

Research Paper

Treatment preferences of orthopedic surgeons for closed, isolated middle-third diaphyseal long bone fractures without neurovascular injury in children: A cross-sectional survey

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ABSTRACT

Objective: This study aimed to assess the treatment trends and the factors influencing the treatment methods of Orthopaedic Surgeons in closed, isolated, middle-third diaphyseal long bone fractures without any neurovascular injury in children.

Methods: This was a cross-sectional electronic survey of Turkish Orthopaedic Surgeons who were active members of the Turkish Society of Children's Orthopaedics (TSCO) and still managing the children's fractures in their daily clinical practice. An initial e-mail including the electronic survey followed by three reminder e-mails was sent to 110 members, and then reminder telephone calls were made.

Results: The survey response rate was 66/110 (60%). In recent years, a definitive trend to surgical treatment was not seen 98%, 77%, 39%, and 88% of the responders in the closed humerus, forearm, femur, and tibia mid-shaft fractures, respectively. Neither the years of expertise nor the intensity of daily pediatric patients of the participants did not affect the treatment trend in any fracture scenarios. The patient's age was the most cited factor influencing the responders' decisions on whether conservative or surgical treatment would be performed in each fracture scenario. The most cited lowest age limits for surgical treatment included mid-shaft fractures of the humerus, forearm, femur, and tibia, were the adolescent age group, 10-12 years, six years, and ten years, respectively.

Conclusion: This is the first study assessing the daily clinical practice of members of TSCO in the management of closed, isolated, non-complicated middle-third diaphyseal long bone fractures in children just before the covid-19 pandemic started. A marked tendency toward surgical treatment is seen in femur mid-shaft fractures, followed by forearm mid-shaft fractures up to a certain level. The patient's age is the main determinant of the responders' decisions on the type of treatment in closed, isolated, non-complicated middle-third diaphyseal long bone fractures in children.

Introduction

The annual rate of fracture-related problems is about 4-5 per 1000 children.¹ Most of the children's fractures can successfully be treated by conservative methods.² Surgical treatment of children's fractures has considerable medical and economic impacts on patients, parents, and health-care providers.³ Surgical treatment is primarily indicated in fractures with a failed history of conservative treatment; open fractures, fractures with vascular injuries, multiple fractures, intraarticular fractures, some pathologic fractures, and some specific fractures cannot primarily be treated by conservative methods.² There has been an increased tendency toward surgical treatment in children's fractures for the last 3 decades.⁴ A substantial increase in the overall rate of surgical treatment in children's fractures is mainly due to the increasing trend of surgical treatment in the upper-extremity fractures particularly in forearm fractures.³

Radius is the most commonly fractured long bone in children. Humerus, radius-ulna, femur, and tibia middle-third diaphyseal fractures constitute about 15% of the fractures in children.¹ The development of flexible

intramedullary nailing has inevitably increased the rate of surgical treatment in such fractures.⁴ However, controversy still exists about which pediatric patients with closed, isolated middle-third diaphyseal long bone fractures without any neurovascular injury really need surgical treatment.

To our knowledge, any nationwide survey assessing the orthopedic surgeons' treatment preferences and the factors influencing the type of treatment in long bone mid-shaft fractures of children has not been conducted in Turkey. The aim of this cross-sectional nationwide survey was to assess whether or not there was a tendency toward surgical treatment among the orthopedic surgeons, who were active members of the Turkish Society of Children's Orthopaedics (TSCO), for closed, isolated, middle-third diaphyseal long bone fractures without any neurovascular injury in children. It was also aimed to assess whether or not this surgical trend was related to the surgeons' previous experiences and pediatric patient intensities in the daily clinical practice. Another purpose of this survey study was to determine the factors influencing the surgeons' treatment methods for such fractures.

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Materials and Methods

The content of the present study was initially approved by the institutional board of ethics (no:118/026) as well as the board of TSCO which then provided the correspondence information of the members of the society to the authors of the present study. This was a cross-sectional electronic survey of Turkish orthopedic surgeons who were active members of TSCO and still managing the children's fractures in the daily clinical practice. An initial e-mail including the final electronic version of the survey was sent to 110 members in June 2019. This e-mail was followed by 3 reminder e-mails at 1, 2, and 3 months. Then reminder mobile telephone calls were made to the members who still did not participate in the survey. December 2019 was the date when the last response was received, and the survey was terminated. The first part of the survey included basic information about the participants' years of expertise as an orthopedic surgeon and the percentage of the management of patients in the daily practice who were between 0 and 16 years of age. The second part included four hypothetical scenarios about closed, isolated middle-third diaphyseal humerus, radius-ulna, tibia, and femur fractures without any neurovascular injury in children. It was asked whether or not the participants' tendency toward surgical treatment had increased in each fracture type in the recent years and to mark one or more of the previously determined multiple-choice factor(s) affecting the type of treatment method in each fracture scenario in the daily clinical practice (Tables 1-5). The participants were also asked to fill in the blanks by giving detailed information about the factors which they had cited in each fracture scenario, if necessary.

