Indian Journal of Orthopaedics (2022) 56:142–149
https://doi.org/10.1007/s43465-021-00448-9

ORIGINAL ARTICLE

A Prospective Study Evaluating Factors Affecting Functional Outcome in Patients with Floating Elbow Injury

Sumeet Verma[1] · Deepak Kumar[1] · Aman Hooda[1] · Praveen Sodavarapu[1] · Karmesh Kumar[1] · Vijay G. Goni[1]

Received: 23 August 2020 / Accepted: 25 June 2021 / Published online: 1 July 2021

Abstract

Background Floating elbow injuries are complex injuries. Due to frequent association with severe soft tissue injuries and polytrauma, they have unpredictable functional outcome. This prospective study is aimed to evaluate the factors affecting functional outcome.

Methods Thirty patients with floating elbow injuries were treated at a level 1 trauma center from July 2018 to June 2019 with minimum follow-up of 9 months. The outcome was assessed by disability for arm shoulder and hand score (DASH) and mayo elbow performance score (MEPS).

Results The overall incidence was 16.09 per 1000, mostly caused by road traffic accidents and all cases were managed surgically. Age, gender, education, occupation, arm dominance, and mechanism of injury did not significantly affect the outcomes. Open fractures and patients requiring staged procedure were associated with poorer outcomes ($p < 0.05$); however, delay in surgery for more than 24 h significantly increased the rate of complications. There was no statistical difference in the proportion of patients who had nerve injury pre operatively and post operatively on the final outcome.

Conclusion Floating elbow injuries are relatively rare but nowadays the numbers are on the rise. Timely intervention with a multimodal approach and well-supervised rehabilitation can assure better final outcome.

Keywords Floating elbow · Prognostic factor · Functional outcome · Polytrauma

Introduction

Classical floating elbow injury is a constellation of injuries involving the supracondylar or humeral diaphyseal area and proximal part of radius and ulna, initially described by Stanitski and Micheli [1]. Floating elbow variants include concomitant articular fracture or the fracture dislocation of elbow or both, fracture distal humerus with shaft radius or ulna or both that can act as functionally floating elbow [2, 3]. It has been reported to occur in combination—severe soft tissue damage and neurovascular injury [4]. As per the available literature on floating elbow, it has an unpredictable clinical outcome after treatment [5]; however, surgical treatment has been widely accepted as the best possible treatment for these injuries [2].

The outcomes of floating elbow injuries can be affected by severity, pattern of injury, type of fixation done for humerus and forearm, open fracture, multiple injuries and risk factors like age, arm dominance, level of activity [6]. Therefore, there is increased demand for such data on floating elbow injuries that can help to plan and monitor the effectiveness of measures to manage floating elbow injuries. Taking into consideration all these facts, this study was designed to evaluate the incidence, risk factors, fracture patterns, associated injuries, average delay in the treatment and the functional outcomes of floating elbow injuries

✉ Vijay G. Goni
vijaygoni@gmail.com

Sumeet Verma
drsmtverma@gmail.com

Deepak Kumar
drdeepaknegimt@gmail.com

Aman Hooda
amanhooda_10@yahoo.com

Praveen Sodavarapu
praveen.omc.2k8@gmail.com

Karmesh Kumar
karmeshbeniwal@gmail.com

[1] Department of Orthopaedics, Post Graduate Institute of Medical Education and Research, Sector 12, Chandigarh 160012, India

and its variants in a tertiary care center in an Indian setup, to make suggestions regarding adequate management and rehabilitation.

Materials and Methods

This was a prospective cohort study, which included patients presenting with a floating elbow injury and its variants to Level 1 Trauma Centre [AS1] from 1 July 2018 to 30 June 2019. The patients aged more than 18 years with classical floating elbow injuries and variants such as fracture distal humerus with shaft ulna or shaft radius or both, shaft humerus fracture with proximal ulna or a radial head fracture or both, intra-articular fracture of elbow and fracture associated dislocation of the elbow were included in the study group, including both closed fractures and open grade 1, 2, 3a and 3b injuries. The patients having vascular injury (Gustilo Anderson grade 3c), preoperative brachial plexus injury, history of neuromuscular disorder, and patients not consenting to be the part of the study were excluded from this study group.

