic evaluation at 6 weeks post-surgery.

Pins are removed 4 weeks after the index procedure in 58.2% of cases (n=107) while the 40.2% (n=14) of respondent remove the hardware 3 weeks after the surgery (Table 4) (YiP: p=0.81; SHFpY: p=0.4). Following pins removal, all respondents require a radiographic assessment of the elbow; 9.8% (n=18) and 6% (n=11) of the respondents perform a second and third radiographic check during follow-up, respectively (YiP: p>0.05; SHFpY: p>0.05) (Figure 2).

Factors influencing the outcome

Among respondents, 72.3% (n=133) (YiP: p=0.41; SHFpY: p=0.79) rated fracture type as of “crucial importance” for

Table 2. Surgical timing preferences.

When do you usually surgically treat the SHF?				
Within 6 h	Within 8 h	Within 12 h	Within 24 h	More than 24 h
37 (20.1)	31 (16.8)	48 (26.1)	61 (33.2)	7 (3.8)
<i>Answers according years of practice (p=0.82)</i>				
0–5 years (9); 6–10 years (5); >10 years (23)	0–5 years (5); 6–10 years (5); >10 years (21)	0–5 years (7); 6–10 years (8); >10 years (33)	0–5 years (14); 6–10 years (11); >10 years (36)	0–5 years (0); 6–10 years (2); >10 years (5)
<i>Answers according SHFs per year (p=0.31)</i>				
0–10 (8); 11–20 (13); 21–30 (8); >30 (8)	0–10 (8); 11–20 (7); 21–30 (10); >30 (6)	0–10 (6); 11–20 (13); 21–30 (11); >30 (18)	0–10 (11); 11–20 (13); 21–30 (22); >30 (15)	0–10 (1); 11–20 (2); 21–30 (0); >30 (4)
During nocturnal hours, you prefer:				
Always surgically treat the fracture		Before midnight, surgically treat the fracture; after midnight, delay the surgery to the following morning		Always delay the surgery to the following morning
38 (20.7)		109 (59.2)		37 (20.1)
<i>Answers according years of practice (p=0.64)</i>				
0–5 years (6); 6–10 years (8); >10 years (24)		0–5 years (24); 6–10 years (18); >10 years (67)		0–5 years (5); 6–10 years (5); >10 years (27)
<i>Answers according SHFs per year (p=0.98)</i>				
0–10 (6); 11–20 (12); 21–30 (9); >30 (11)		0–10 (21); 11–20 (27); 21–30 (32); >30 (29)		0–10 (7); 11–20 (9); 21–30 (10); >30 (11)
<i>p=0.98</i>				
In delayed cases, you usually:				
Splint the fracture	Reduce and splint the fracture	Use skin traction	Use trans-skeletal traction	
132 (71.7)	49 (26.6)	2 (1.1)	1 (0.5)	
<i>Answers according years of practice (p=0.06)</i>				
0–5 years (29); 6–10 years (17); >10 years (86)	0–5 years (6); 6–10 years (13); >10 years (30)	0–5 years (0); 6–10 years (0); >10 years (2)	0–5 years (0); 6–10 years (1); >10 years (0)	
<i>Answers according SHFs per year (p=0.86)</i>				
0–10 (24); 11–20 (35); 21–30 (38); >30 (35)	0–10 (10); 11–20 (13); 21–30 (12); >30 (14)	0–10 (0); 11–20 (0); 21–30 (1); >30 (1)	0–10 (0); 11–20 (0); 21–30 (0); >30 (1)	

SHFs: supracondylar humerus fractures.

expected outcome of SHFs treatment, followed by surgeon experience (71.2%; n=131) (YiP: p=0.33; SHFpY: p=0.23), type of treatment (58.7%; n=198) (YiP: p=0.74; SHFpY: p=0.79), pin configuration (40.8%; n=75) (YiP: p=0.52; SHFpY: p=0.05), patients’ age (25.5%, n=47) (YiP: p=0.13; SHFpY: p=0.02), surgical approach (20.1%; n=37) (YiP: p=0.73; SHFpY: p=0.68), number of pins (YiP: p=0.79; SHFpY: p=0.73) and timing of surgery (YiP: p=0.4; SHFpY: p=0.22) (18.5%; n=34), radiographic follow-up (15.8%; n=29) (YiP: p=0.5; SHFpY: p=0.3), patients’ weight (7.6%; n=14) (YiP: p=0.35; SHFpY: p=0.43), socio-economic status of the patient (7.1%; n=13) (YiP: p=0.35; SHFpY: p=0.26), and post-operative physical therapy (6.5%; n=12) (YiP: p=0.11; SHFpY: p=0.002) (Tables 5 and 6).