Statistical analysis

A free website statistical calculator was used for the statistical analysis of the data.⁵ A 2×2 Chi-square test was used for comparing the frequencies between 2 groups. If the expected cell totals were less than 5, then a Fisher's exact test was used. A *P*-value less than .05 was considered significant.

Results

Among 110 members whom the authors had initially contacted, 66 (60%) completed the survey. It was seen that 77% of the responders worked as an orthopedic surgeon for more than 10 years (Table 1). In 61% of the participants, more than 50% of the patients were between 0 and 16 years of age in the daily clinical practice (Table 1).

HIGHLIGHTS

- There's a paucity of data of The orthopedic surgeons' treatment preferences and the factors influencing the type of treatment in long bone mid-shaft fractures of children in Turkey. This study aimed to assess the treatment preferences of the members of the Turkish Society of Children's Orthopaedics in uncomplicated long bone mid-shaft fractures.
- There were none definitive trend in surgical treatment for uncomplicated humerus, forearm and tibia midshaft fractures. However there was an obvious trend toward surgical treatment for femur middle-third diaphyseal fractures.
- Innovations seen in the medical technology, improved health services, increased expectations of the parents and patients about functionality, surgical training programs which underestimate the conservative treatment methods, court issues, and childhood obesity are the known reasons for the increased tendency toward surgical treatment in children's fractures. However, treatment preferences in fractures and the factors influencing the fracture treatment decisions may show geographical variances.

Humerus middle-third diaphyseal fractures

A definitive increase in the tendency toward surgical treatment in the mentioned type of humerus mid-shaft fractures did not occur in all but one responder (98%) (Table 1). The treatment trend was not associated with either the previous experience of the participants in terms of years or the number of pediatric patients managed in the daily clinical practice (Table 1). The age of the patient was the most cited factor (59%) which influenced the responders' decisions on whether conservative or surgical treatment would be performed (Table 2). The adolescent age group was the most preferred age group for the surgical treatment indication (Table 2). Current evidence-based medicine (EBM) knowledge (56%) was the second-ranked factor affecting the participants' decisions on the treatment method (Table 2).

Radius-ulna middle-third diaphyseal fractures

A significant increase in the tendency toward surgical treatment in the mentioned type of forearm mid-shaft fractures was not seen in 77% of the responders and 2% was unbiased (Table 1). Years of expertise as an orthopedic surgeon as well as the intensity of pediatric patients management in the daily clinical practice did not correlate with the treatment trend (Table 1). Age of the patient (86%) followed by current EBM knowledge (58%) and fracture pattern (52%) were the three most commonly cited factors that influenced the participants' treatment choices (Table 3). The most commonly mentioned lowest age limit for surgical treatment ranged from 10 to 12 years (Table 3).

Femur middle-third diaphyseal fractures

It was seen that 58% of the responders had an obvious trend to surgical treatment in the mentioned type of femur mid-shaft fractures and 3% was undecided (Table 1). The treatment trend was not influenced either by the years of expertise or by the daily pediatric patient ratio of the responders (Table 1). The age of the patient (92%) was the most frequently mentioned factor affecting the type of treatment and 6 years of age was noted as the lowest age limit for surgical treatment by a majority (Table 4). The weight of the patient (77%) was the second-ranked factor (Table 4).

Tibia middle-third diaphyseal fractures

The tendency toward surgical treatment did not precisely increase in the closed tibia mid-shaft fractures in 88% of the responders and 6% was unable to make a final decision (Table 1). Neither the previous experience in terms of years nor the management number of daily pediatric patients of the participants influenced the treatment trend (Table 1). The age of the patient (70%) was the most commonly marked factor which influenced the participants' treatment types (Table 5). The most frequently mentioned lowest age limit for surgical treatment was 10 years (Table 5). Fracture pattern (55%), daily activity of the patient (50%), and current EBM knowledge (45%) were the three other commonly marked factors (Table 5).