Patients who presented with floating elbow injuries were divided into three groups with subgroups in the same manner that Fraser and Hunter classified ipsilateral fractures of the femur and tibia in 1978 [7] (Fig. 1). For open fractures, Gustilo–Anderson classification [8] was used. CT scan was done in cases of intra-articular fracture patterns for better delineation of fracture pattern. Patients were shifted to the operative room as soon as possible after adequate resuscitation and stabilization.

The data were collected with special emphasis on patient demographics, functional outcomes, and complications. The management of floating elbow injuries was performed in a single stage or multiple stages, which were determined by the type of fracture, associated soft tissue injuries, and general condition of the patient. Patients requiring soft tissue coverage were managed meticulously by the plastic surgery team. Intravenous antibiotics were given as per institutional antibiotic protocol. The pain was managed with oral and intravenous analgesics. The range of motion exercises were started from day one of the postoperative period wherever feasible. Oral Indomethacin 25 mg thrice a day for 4–6 weeks was given to the patients with a high risk of heterotopic ossification like patients with fractures involving elbow joint, intra-articular fracture and patients with severe soft tissue injuries [9].

On each visit, clinical evaluation and radiology of the involved part were checked to see the progress of bony union, implant status, and any complication. The functional outcome was assessed by Mayo Elbow Performance Score (MEPS) [10] and Disability of the Arm Shoulder and

GROUP		TYPE OF FRACTURE
GROUP1	Group1a	Involves Shaft of humerus and shaft of radius and ulna
	Group1b	Involves shaft of humerus and either radius or ulna
GROUP2	Group2a	Shaft of humerus and intraarticular both bone forearm (Radius and ulna)
	Group2b	Intraarticular humerus and shaft of both radius and ulna or either
GROUP3		Intraarticular humerus and both radius and ulna or either

Fig. 1 Groups on basis of anatomic site of fracture in floating elbow

Hand (DASH) score system [11]. The DASH scores were categorized into four categories of excellent (0–5), good (6–15), satisfactory (15–35), and poor (more than 35). The MEPS was used to categorize in four categories of excellent (90–100), good (75–89), fair (60–74), and poor, less than 60 [12].

Statistical Analysis

Data acquired were entered into Microsoft excel sheet and analyzed with Statistical Package for Social sciences (SPSS Inc., Chicago, IL, Version 7.0 for windows 10).

We used descriptive analysis for describing the numerical data in terms of mean and standard deviation or median and interquartile range. We also transformed the numerical data of DASH scores and MEPS. Two categorical variables for comparing the functional outcome of DASH scores and MEPs were used at 6 weeks, 3 months, 6 months, and at final follow-up and used the Chi-square test of association. In the cells where the value was less than 5, we used Fisher's exact test. For comparing the numerical outcome such as pronation, supination, and range of motion, a paired *t* test was used. Similarly, we used the Chi-square test of analysis for finding prognostic factors for various outcomes such as DASH scores, MEPS, union, and nerve injury. For all the tests of association, a *p* value less than 0.05 was considered to be statistically significant.

Results

The incidence was found to be 16.09 cases per 1000 orthopedic injuries over 1 year. Most injuries were caused by road accidents (76.7%) followed by machine-related injuries (13.3%) and rest were caused by fall from a significant height (10%). The majority of injuries belonged to Group 1 (53.3%) followed by Group 2 (33.4%) while there were four cases for Group 3. We observed that most patients were right dominant (53.3%) (Table 1). The majority of cases (86.7%) were managed as single-stage procedures while four cases (13.33%) were managed with two-stage procedures. Age, gender, education, and occupation of patients with floating elbow injuries and its variants were not statistically significant to influence the functional outcome of patients (p value > 0.05). We observed that the groups of injuries, side, dominancy, and mechanism of injury were not statistically significant in predicting the functional outcome of floating elbow injuries; however, intra-articular fracture tends to influence the outcome but was not statistically significant. We found that the open and closed nature of injury and type of surgery (ORIF, External fixator, Intramedullary nail) done to manage the injuries were statistically significant in predicting the final outcome, favoring the ORIF group ($p = 0.013$, $p = 0.005$). Delay in surgery for more than 24 h was statistically significant to predict complications like stiff elbow, decreased ROM of the elbow, wrist, and shoulder, and nerve injury ($p = 0.024$). The results were analyzed with the minimum follow-up of 9 months (range 9–24 months and mean 16 months) (Tables 2, 3).

