Comparative analysis of inpatient costs for the surgical treatment of distal radial fractures in children and adults: a retrospective cohort study from a single surgeon's experience

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Purpose: Distal radial fractures are common in children and older adults, and numerous studies have analyzed their medical costs. However, no study has attempted to compare the medical costs of distal radial fractures in children and adults requiring surgical treatment in Korea. We therefore investigated this issue for the first time.

Methods: The study retrospectively analyzed 96 pediatric and adult patients who underwent surgery for distal radial fractures performed by a single surgeon between January 2021 and January 2023. Patients were divided into adult (>16 years) and pediatric (≤16 years) groups. We examined patients’ demographic factors, surgical details, and inpatient costs.

Results: The average total inpatient cost in the pediatric group was 1,640,000 Korean won (KRW), compared to 2,940,000 KRW in the adult group. The largest difference was in surgical material costs, which were approximately 700,000 KRW more expensive in adults. Kirschner wires were mainly used during surgery for pediatric patients, whereas volar locking plates were mainly used for adults. The number of C-arm fluoroscopy images obtained during surgery was higher in pediatric patients than in adults. The reoperation rate was higher in pediatric patients.

Conclusion: The inpatient costs of surgical treatment for pediatric patients with distal radius fractures were lower than for adults, primarily due to differences in the costs of surgical materials. However, the reoperation rate was higher in the pediatric group, and radiation exposure was also greater. Policy adjustments may be necessary to address these unique challenges in the treatment of pediatric wrist fractures.

Keywords: Wrist fractures, Kirschner wires, Volar locking plates, Costs and cost analysis, Radius fractures

Introduction

Distal radial fractures are common in children and older adults [1,2]. Among all fractures in children, distal radial fracture has the highest incidence of 19.9% and mainly occurs between the ages of 8 and 16 years in boys. The peak incidence of distal radial and ulnar fractures is observed during the preadolescent growth spurt [3]. The distal radius fractures in adults, on the other hand, gradually increase after the age of 40 years. The incidence is highest in women aged 70 to 79 years, and it is significantly higher in women than in men due to osteoporosis [1,4,5]. In Korea, the incidence of distal radial fractures is increasing the most among all osteoporot-
ic fractures [6]. Consequently, numerous studies analyzing medical costs for distal radial fractures have been conducted [7-10]. In particular, with regard to the surgical treatment of distal radial fractures, research is being conducted to analyze and reduce medical costs, including those on trends in surgical device selection, cost-effectiveness, utility of episode-based bundled payments, and cost variant analysis during open reduction and internal fixation (ORIF) [11-14]. Distal radius fractures in adults and children have different characteristics, and the preferred surgical method also differs. For example, intra-articular fractures are less common in children than in adults [2,15]. The most preferred surgical method is ORIF with a volar locking plate (VLP) in adults, but closed reduction percutaneous pinning (CRPP) is most preferred in children [11,16]. Although children and adults show different characteristics in distal radius fractures, there has been no study on how this affects surgical treatment costs. Therefore, this study aimed to compare and analyze medical costs for distal radial fractures in children vs. adults who underwent surgical treatment. We hypothesize that, even with surgical treatment, medical costs for children would be lower than those for adults.

Methods

Ethics statement: This study was approved by the Institutional Review Board of Chungnam National University Sejong Hospital (No. 2023-07-009). The study was performed in accordance with the Declaration of Helsinki, and written informed consent was waived due to its retrospective nature.

1. Patient selection

This retrospective study included patients with distal radial fractures treated with surgical treatment between January 2021 and January 2023. The inclusion criteria were (1) patients who received surgical treatment only for radial fractures among those with radial or radio-ulnar fractures and received conservative treatment for accompanying ulnar fractures, (2) those who underwent outpatient follow-up for at least 6 months. Patients with the following characteristics were excluded: (1) pathologic fractures, (2) open forearm injury including neurovascular injury, (3) treatment for conditions unrelated to distal radius fracture during the hospital stay, (4) bilateral distal radial fractures, and (5) presence of fractures other than ipsilateral ulnar fractures. Of 230 patients with distal radial fractures, 96 were finally included (Fig. 1). The surgery was performed by a single surgeon, and patients were divided into adult and pediatric groups, with the age of 16 years considered as the cutoff.

We investigated demographic factors such as the patient's age and sex, as well as surgical time, implants used in surgery, number of C-arm fluoroscopy scans during surgery, length of hospital stay, and cases of reoperation related to distal radius fracture surgery were evaluated. The surgical time was recorded as the surgical time recorded in the medical record. We saved all C-arm fluoroscopy scans at the time of surgery. By counting the saved C-arm fluoroscopy scans, the number of C-arm fluoroscopy scans during surgery was confirmed.