Discussion

The 2020 EPOS SHFs questionnaire received the highest response rate (46.3%) among EPOS surveys; in fact, most

of the previous questionnaires received a variable response rate, between 23% and 43%.^{13–17} Concerning the previously published SHFs surveys from other scientific societies, they reported limited evidence, focused on specific fracture patterns only, did not detail the post-operative protocol, and in some cases were limited to a restricted cohort of a nation cohort.^{2,7,18,19} The 2020 EPOS SHFs survey provided data on the management and follow-up of SHFs from more than 20 countries. Surgeon experience, type of fracture, and pins configuration were the main factors influencing the outcome of SHFs in children.

Gartland’s type II SHFs represent a relatively broad spectrum of lesions ranging from mildly extended fractures to fractures with coronal and/or rotatory malalignment, and controversy regarding their management exists. Most type II SHFs are treated surgically by the large majority of respondents although 15% agree that closed reduction and casting is a valuable option in this sub-group of patients.^{20,21} Moraleda et al.²² reported type II SHFs

Table 3. Patient position, pinning configuration, and surgical approach preferences.

Which patient position do you prefer?					
Supine	Prone			I use both indifferently	
156 (84.8)	11 (6.0)			17 (9.2)	
<i>Answers according years of practice (p=0.30)</i>					
0–5 years (28); 6–10 years (30); >10 years (98)		0–5 years (3); 6–10 years (1); >10 years (7)		0–5 years (4); 6–10 years (0); >10 years (13)	
<i>Answers according SHFs per year (p=0.15)</i>					
0–10 (26); 11–20 (38); 21–30 (49); >30 (43)		0–10 (2); 11–20 (4); 21–30 (1); >30 (4)		0–10 (6); 11–20 (6); 21–30 (1); >30 (4)	
Which percutaneous pinning configuration do you prefer?					
Cross pin configuration	Two parallel lateral pins	Two divergent lateral pins	Three lateral pins	One medial pin and two lateral pins	Others
62 (33.7)	27 (14.7)	44 (23.9)	21 (11.4)	29 (15.8)	1 (0.5)
<i>Answers according years of practice (p=0.60)</i>					
0–5 years (11); 6–10 years (11); >10 years (40)	0–5 years (8); 6–10 years (3); >10 years (16)	0–5 years (8); 6–10 years (8); >10 years (28)	0–5 years (3); 6–10 years (1); >10 years (17)	0–5 years (5); 6–10 years (8); >10 years (16)	0–5 years (0); 6–10 years (0); >10 years (1)
<i>Answers according SHFs per year (p=0.40)</i>					
0–10 (14); 11–20 (19); 21–30 (11); >30 (18)	0–10 (2); 11–20 (9); 21–30 (6); >30 (10)	0–10 (10); 11–20 (8); 21–30 (16); >30 (10)	0–10 (2); 11–20 (6); 21–30 (6); >30 (7)	0–10 (6); 11–20 (6); 21–30 (11); >30 (6)	0–10 (0); 11–20 (0); 21–30 (1); >30 (0)
Which surgical approach do you prefer?					
Medial approach	Lateral approach		Medial and lateral combined approach	Posterior approach	Anterior approach
27 (14.7)	75 (40.8)		20 (10.9)	15 (8.2)	47 (25.5)
<i>Answers according years of practice (p=0.61)</i>					
0–5 years (4); 6–10 years (4); >10 years (19)	0–5 years (20); 6–10 years (13); >10 years (42)		0–5 years (4); 6–10 years (3); >10 years (13)	0–5 years (1); 6–10 years (3); >10 years (11)	0–5 years (6); 6–10 years (8); >10 years (33)
<i>Answers according SHFs per year (p=0.001)</i>					
0–10 (1); 11–20 (5); 21–30 (8); >30 (13)	0–10 (13); 11–20 (24); 21–30 (15); >30 (23)		0–10 (9); 11–20 (4); 21–30 (6); >30 (1)	0–10 (6); 11–20 (4); 21–30 (2); >30 (3)	0–10 (5); 11–20 (11); 21–30 (20); >30 (11)