Table 1 Socio-demographic and injury characteristics of 30 patients

Parameter	Attributes	$N = 30$
Gender	Male	23
	Female	7
Education	Graduate and post-graduate	13
	Twelfth	8
	Till tenth	8
	Illiterate	1
Occupation	Driver, daily wager, factory worker	11
	Students and housewife	10
	Government and private job	7
	Shop keeper	2
Mechanism of injury	Fall from height	3
	Machine injury	4
	Road side accident	23
Group of injury	1a	13
	1b	3
	2a	2
	2b	8
	3	2
Side	Right	16
	Left	14
Dominant hand	Yes	16
	No	14
Type of surgery	Single stage	26
	Multiple stage	4
Open or closed	Open	13
	Closed	17
Duration of surgery	Less than 24 h	17
	More than 24 h	13
Nerve injury preoperative	Yes	9
	No	21

DASH and MEPS Score

The mean DASH score in group 1, 2, and 3 were 19.9, 18, and 40.15, respectively (Fig. 2). There was statistically significant improvement ($p = 0.000$) in DASH scores at three follow-up periods of 6 weeks, 3 months, and 6 months. The mean MEPS score in groups 1, 2, and 3 were 89.4, 87.5, and 77.5, respectively (Fig. 2). There was a statistically significant improvement in MEPS at 6 months when compared to 3 months ($p = 0.003$).

Table 2 Prognostic factors for DASH and MEPS at 6 months

Parameters	Attributes	DASH at 6 months				*p* value	MEPS at 6 months				MEPS
		Excellent	Good	Poor	Satisfactory	DASH	Excellent	Fair	Good	Poor	*p* value
Category of age	18–25 (Gp1-7, Gp2-3, Gp3-1, op-4, closed-7)	1	5	4	2	0.569	6	2	3	1	0.696
	25–35 (Gp1-7, Gp2-5, Gp3-1, op-9, closed-4)	2	3	2	5		7	1	4	0	
	More than 35 (Gp1-4, Gp2-2, op-1, closed-5)	1	3	0	2		5	0	1	0	
Sex	Male (Gp1-16, Gp2-5, Gp3-2, op-13, closed-10)	4	7	5	7	0.491	14	3	6	0	0.238
	Female (Gp1-2, Gp2-5, op-1, closed-6)	0	4	1	2		4	0	2	1	
Category education	12th or above (Gp1-10, Gp2-9, Gp3-2, op-9, closed-12)	4	7	3	7	0.3436	14	1	5	1	0.379
	Less than 12th	0	4	3	2		4	2	3	0	
Occupation	Government and private job	2	0	1	4	0.198	4	0	3	0	0.407
	Driver, daily wager, factory worker	1	4	4	2		6	3	2	0	
	Shop keeper	0	2	0	0		2	0	0	0	
	Students and housewife	1	5	1	3		6	0	3	1	
Categories of injury group	1 (op-6, closed-12)	2	7	4	5	0.782	11	2	5	0	0.445
	2 (op-5, closed-5)	2	4	1	3		7	0	2	1	
	3 (open-2)	0	0	1	1		0	1	1	0	
Articular involvement	Extraarticular (Group 1)	2	7	4	5	0.9376	11	2	5	0	0.662
	Intraarticular(Group 2 and 3)	2	4	2	4		7	1	3	1	
Open or closed	Open (Gp1-6, Gp2-5, Gp3-2)	2	1	5	5	**0.021**	**4**	**3**	**6**	**0**	0.011
	Closed (Gp1-12, Gp2-5)	2	10	1	4		14	0	2	1	
Side	Right (Gp1-12, Gp2-2, Gp3-2, op-7, closed-9)	1	7	5	3	0.146	9	3	3	1	0.223
	Left (Gp1-6, Gp2-8, op-7, closed-7)	3	4	1	6		9	0	5	0	
Dominant hand	Yes	1	7	5	3	0.146	9	3	3	1	0.223
	No	3	4	1	6		9	0	5	0	
Duration between surgery and hospital arrival	Less than 24 h (Gp1-8, Gp2-7, Gp3-2, op-12, closed-4)	3	4	5	5	0.247	8	3	5	1	0.234
	More than 24 h (Gp1-10, Gp2-3, op-1, closed-13)	1	7	1	4		10	0	3	0	
Type of surgery	Single stage (Gp1-16, Gp2-9, Gp3-1, op-9, closed-17)	4	11	3	8	**0.025**	**18**	**2**	**5**	**1**	0.046
	Multiple stage (Gp1-2, Gp2-1, Gp3-1, op-4)	0	0	3	1		0	1	3	0	