2. Inpatient cost

Medical costs in Korea are broadly classified into health care benefits, selective health care benefits, and non-benefits. Costs in health care and selective health care benefits are shared between the National Health Insurance Service and the patient. Non-benefit costs are entirely paid by the patient in full. This study included only health care and selective health care benefits corresponding to the National Health Insurance Service of Korea. Costs were obtained with the cooperation of the hospital's administrative department, and all data were processed anonymously. All costs were assessed from hospitalization until discharge and categorized as follows: costs of computed tomography (CT), simple radiography, anesthesia, surgery, surgical materials, laboratory tests, injections, medication, and hospitalization. The cost of surgery refers only to the surgical fee and varies depending on whether the fracture is intra-articular or extra-ar-
The cost of surgical materials includes the cost of VLP and screws, titanium elastic nails (TEN), and Kirschner wires (K-wires) used in surgery, as well as basic consumables used in preparation for surgery and anesthesia. For example, the heparin lock that connects the intravenous line, normal saline solution used during surgery, and dressing materials are also included in the cost of surgical materials. Injection costs include the costs of drugs used for intravenous injection, such as intravenous fluids and antibiotics. Hospitalization costs include food costs, hospital room fees, inpatient safety management fees, and infection prevention management fees. The cost analysis considered only hospitalizations due to fracture surgery, and all outpatient costs or costs due to subsequent metal removal surgery were excluded. Because outpatient protocols may vary depending on the circumstances of the doctor and patient. Additionally, metal removal may not be desired in some patients, so this study only analyzed costs incurred during hospitalization for fracture surgery.

3. Statistical methods

Age, sex, surgical time, number of C-arm fluoroscopy scans during surgery, instruments used in the surgery, reoperation related to distal radius fracture surgery, length of hospital stay, and inpatient costs were analyzed. The Mann-Whitney test was used for continuous variables, and the Pearson chi-square test was used for categorical variables. All analyses were conducted using IBM SPSS Statistics ver. 28 (IBM Corp., Armonk, NY, USA). A p-value of < 0.05 was considered statistically significant.

Results

The study included 30 pediatric and 66 adult patients. The mean age of the pediatric group was 9.9 ± 3.0 years, whereas that of the adult group was 58.0 ± 17.5 years. The pediatric group comprised a higher number of males (male, 21 and female, nine), and the adult group included more females (male, 15 and female, 51). K-wire was mainly used in the pediatric group during surgery, and VLP was predominantly used in the adult group. The number of C-arm fluoroscopy images taken during surgery in the pediatric group was 114.2 ± 97.0 and in the adult group was 53.8 ± 36.9. It was more than twice as many in the pediatric group, and this was statistically significant (p = 0.002). Surgical time differed by approximately 18 minutes between the two groups and was longer in the adult group. Three cases in the pediatric group required reoperation, two of which occurred after surgery using K-wire. In one case, the occurrence of a physeal bar necessitated physeal bar resection, and in another case, refixation was performed using K-wire due to reduction loss. In the third case, skin irritation occurred after surgery using TENs. During reoperation, the rod was cut shorter and wound debridement was performed (Table 1).

The average total inpatient cost in the pediatric group was 1,669,583 ± 343,193 Korean won (KRW), and that in the adult group was 2,939,373 ± 431,998 KRW, significantly lower in the pediatric group than in the adult group (p < 0.001). The largest difference in detailed cost items was in surgical material cost, which was more expensive in the adult group by approximately 700,000 KRW (Table 2), accounting for 55% of the difference in total inpatient cost between the pediatric and adult groups. The next largest difference in cost between the two groups was in hospitalization and surgery costs, accounting for 16% and 14%, respectively. The difference in imaging tests including CT and simple radiography accounted for 7% (Fig. 1).

Table 1. Comparison of demographic and surgery-related factors between pediatric and adult patients

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Pediatric group (aged ≤ 16 yr)</th>
<th>Adult group (aged &gt; 16 yr)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of patients</td>
<td>30</td>
<td>66</td>
<td></td>
</tr>
<tr>
<td>Age (yr)</td>
<td>9.9 ± 3.0</td>
<td>58.0 ± 17.5</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Sex, male:female</td>
<td>21:9</td>
<td>15:51</td>
<td></td>
</tr>
<tr>
<td>Surgical time (min)</td>
<td>69.1 ± 27.0</td>
<td>86.7 ± 17.6</td>
<td></td>
</tr>
<tr>
<td>Surgical instruments used, K-wire:TENs:VLP</td>
<td>20:8:2</td>
<td>4:0:62</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>No. of C-arm fluoroscopy scans during surgery</td>
<td>114.2 ± 97.0</td>
<td>53.8 ± 36.9</td>
<td>0.002</td>
</tr>
<tr>
<td>Length of hospital stay (day)</td>
<td>3.3 ± 0.7</td>
<td>4.6 ± 0.9</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>No. of reoperation cases</td>
<td>3a</td>
<td>0</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

Values are presented as number only or mean ± standard deviation.