SHFs: supracondylar humerus fractures.

treated conservatively tend to develop mild cubitus varus and mild increase in elbow extension. O'Hara et al.²³ recommended conservative treatment in type IIA and Kirschner wire fixation in type IIB fractures. Similarly, Ariyawatkul et al.²⁴ suggest surgical treatment for type IIB fractures and found that if the lateral capitellar-humeral angle difference or the shaft condylar angle difference from the uninjured side is less than 18°, type IIA fractures are stable enough to be treated by cast immobilization. In contrast, Pham et al.²⁵ reported excellent results in type IIB SHFs treated with Blount's technique.

Gartland's type III SHFs are managed by closed reduction and percutaneous pinning in most cases. Present evidence suggests that delaying surgery by up to 3 days from injury in closed supracondylar humeral fractures without neurovascular injury is safe and does not significantly increase the risk of peri- and post-operative complications, or the need for open reduction.²⁶ However, clear guidelines regarding timing of surgery are not available due to the lack of high-quality trials.

Despite the fact that timing of surgery was considered to be of "average" or "crucial importance" by almost two-third of the respondents, our data are not conclusive, and the only clear information concerns the preference of treating SHFs within 24 h from injury. About 60% of respondents postpone surgery to the next day if patients are admitted after midnight; this percentage rises to 80% if surgeons postponing to the next days all fractures admitted during the night shift are added. This approach is supported by the literature; in fact, pinning errors have been found to be more frequent in surgeries performed at night,²⁷ probably due to inadequate facilities or staff.²⁷ When surgery is postponed, the use of skin or trans-skeletal traction is avoided by 98.3% of the EPOS members, who prefer to splint the fracture with (26.6%) or without (71.7%) a preliminary closed reduction.

Another highly debated issue is the positioning of the patient. Presently, the evidence supporting prone versus supine positioning is scarce, and of limited evidence.^{28,29} The choice of position is based on surgeon experience, and