Table 3 Associated injury in patients with floating elbow

Associated injury	Yes—14 patients (46.7%) No—16 patients (53.3%)	Number of patients
Associated injury details	Blunt trauma abdomen	1
	Blunt trauma chest	1
	Facio-maxillary injury	1
	Left acetabulum n hip dislocation	1
	Left segmental femur, right proximal tibia fracture closed without neurovascular defect	1
	Left shaft of femur fracture, open knee joint, left Lisfranc injury	1
	Left patella open Grade 2 without neurovascular defect	1
	Open knee joint, left both bone leg fracture open grade 1, right medial malleolus fracture closed without neurovascular defect	1
	Right acetabulum fracture closed without neurovascular defect and blunt trauma abdomen, managed conservative	1
	Right both bone leg fracture	1
	Right mangled lower extremity	1
	Right scapula with acromioclavicular joint disruption	1
	Right sacroiliac joint disruption, bilateral superior pubic rami, inferior pubic rami, left iliac blade fracture, with sacrum fracture closed without neurovascular defect	1
	Right shaft of femur fracture closed without neurovascular defect	1

Fig. 2 Mean outcome scores and mean range of motion in different groups

Mean score	Group1 (50.9%)	Group 2 (33.4%)	Group 3 (6.7%)	Associated Injuries
Mean DASH	19.9	18	40.5	19.2
Mean MEPS	89.4	87.5	77.5	91.07
Mean ROM	107	100.5	82.5	110
Mean Pronation	67	64.0	72.5	56.8
Mean Supination	60	66.5	87.5	69

Pronation, Supination, and Range of Motion

The mean pronation and supination in groups 1, 2, and 3 were 67, 64, 72.5 and 60, 66.5, 87.5, respectively (Fig. 2), while the mean range of motion was 107, 100.5 and 82.5, respectively. It was observed that the mean degree of pronation, supination, and range of motion improved from 6 weeks to 3 months and from 3 to 6 months. The improvement was found significant statistically using a paired *t* test ($p = 0.000$) (Fig. 3).