Discussion

The data obtained from national and institutional patient registries as well as the results of some survey studies have clearly revealed the increased trend of surgical treatment in children's fractures.⁴ Humerus supracondylar, forearm, and femur shaft fractures are the three fractures that have gained the most considerable trend in surgical treatment in children over the years.⁴ A scientific study reporting the nationwide rate of surgical treatment in children's fractures based on the data obtained from the national patient

Table 1. The treatment trends of the responders in four types of fracture scenarios

| | Humerus mid-shaft fracture | Forearm mid-shaft fracture | Femur mid-shaft fracture | Tibia mid-shaft fracture |
|---|----------------------------|----------------------------|--------------------------|--------------------------|
| Years of expertise as an orthopaedic surgeon | | | | |
| ≤10 years | Y:0 N:14 U:0 | Y:4 N:10 U:0 | Y:10 N:4 U:0 | Y:2 N:11 U:1 |
| >10 years | Y:0 N:51 U:1 | Y:10 N:41 U:1 | Y:28 N:22 U:2 | Y:2 N:47 U:3 |
| P (Y&U vs N) | 1,0** | 0,720** | 0,350* | 0,351** |
| % of 0- to 16-year-old patients in daily clinical practice | | | | |
| ≤50% | Y:0 N:26 U:0 | Y:4 N:22 U:0 | Y:14 N:12 U:0 | Y:1 N:23 U:2 |
| >50% | Y:0 N:39 U:1 | Y:10 N:29 U:1 | Y:24 N:14 U:2 | Y:3 N:35 U:2 |
| P (Y&U vs N) | 1,0** | 0,251* | 0,365** | 1,0** |
| Total | Y:0 N:65 U:1 | Y:14 N:51 U:1 | Y:38 N:26 U:2 | Y:4 N:58 U:4 |

Y, The responder's tendency toward surgical treatment definitely increased.
 N, The responder's tendency toward surgical treatment definitely not increased.
 U, Undecided.
 *Chi-square test.
 **Fisher's exact test.

registry systems has not been published yet, in Turkey. Therefore, the authors of the present study aimed to report the daily clinical practice of the members of the TSCO concerning the treatment of children's fractures in order to increase the awareness of the medical community to the current trends in the treatment of particular fractures in children.

There are a couple of shortcomings of the present study. First, this cross-sectional survey was completed just before the covid-19 pandemic started, unfortunately, the effects of such a pandemic on the treatment preferences of surgeons could not be evaluated. It was recently reported that the overall rate of surgical treatment in children's fractures during covid-19 pandemic was significantly higher than the one in the same date range of the previous years.^{6,7} So, a similar further survey including the pandemic variable may provide a new information about how and why the covid-19 pandemic has influenced the surgeons' treatment decisions in children's fractures. Second, the response rate of the survey was about 60% which might be considered not convincing. However, any data about the survey response rate of TSCO members has not been available yet, so we think the results obtained from this study are valuable due to the fact that such a survey in Turkey has not been conducted before. Third, the conclusions drawn from this survey cannot be universally

adaptable, as the treatment preferences of surgeons in children's fractures can vary in different geographical regions.

Innovations seen in the medical technology, improved health services, increased expectations of parents and patients about particularly the functionality, facilitating families' adaptation to a normal life, resident and fellow training programs which underestimate the conservative treatment methods, court issues, and childhood obesity are the known reasons for the increased tendency toward surgical treatment in children's fractures.⁴ The absolute indications for the surgical fixation of humerus shaft fractures in children are quite limited.^{8,9} However, even in such a fracture with the higher union and lower functional impairment rates, a marked shift from conservative treatment to surgical fixation was reported although the severity of the humerus shaft fractures had not changed over the years.⁸ On the contrary, 98% of the responders of the present survey advocated the priority of conservative treatment for closed, isolated, uncomplicated humerus mid-shaft fractures in children. The majority of the mid-shaft forearm fractures in children can be treated by closed reduction and casting.⁹ In spite of the increasing trend toward surgical treatment, the best treatment method still remains uncertain particularly when absolute indications for the surgical treatment are excluded in forearm mid-shaft fractures.¹⁰ Besides, the long-term