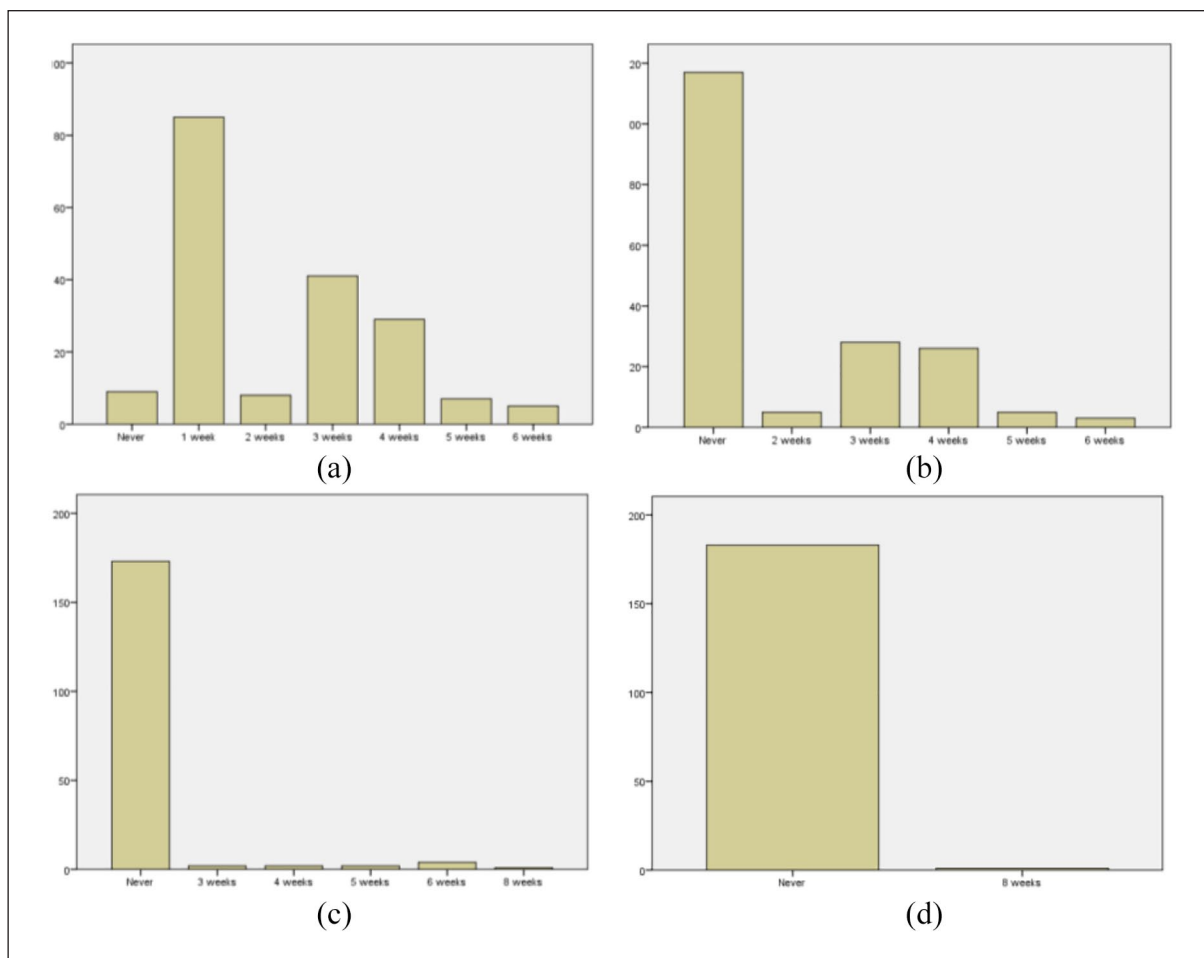


Figure 1. Post-operative X-ray follow-up scheduler: (a) weeks for the first follow-up, (b) N weeks for the second follow-up, (c) weeks for the third follow-up, and (d) weeks for the fourth follow-up.

Table 4. Pins removal preferences.

In case of percutaneous pinning, when do you remove the pin?				
After 3 weeks	After 4 weeks	After 5 weeks	After 6 weeks	After 8 weeks
74 (40.2)	107 (58.2)	0 (0)	0 (0)	3 (1.6)
<i>Answers according years of practice (p=0.81)</i>				
0–5 years (14); 6–10 years (14); >10 years (46)	0–5 years (21); 6–10 years (16); >10 years (70)	0–5 years (0); 6–10 years (0); >10 years (0)	0–5 years (0); 6–10 years (0); >10 years (0)	0–5 years (0); 6–10 years (1); >10 years (2)
<i>Answers according SHFs per year (p=0.40)</i>				
0–10 (7); 11–20 (26); 21–30 (23); >30 (18)	0–10 (26); 11–20 (22); 21–30 (23); >30 (18)	0–10 (0); 11–20 (0); 21–30 (0); >30 (0)	0–10 (0); 11–20 (0); 21–30 (0); >30 (0)	0–10 (1); 11–20 (0); 21–30 (0); >30 (2)

prone position been shown to facilitate reduction, to use the C-arm more easily, and to reduce the rate of iatrogenic nerve injury.^{30,31} However, it could make upper airways management, as well as treatment of polytrauma patients, more difficult; in addition, when the exposure of the antecubital fossa is needed for reduction or neurovascular exploration, the patient should be repositioned.³² However, only 11 out of 184 (6%) respondents declared to position the patient prone, while 17 (9.2%) declared to perform the

operation with the patient in this position only in selected cases. With 84.8% of the preference, the supine position was the preferred one because is quicker, it allows for standard anesthesia management and it gives the possibility to perform an anterior, anteromedial, or anterolateral approach, if conversion to open reduction is required.²⁸ Following fracture reduction, in patients supine, the elbow is locked in hyperflexion and external rotation, and this could result in loss of reduction, increase of forearm