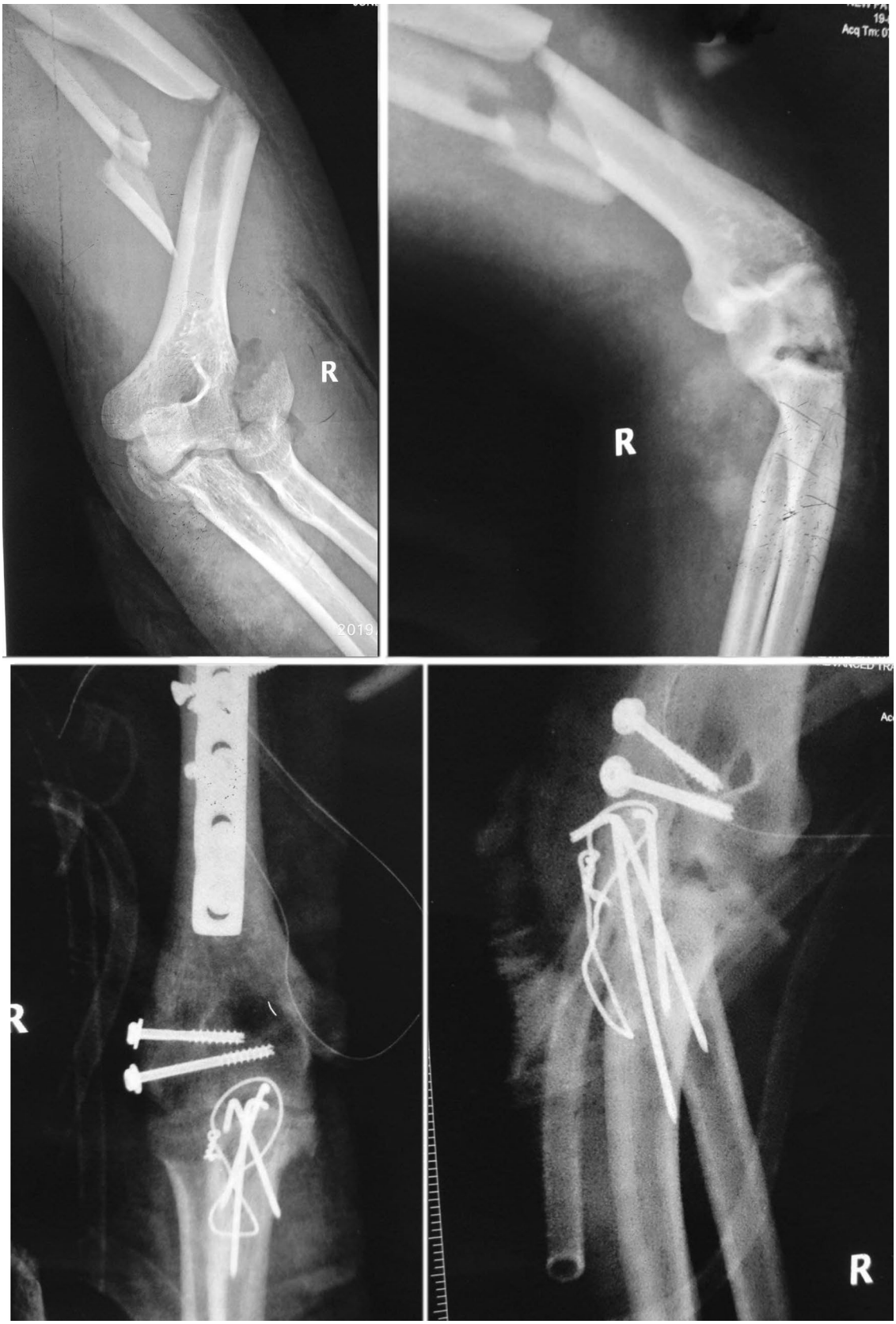

Fig. 3 Preoperative and postoperative radiographs of a patient with group 3 type of floating elbow injury

The overall mean values of DASH score, MEPS, Range of motion, pronation and supination were 20.6, 88, 103°, 66° and 64°, respectively.

Nerve Injury

Nine patients (30%) with preoperative nerve injury cases were surgically explored and found to have neuropraxia, hence were managed conservatively. There was no statistical difference in the proportion of patients who had nerve injury before or after surgery on the final outcome of these injuries ($p > 0.05$).

Union

Union was achieved in 86.7% of cases and four cases had nonunion; two cases (6.7%) had nonunion of radius and ulna, two cases (6.6%) had nonunion of humerus and radius. It was found that nonunion was observed in cases with open grade 3b and those treated with external fixator with delay in surgery for more than 24 h. All patients underwent re-surgery and union was achieved.

Complications

Nine patients (30%) presented with different complications such as stiff wrist, decreased elbow range of motion, stiff shoulder, postoperative nerve injury, and decreased ROM in the wrist. Associated multisystem injuries and delay in surgery were the factors which were statistically significant for causing these complications ($p = 0.024$).

Discussion

Floating elbow is a rare injury caused by high-energy trauma, it occurs in combination with severe soft tissue damage leading to open fracture and neurovascular injury [4]. Floating elbow injury significantly affects the normal routine activities of the person suffering from it. We searched for the possible prognostic factors that can influence the outcome of floating elbow injuries; we included age, sex, education, occupation, side, dominance, type of surgery, open and closed fracture, type of injury pattern, duration between surgery and hospital arrival, nerve injury, mechanism of injury, as our expected prognostic factors (Table 2).