Table 2. The list of factors affecting the responders' decisions on the treatment method for closed, isolated, non-complicated humerus mid-shaft fractures (N=66)

| Factors affecting the decision on the treatment method | No | Explanation for the surgical treatment preference |
|--|----|--|
| Age of the patient | 39 | Lowest age limit: 10 years (7), 12-13 years (6), 14-16 years (6) |
| Current evidence-based medicine | 37 | |
| Fracture pattern | 24 | Transverse (7), comminuted (2) |
| Daily activity of the patient | 23 | Licensed athlete (11) |
| Mechanism of injury | 22 | High energy (10) |
| Weight of the patient | 21 | BMI ≥ 25 (3), BMI ≥ 30 (7) |
| Previous training and experience of the surgeon in treatment possibilities | 19 | |
| Parents' expectations about the healing process | 8 | |
| Economical aspects of the treatment possibilities | 5 | |
| Technical facilities of the surgeon's institution | 5 | |
| Other | 7 | Always conservative treatment in such a fracture (5), risk for lost to follow-up (1), failure risk in remodulation (1) |

Table 3. The list of factors affecting the responders' decisions on the treatment method for closed, isolated, non-complicated radius-ulna mid-shaft fractures (N=66)

| Factors affecting the decision on the treatment method | No | Explanation for the surgical treatment preference |
|--|----|--|
| Age of the patient | 57 | Lowest age limit; 6 years (2), 8-9 years (7), 10 years (10), 11-12 years (12), 13-14 years (7) |
| Current evidence-based medicine | 38 | |
| Fracture pattern | 34 | Comminuted (8), transverse (2), spiral (2), oblique (1) |
| Daily activity of the patient | 29 | Licensed athlete (16) |
| Mechanism of injury | 19 | High energy (8) |
| Previous training and experience of the surgeon in treatment possibilities | 18 | |
| Weight of the patient | 16 | BMI \geq 25 (1), BMI \geq 30 (4) |
| Parents' expectations about the healing process | 11 | |
| Economical aspects of the treatment possibilities | 7 | |
| Technical facilities of the surgeon's institution | 4 | |
| Other | 2 | Always conservative treatment in such a fracture (1), risk for lost to follow-up (1) |

functional and radiological outcomes of closed radius-ulna shaft fractures treated by closed reduction and casting were reported to be excellent.¹¹ Although, closed reduction and casting is still the primary treatment method in 77% of the responders of the present survey, a certain or a possible trend to surgical treatment in about one-quarter of the responders cannot be underestimated in closed, uncomplicated forearm mid-shaft fractures in children. An age-based treatment outline has been developed and used for femur mid-shaft fractures in children for many years.^{9,12} Although an increased trend to surgical treatment in femur mid-shaft fractures in children was observed, a high level of scientific evidence has still been limited about the best treatment method in each age group.^{12,13} A definitive trend in surgical treatment for closed, isolated femur mid-shaft fractures without any neurovascular injury was seen in 58% of the participants in the present survey. We think that the main reason for this considerable increase is the surgeons' decisions on lowering the surgical treatment age limits even in such simple fractures. The

majority of the closed mid-shaft tibia fractures in children can successfully be treated by closed reduction and casting.¹⁴ However, an increased rate in the surgical treatment of pediatric tibia shaft fractures was reported, but the total rate of complications was found to be higher in surgically treated patients than in non-surgically treated patients.^{14,15} In 88% of the responders of the present survey, there was no increased tendency toward surgical treatment in such tibia mid-shaft fractures, while the rest of the responders were either prone to surgical treatment or unbiased. We think that the future treatment approaches of the surgeons in closed tibia mid-shaft fractures require close monitoring. The results of the present study also revealed that the treatment trends of the responders in each fracture scenario were not related to the years of expertise as an orthopedic surgeon and to the intensity of the pediatric patients managed in the daily clinical practice. This finding may show an existing harmony concerning the treatment process of closed, isolated, uncomplicated long bone mid-shaft fractures in children among the members of TSCO.