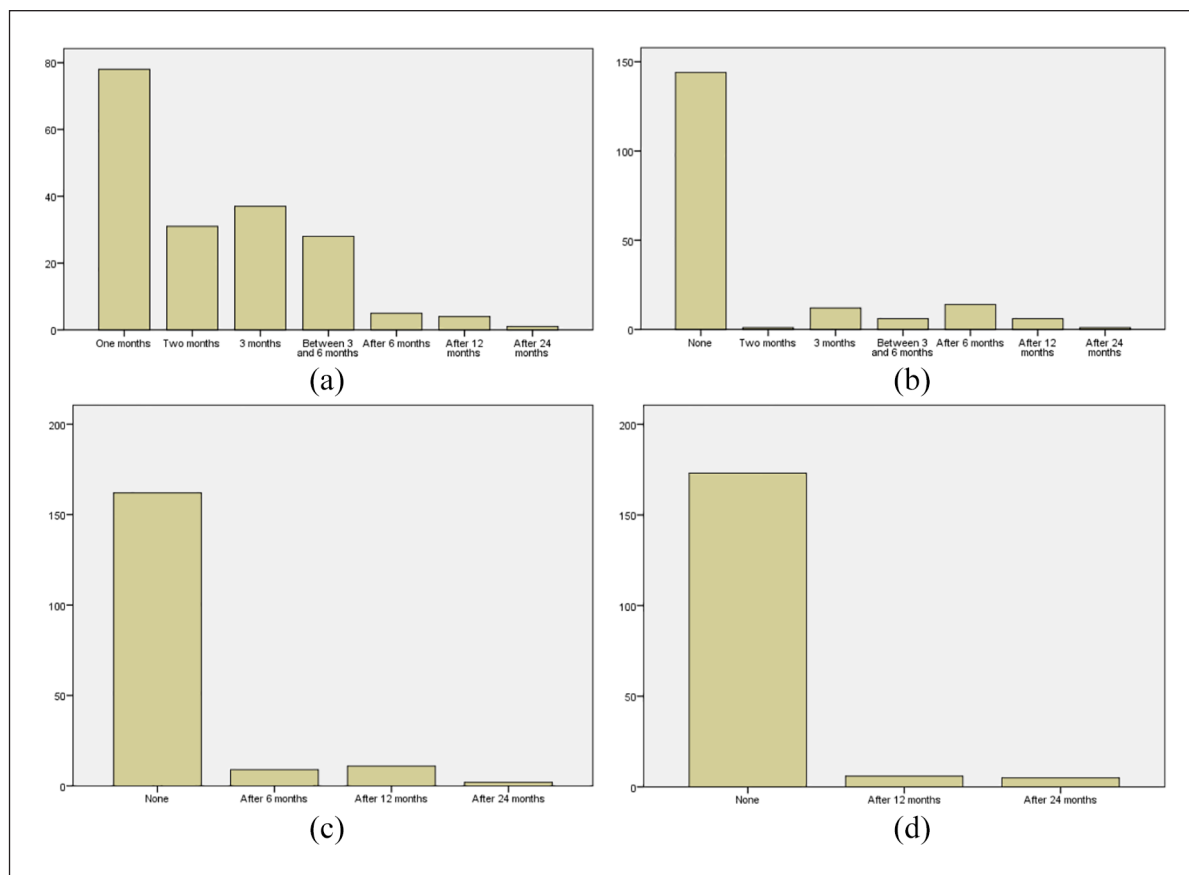


Figure 2. Post-pins removal X-ray follow-up scheduler: (a) weeks for the first follow-up, (b) N weeks for the second follow-up, (c) weeks for the third follow-up, and (d) weeks for the fourth follow-up.

Table 5. Parameters influencing the outcome.

Option	Not important at all, n (%)	Low importance, n (%)	Average importance, n (%)	Crucial importance, n (%)	Years of practice	SHFs per year
Surgeon experience	0 (0.0)	3 (1.6)	50 (27.2)	131 (71.2)	$p=0.33$	$p=0.23$
Patient's age	10 (5.4)	41 (22.3)	86 (46.7)	47 (25.5)	$p=0.13$	$p=0.02$
Patient's weight	38 (20.7)	79 (42.9)	53 (28.8)	14 (7.6)	$p=0.35$	$p=0.43$
Patient's socio-economic status	98 (53.3)	48 (26.1)	25 (13.6)	13 (7.1)	$p=0.35$	$p=0.26$
Type of fracture	0 (0.0)	13 (7.1)	38 (20.7)	133 (72.3)	$p=0.41$	$p=0.79$
Type of treatment	2 (1.1)	10 (5.4)	64 (34.8)	108 (58.7)	$p=0.74$	$p=0.76$
Timing	8 (4.3)	55 (29.9)	87 (47.3)	34 (18.5)	$p=0.40$	$p=0.22$
Surgical approach	8 (4.3)	45 (24.5)	94 (51.1)	37 (20.1)	$p=0.73$	$p=0.68$
Pins number	7 (3.8)	39 (21.2)	104 (56.5)	34 (18.5)	$p=0.79$	$p=0.73$
Pins configuration	5 (2.7)	23 (12.5)	81 (44.0)	75 (40.8)	$p=0.52$	$p=0.05$
Radiological follow-up	20 (10.9)	70 (38.0)	65 (35.3)	29 (15.8)	$p=0.50$	$p=0.30$
Post-operative physical therapy	81 (44.0)	61 (33.2)	30 (16.3)	12 (6.5)	$p=0.11$	$p=0.002$