In previously published data on incidence [13–17], the floating elbow injuries are very rare injuries and thus had a very low incidence. Stoik et al. [18] found an incidence of 1 patient per year in their study; however, in our study, incidence was 16.09 cases per 1000 orthopedic injuries over 1 year. Higher incidence can be attributed to the fact that our institute is a tertiary care center that provides services to a large population and receives a large number of referrals of patients with polytrauma. Jockel et al. [6] observed that the patient's age, arm, dominance, type of surgery, multiple surgeries, and fracture patterns were not statistically significant to influence the functional outcome, and our study also shows similar findings.

Pierce and Hodorski [13], Solomon et al. [4] and Yokoyama et al. [3] reported poorer outcomes in patients with associated radial nerve palsy and Ditsios et al. [19] found that nerve injury leads to poor clinical outcome. However, Jimenez-Diaz et al. [20] concluded that nerve injury is not statistically significant in predicting the functional outcome of these injuries. We observed that nerve injury was not statistically significant to influence the long-term functional outcome, which could be attributed to the fact that all the nerve injuries were neuropraxia in our study, and recovered subsequently without any intervention.

Bisinella and Bellon [21] in their case series found that associated injuries with floating elbow injuries need planning regarding timing of surgical intervention and this can reduce the risk of complication and result in good functional outcome, which was also applicable in our study. We found that patients with multisystem injuries (46.7%) such as polytrauma, blunt trauma abdomen, blunt trauma chest, and head injury (Table 3) suffered complications such as stiffness of elbow, shoulder, and wrist, death due to head injury and amputation due to severe soft tissue injury.

Jimenez-Diaz et al. [20] and Yokoyama et al. [3] found correlation between associated multisystem injuries, open nature and anatomic site and the complications such as infection or nonunion with functional outcome; however, they did not evaluate the relationship of factors such as timing of surgery, open/closed fracture and associated nerve injury on functional outcome. We found that open nature and type of technique used for fixation had a significant influence on final functional outcomes ($p = 0.013$, 0.005, respectively), whereas the timing of surgery affected the outcomes in terms of complications ($p = 0.024$). Stoik et al. [18] found that the conservative method of management of these injuries definitely leads to complete loss of function and thus emphasized on surgical stabilization of these fractures both above and below elbow to improve functional outcome; this finding can also be reiterated with our study.

In our study that there was a significant improvement in DASH scores, MEPS scores, range of motion, and pronation/supination during follow-up from 3 to 6 months ($p < 0.05$). The open fractures with grade 3b and intra-articular fractures which were managed with an external fixator or square nail showed poor DASH score, MEPS score, decreased elbow ROM and nonunion ($p > 0.05$). We observed that educated patients had a tendency towards better functional outcomes as compared to uneducated patients. Five patients who were lost to follow-up, all were from low socioeconomic status

and the majority of them were not educated. Although it was not statistically significant ($p > 0.05$), but it is an important factor in developing countries like ours.

Ditsios et al. [19] found intra-articular fractures to have a poorer outcome; we also observed that intra-articular fracture tends to influence the outcome but was not statistically significant in our study. We also observed that Group 1 and 2 types of injuries (Fig. 2) had better functional outcomes as compared to Group 3, although it was not statistically significant.

Strength and Limitations

It is the first prospective study that describes factors influencing the functional outcome of floating elbow injuries and their variations. All cases were operated at the same institute and by the same surgeon and data were collected by a single investigator throughout the period of study to avoid false data and to maintain uniformity. The limitation was the small sample size and relatively shorter duration of follow-up.

Conclusion

The incidence of floating elbow injuries is increasing day by day and frequently associated with polytrauma. The functional outcome of these injuries is not affected by differences in age, gender, education, occupation, side/dominance, and anatomic site of fractures. However, open fracture, type of surgery performed, and delay in surgery have a significant influence on the final outcome. Neuropraxic nerve injuries recover over a period of time and did not influence the final outcome significantly. Timely intervention and a multimodal approach can lead to good results.

Declarations

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical Approval Obtained.

Informed Consent Obtained.