Table 4. The list of factors affecting the responders' decisions on the treatment method for closed, isolated, non-complicated femur mid-shaft fractures (N=66)

| Factors affecting the decision on the treatment method | No | Explanation for the surgical treatment preference |
|--|----|--|
| Age of the patient | 61 | Lowest age limit; 4-5 years (10), 6 years (17), 9-10 years (6), 12 years (1) |
| Weight of the patient | 51 | BMI \geq 25 (3), BMI \geq 30 (4), \geq 40 kg (3), \geq 50 kg (4), surgery not suitable \leq 15-20 kg (3) |
| Current evidence-based medicine | 40 | |
| Fracture pattern | 39 | Comminuted (11), spiral-oblique (5), transverse (1) |
| Daily activity of the patient | 35 | Licensed athlete (10), school-age (1) |
| Mechanism of injury | 28 | High energy (12) |
| Previous training and experience of the surgeon in treatment possibilities | 18 | |
| Parents' expectations about the healing process | 11 | |
| Technical facilities of the surgeon's institution | 7 | |
| Economical aspects of the treatment possibilities | 5 | |
| Other | 2 | Parents' business stress (2) |

Table 5. The list of factors affecting the responders' decisions on the treatment method for closed, isolated, non-complicated tibia mid-shaft fractures (N=66)

| Factors affecting the decision on the treatment method | No | Explanation for the surgical treatment preference (if any) |
|---|----|---|
| Age of the patient | 46 | Lowest age limit; 6 years (1), 8 years (2), 10 years (12), 11-12 years (2), 14-16 years (4) |
| Fracture pattern | 36 | Comminuted (7), spiral-oblique (3), transverse (2), segmental (1) |
| Daily activity of the patient | 33 | Licensed athlete (14) |
| Current evidence-based medicine | 30 | |
| Weight of the patient | 27 | BMI \geq 30 (5), \geq 40 kg (2) |
| Mechanism of injury | 25 | High energy (10) |
| Previous training and experience of the surgeon about treatment possibilities | 16 | |
| Parents' expectations about healing process | 8 | |
| Technical facilities of the surgeon's institution | 2 | |
| Economical aspects of the treatment possibilities | 2 | |
| Other | 7 | always conservative treatment in such a fracture (5), rapid recovery for returning back to school (1), shortening $>$ 1, 5-2 cm |

Patient-related factors like age and weight, fracture-related factors such as type, pattern and severity, socioeconomic factors, and parent, surgeon- or institution-related factors can influence the surgeons' treatment choices in children's fractures.² The results of the present study revealed that the age of the patient was the most significant factor which influenced the responders' decisions on whether conservative or surgical treatment would be performed in all these fracture scenarios. The most cited lowest age limits for surgical treatment for closed mid-shaft fractures of the humerus, forearm, and femur and tibia were in adolescent age groups 10-12, 6, and 10 years, respectively. However, a notable number of responders indicating lower age limits for surgical treatment in 3 of the 4 fracture scenarios (10 years for humerus, 8-9 years for forearm, and 4-5 years for femur fractures) cannot be ignored. We think that lowering the age limits for the surgical treatment of children's fractures is a multifactorial universal issue. In the long bone mid-shaft fractures of the upper limb, EBM knowledge was the second most significant determinant of the participants' treatment decisions. It should be kept in mind that high-level of scientific evidence proving the long-term functional superiority of surgical treatment over conservative treatment in almost all the children's fractures is currently unavailable.⁴ In the closed femur mid-shaft fracture scenario, the weight of the patient was the second most important factor which influenced the participants' decisions on the treatment method. We think this is indeed a factor related to the age of the patient and already an expected finding. In the closed tibia mid-shaft fracture scenario, the fracture pattern (mostly comminuted) and daily activity of the patient (mostly licensed athlete patient) were the other two most common factors leading the participants to choose surgical treatment. We believe that these factors are related to the functionality of the patient. Parents' expectations about the healing process, economical aspects of the treatment possibilities, and technical facilities of the surgeon's institution were the three least commonly marked factors that influenced the participants' decisions on the treatment method in all these fracture scenarios. We think these are geographical area and country-dependent factors and can show variances in different regions of the world.

In conclusion, this is the very first study assessing the daily clinical practice of members of TSCO in the management of closed, isolated, non-complicated middle-third diaphyseal long bone fractures in children just before the covid-19 pandemic started. A high level of preference on the conservative treatment in humerus mid-shaft fractures is still continuing. A considerable tendency toward surgical treatment is seen in femur mid-shaft fractures followed by forearm mid-shaft fractures up to a certain level. The age of the patient is the main determinant of the responders' decisions on the type of treatment for closed, isolated, uncomplicated mid-shaft long bone fractures in children. However, treatment preferences in fractures and the factors

influencing the fracture treatment decisions may show geographical variances.

Ethics Committee Approval: Ethical committee approval was received from the Clinical Research Ethics Committee of TOBB University of Economics and Technology, School of Medicine (Approval No: 118/026).

Informed Consent: Written informed consent was obtained from all participants who participated in this study.

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