compartment pressure, and anterior displacement of the ulnar nerve.³²

Pins configuration and pin number were considered “average” or “crucial” factors in the management of SHFs by 84.8% and 75% of the respondents, respectively. Nevertheless, no clear preference was revealed by the survey about pin configuration as crossed pins

(33.7%) and two divergent lateral (23.9%) pins were mostly done. This result reflects the uncertainty of the literature with several biomechanical^{33–36} and clinical^{37–39} studies reporting the superiority of a pin configuration over the others. Crossed pinning has been found to be the most stable configuration in different fracture patterns,^{33–36} especially when three k-wire (two lateral and

one medial) are used;³³ however, a recent metanalysis³⁹ reported 4.9% of iatrogenic ulnar nerve injury in crossed pinning, but the performance of safe procedure for the medial pin⁴⁰ can significantly reduce the risk of injuring the nerve.^{37,38} To avoid ulnar nerve injury, lateral pinning is the preferred fixation technique by 50% of respondents; in particular, most surgeons use two lateral pins (38.6%) and the remaining three (11.4%).

Open reduction is indicated when closed reduction is not possible due to issue entrapment (i.e. muscle, median nerve, brachial artery), compartment syndrome, and neurologic and/or vascular injury.^{27,41} When conversion to open reduction is required, most respondents (40.8%) select the lateral approach although it does not show any advantage over the anterior approach, and it does increase both the risk of injuring the radial nerve and the risk of elbow stiffness.²⁷ It was described that posterior and lateral approaches had higher rates of cubitus varus, while medial and lateral approaches restrict joint motion less than posterior approaches.⁴² In an interesting instructional course, Kzlay et al. suggested to use a surgical approach according to the location of the metaphyseal spike and the displacement of the distal fragment; this approach allows direct visualization of anatomic structures trapped or displaced by the metaphyseal spike.⁴²

Almost the entire sample declared to remove pins between 3 (40.2%) or 4 (58.2%) weeks after the initial surgery. As for the follow-up, the survey did not provide any clear indication, and it is highly likely that every surgeon or every institution adopts a specific protocol.

Ninety-five percent of the respondents require post-operative elbow radiographs, and half of them performs a radiographic check 1 week after surgery. In order to limit exposure to radiation, expenses and time away from work for caregivers, Mansor et al.⁴³ recommend to carry out a single radiographic check 1 week after the surgery, in case the risk of loss of reduction is high (engagement of fragments, bi-cortical engagement, and pins crossing at the fracture site); when adequate fixation is obtained intraoperatively, the radiographic check is recommended after 3–4 weeks, at the time of hardware removal. All respondents unanimously require AP and lateral elbow radiographs at the time of pins removal; in particular, one-third request additional radiographs 1 month or more after hardware removal.

Only the 22.8% of the respondents believe PT can influence the outcome of SHFs. Several authors did not report any benefit from a short course of PT on elbow function or motion.^{44–46} Recently, two pilot trials^{47,48} analyzed the benefits of video gaming in restoring normal elbow function and in reducing pain after conservative or surgical treatment. In particular, tennis, boxing, and bowling gaming could shorten recovery time,⁴⁸ and should be considered in the holistic management of elbow injuries.⁴⁷

This study carries some limitations. First, the surveys gathered answers from EPOS members only. Second, surgeons of different age and different level of expertise responded to the survey; moreover, the comparison between European and not-European members were not performed as the differences between national health systems could induce a selection bias. In addition, the survey may include answers from surgeons not treating SHFs on a regular basis. Finally, the survey can report the surgeons' answers in a hypothetical case, but not what they effectively perform in their everyday practice. Despite such limitations, the survey had an excellent response rate of 46.3% higher than most other surveys.^{13–17}

In conclusion, surgeon experience, type of fracture, treatment modality, and pins configuration were indicated as the main factors influencing the outcome of SHFs. EPOS members agreed on the treatment modality of Gartland's type II and III SHFs, patient positioning, and timing of hardware removal. Other important issues such as timing of surgery, pins configuration, surgical approach, and post-operative protocol are still debated. Post-operative PT is not considered necessary by a large majority of respondents.