References

1. Stanitski, C. L., & Micheli, L. J. (1980). Simultaneous ipsilateral fractures of the arm and forearm in children. *Clinical Orthopaedics and Related Research, 153*, 218–222.
2. Rogers, J. F., Bennett, J. B., & Tullos, H. S. (1984). Management of concomitant ipsilateral fractures of the humerus and forearm. *Journal of Bone and Joint Surgery. American Volume, 66*, 552–556.
3. Yokoyama, K., Itoman, M., Kobayashi, A., Shindo, M., & Futami, T. (1998). Functional outcomes of" floating elbow" injuries in adult patients. *Journal of Orthopaedic Trauma, 12*, 284–290.
4. Solomon, H. B., Zadnik, M., & Eglseder, W. A. (2003). A review of outcomes in 18 patients with floating elbow. *Journal of Orthopaedic Trauma, 17*, 563–570.
5. Simpson, N. S., & Jupiter, J. B. (1995). Complex fracture patterns of the upper extremity. *Clinical Orthopaedics and Related Research, 318*, 43–53.
6. Jockel, C. R., Gardenal, R. M., Chen, N. C., Golden, R. D., Jupiter, J. B., & Capomassi, M. (2013). Intermediate-term outcomes for floating elbow and floating elbow variant injuries. *Journal of Shoulder and Elbow Surgery, 22*, 280–285.
7. Fraser, R. D., Hunter, G. A., & Waddell, J. P. (1978). Ipsilateral fracture of the femur and tibia. *Journal of Bone and Joint Surgery. British Volume, 60*, 510–515.
8. Paul, H., Kim, M. D., Seth, S., & Leopold, M. D. (2012). Gustilo-Anderson Classification. *Clinical Orthopaedics and Related Research, 470*, 3270–3274.
9. Nauth, A., Giles, E., Potter, B. K., Nesti, L. J., O'Brien, F. P., Bosse, M. J., et al. (2012). Heterotopic ossification in orthopaedic trauma. *Journal of Orthopaedic Trauma, 26*, 684–688.
10. Morrey, B. F. (1985). *The elbow and its disorders*. WB Saunders.
11. Gummesson, C., Ward, M. M., & Atroshi, I. (2006). The shortened disabilities of the arm, shoulder and hand questionnaire (Quick DASH): Validity and reliability based on responses within the full-length DASH. *BMC Musculoskeletal Disorders, 7*, 44.
12. Phadnis, J., Trompeter, A., Gallagher, K., Bradshaw, L., Elliott, D. S., & Newman, K. J. (2012). Mid-term functional outcome after the internal fixation of distal radius fractures. *Journal of Orthopaedic Surgery and Research, 7*, 4.
13. Pierce, R. O., & Hodorski, D. F. (1979). Fractures of the humerus, radius and ulna in the same extremity. *Journal of Trauma, 19*, 182–185.
14. Lange, R. H., & Foster, R. (1985). Skeletal management of humeral shaft fractures associated with forearm fractures. *Clinical Orthopaedics, 195*, 173–177.
15. Reed, F. E., Jr., & Apple, D. F., Jr. (1976). Ipsilateral fractures of the elbow and forearm. *Southern Medical Journal, 69*, 149–151.
16. Simpson, N. S., & Jupiter, J. B. (1995). Complex fracture patterns of the upper extremity. *Clinical Orthopaedics, 318*, 43–53.
17. Smith, D. K., & Cooney, W. P. (1990). External fixation of high energy upper extremity injuries. *Journal of Orthopaedic Trauma, 4*, 7–18.
18. Stoik, W., Marlovits, S., Hajdu, S., & Vécsei, V. (2007). Simultaneous injury to the humerus and forearm on the same side of the body or "the floating elbow" in children and adults. *Osteo Trauma Care, 15*, 69–72.
19. Ditsios, K., Boutsiadis, A., Papadopoulos, P., Karataglis, D., Givissis, P., Hatzokos, I., & Christodoulou, A. (2013). Floating elbow injuries in adults: prognostic factors affecting clinical outcomes. *Journal of Shoulder and Elbow Surgery, 22*, 74–80.
20. Jiménez-Díaz, V., Auñón-Martín, I., Olaya-González, C., Aroca-Peinado, M., Cecilia-López, D., & Caba-Doussoux, P. (2017). Analysis of complications after a floating elbow injury. *European Journal of Orthopaedic Surgery and Traumatology, 27*, 607–615.
21. Bisinella, G., & Bellon, N. (2015). Floating elbow in a polytrauma patient: timing and surgical strategy. *Injury, 46*, 20–22.