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Appendix I

Table 6. Parameters influencing the outcome.

Option	Not important at all, n (%)			Low importance, n (%)			Average importance, n (%)			Crucial importance, n (%)		
Surgeon experience	0 (0.0)	3 (1.6)	50 (27.2)	131 (71.2)	>10 years	6-10 years	>10 years	6-10 years	>10 years	6-10 years	>10 years	
Years of practice	0-5 years	6-10 years	>10 years	0-5 years	6-10 years	>10 years	0-5 years	6-10 years	>10 years	0-5 years	6-10 years	>10 years
$p=0.33$	0	0	0	0	0	3	13	10	27	22	21	88
SHFs per year	0-10	11-20	21-30	0-10	11-20	21-30	0-10	11-20	21-30	0-10	11-20	21-30
$p=0.23$	0	0	0	1	0	1	8	8	14	25	40	30
Patient's age	10 (5.4)	41 (22.3)	86 (46.7)	47 (25.5)	>10 years	6-10 years	>10 years	6-10 years	>10 years	6-10 years	>10 years	
Years of practice	0-5 years	6-10 years	>10 years	0-5 years	6-10 years	>10 years	0-5 years	6-10 years	>10 years	0-5 years	6-10 years	>10 years
$p=0.13$	0	3	7	5	3	33	19	16	51	11	9	27
SHFs per year	0-10	11-20	21-30	0-10	11-20	21-30	0-10	11-20	21-30	0-10	11-20	21-30
$p=0.02$	2	6	1	9	5	15	11	30	22	12	7	15
Patient's weight	38 (20.7)	79 (42.9)	53 (28.8)	14 (7.6)	>10 years	6-10 years	>10 years	6-10 years	>10 years	6-10 years	>10 years	
Years of practice	0-5 years	6-10 years	>10 years	0-5 years	6-10 years	>10 years	0-5 years	6-10 years	>10 years	0-5 years	6-10 years	>10 years
$p=0.35$	5	6	27	15	14	50	9	10	34	6	1	7
SHFs per year	0-10	11-20	21-30	0-10	11-20	21-30	0-10	11-20	21-30	0-10	11-20	21-30
$p=0.43$	3	14	11	17	15	25	10	16	13	4	3	5
Patient's socio-economic status	98 (53.3)	48 (26.1)	25 (13.6)	13 (7.1)	>10 years	6-10 years	>10 years	6-10 years	>10 years	6-10 years	>10 years	
Years of practice	0-5 years	6-10 years	>10 years	0-5 years	6-10 years	>10 years	0-5 years	6-10 years	>10 years	0-5 years	6-10 years	>10 years
$p=0.35$	14	16	68	9	9	30	8	5	12	4	1	8
SHFs per year	0-10	11-20	21-30	0-10	11-20	21-30	0-10	11-20	21-30	0-10	11-20	21-30
$p=0.26$	14	27	23	8	12	17	7	6	8	5	3	2
Type of fracture	0 (0.0)	13 (7.1)	38 (20.7)	133 (72.3)	>10 years	6-10 years	>10 years	6-10 years	>10 years	6-10 years	>10 years	
Years of practice	0-5 years	6-10 years	>10 years	0-5 years	6-10 years	>10 years	0-5 years	6-10 years	>10 years	0-5 years	6-10 years	>10 years
$p=0.41$	0	0	0	1	1	11	5	7	26	29	23	81
SHFs per year	0-10	11-20	21-30	0-10	11-20	21-30	0-10	11-20	21-30	0-10	11-20	21-30
$p=0.79$	0	0	0	2	3	5	5	10	14	27	35	37
Type of treatment	2 (1.1)	10 (5.4)	64 (34.8)	108 (58.7)	>10 years	6-10 years	>10 years	6-10 years	>10 years	6-10 years	>10 years	
Years of practice	0-5 years	6-10 years	>10 years	0-5 years	6-10 years	>10 years	0-5 years	6-10 years	>10 years	0-5 years	6-10 years	>10 years
$p=0.74$	0	0	2	2	0	8	13	11	40	20	20	68
SHFs per year	0-10	11-20	21-30	0-10	11-20	21-30	0-10	11-20	21-30	0-10	11-20	21-30
$p=0.76$	0	1	0	1	1	4	14	18	17	20	27	31
Timing	8 (4.3)	55 (29.9)	87 (47.3)	34 (18.5)	>10 years	6-10 years	>10 years	6-10 years	>10 years	6-10 years	>10 years	

(Continued)

Table 6. (Continued)

Option	Not important at all, n (%)			Low importance, n (%)			Average importance, n (%)			Crucial importance, n (%)		
Years of practice <i>p</i> = 0.40	0-5 years 0	6-10 years 0	>10 years 8	0-5 years 9	6-10 years 11	>10 years 35	0-5 years 20	6-10 years 15	>10 years 52	0-5 years 6	6-10 years 5	>10 years 23
SHFs per year <i>p</i> = 0.22	0-10 0	11-20 0	21-30 3	0-10 8	11-20 16	21-30 19	0-10 18	11-20 25	21-30 21	0-10 8	11-20 7	21-30 8
Surgical approach	8 (4.3)			45 (24.5)			94 (51.1)			37 (20.1)		
Years of practice <i>p</i> = 0.73	0-5 years 3	6-10 years 1	>10 years 4	0-5 years 7	6-10 years 7	>10 years 31	0-5 years 16	6-10 years 18	>10 years 60	0-5 years 9	6-10 years 5	>10 years 23
SHFs per year <i>p</i> = 0.68	0-10 0	11-20 3	21-30 2	0-10 10	11-20 10	21-30 11	0-10 16	11-20 29	21-30 24	0-10 8	11-20 6	21-30 13
Pins number	7 (3.8)			39 (21.2)			104 (56.5)			34 (18.5)		
Years of practice <i>p</i> = 0.79	0-5 years 1	6-10 years 0	>10 years 6	0-5 years 7	6-10 years 8	>10 years 24	0-5 years 22	6-10 years 16	>10 years 66	0-5 years 5	6-10 years 7	>10 years 22
SHFs per year <i>p</i> = 0.73	0-10 2	11-20 2	21-30 1	0-10 8	11-20 9	21-30 7	0-10 16	11-20 28	21-30 32	0-10 8	11-20 9	21-30 10
Pins configuration	5 (2.7)			23 (12.5)			81 (44.0)			75 (40.8)		
Years of practice <i>p</i> = 0.52	0-5 years 1	6-10 years 0	>10 years 4	0-5 years 4	6-10 years 2	>10 years 17	0-5 years 19	6-10 years 16	>10 years 46	0-5 years 11	6-10 years 13	>10 years 51
SHFs per year <i>p</i> = 0.05	0-10 1	11-20 1	21-30 0	0-10 3	11-20 4	21-30 3	0-10 16	11-20 22	21-30 28	0-10 14	11-20 21	21-30 20
Radiological follow-up	20 (10.9)			70 (38.0)			65 (35.3)			29 (15.8)		
Years of practice <i>p</i> = 0.50	0-5 years 3	6-10 years 2	>10 years 15	0-5 years 9	6-10 years 12	>10 years 49	0-5 years 15	6-10 years 12	>10 years 38	0-5 years 8	6-10 years 5	>10 years 16
SHFs per year <i>p</i> = 0.30	0-10 1	11-20 4	21-30 6	0-10 12	11-20 20	21-30 23	0-10 15	11-20 17	21-30 12	0-10 6	11-20 7	21-30 10
Post-operative physical therapy	81 (44.0)			61 (33.2)			30 (16.3)			12 (6.5)		
Years of practice <i>p</i> = 0.11	0-5 years 10	6-10 years 14	>10 years 57	0-5 years 12	6-10 years 14	>10 years 35	0-5 years 9	6-10 years 3	>10 years 18	0-5 years 4	6-10 years 0	>10 years 8
SHFs per year <i>p</i> = 0.002	0-10 9	11-20 17	21-30 29	0-10 12	11-20 19	21-30 18	0-10 6	11-20 10	21-30 3	0-10 7	11-20 2	21-30 1