K-wire, Kirschner wires; TENs, titanium elastic nails; VLP, volar locking plate.

a) Physeal bar, 1; reduction loss, 1; and skin irritation, 1.
Discussion

In our study, we found that the total inpatient cost of the pediatric group was approximately 57% of that of the adult group, and surgical time was approximately 80% of that of the adult group. Moreover, the total inpatient cost between the groups differed by approximately 1,270,000 KRW, of which surgical material costs accounted for 55%. Consequently, the adult group paid more in all areas, except simple radiology imaging. C-arm fluoroscopy scans were performed more than twice as frequently in the pediatric group. Reoperations were found only in the pediatric group. As a result, pediatric patients incur less cost than adult patients, have more frequent reoperation, and are exposed to more radiation during surgery.

The total inpatient cost of distal radial fractures in both the adult and pediatric groups was significantly lower than that in other countries. In the United Kingdom, Shyamalan et al. [7] analyzed the cost of surgery using VLP and K-wire and found that the total inpatient cost for the VLP group averaged 4,410,000 KRW and that for the K-wire group averaged 1,320,000 KRW (1 pound equals 1,994 KRW). However, in this study, all the patients were discharged within 24 hours. According to a study in Singapore by Toon et al. [8], the total cost of distal radial fractures treated using ORIF with VLP, in patients with a mean age of 52.1 years, was approximately 6,750,000 KRW (1 Singapore dollar equals 850 KRW). Another study from the United States by Rajan et al. [9] reported the average cost for ORIF surgery as approximately 11,810,000 KRW and that for CRPP surgery as approximately 8,870,000 KRW (1 US dollar equals 1,161 KRW). Kazmers et al. [14] reported that implant choice was a predominant driver of surgical costs. Similar-ly, our results showed that surgical materials had the largest cost difference between pediatric and adult groups (Fig. 2).

In our study, reoperation occurred only in the pediatric group, which is similar to other studies. Rajan et al. [9] reported the loss of reduction rate of 4% and major complications requiring surgery of 6% in the CRPP group. Conversely, in the ORIF

Table 2. Comparison of inpatient costs between pediatric and adult patients

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pediatric group (aged ≤ 16 yr)</th>
<th>Adult group (aged &gt; 16 yr)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total inpatient cost per person</td>
<td>1,669,583 ± 343,193</td>
<td>2,939,373 ± 431,998</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Computed tomography</td>
<td>30,078 ± 61,185</td>
<td>151,355 ± 1,216</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Simple radiography</td>
<td>82,496 ± 35,525</td>
<td>49,765 ± 26,576</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Anesthesia</td>
<td>240,697 ± 62,680</td>
<td>273,105 ± 71,812</td>
<td>0.036</td>
</tr>
<tr>
<td>Surgery</td>
<td>376,290 ± 45,458</td>
<td>558,939 ± 56,661</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Surgical material</td>
<td>407,033 ± 173,959</td>
<td>1,100,214 ± 242,910</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Laboratory test</td>
<td>19,814 ± 2,745</td>
<td>39,517 ± 41,747</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Injection</td>
<td>46,700 ± 27,616</td>
<td>88,174 ± 13,486</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Medication</td>
<td>7,457 ± 2,705</td>
<td>16,602 ± 8,530</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Hospitalization</td>
<td>459,016 ± 173,929</td>
<td>661,720 ± 192,137</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

Values are presented as mean±standard deviation. KRW, Korean won.

Fig. 2. Percentage difference by category of total inpatient costs for pediatric and adult populations. The difference in surgical material costs accounted for 55% of the difference in total inpatient cost, followed by hospitalization and surgery costs, at 16% and 14%, respectively.
group, the loss of reduction rate was 1% and major complications requiring surgery were 5%, significantly lower than that of the CRPP group. Karantana et al. [10] also obtained similar results, with 13 of 64 patients with CRPP requiring reoperation, and only 4 of 66 patients with ORIF using VLP requiring reoperation. Additionally, there was no statistical difference in surgical time between the CRPP and ORIF groups.

In the pediatric group, the reoperation rate was 10%. In general, distal radius fractures in children occur more often in the proximal area than in adults [2]. Because of this, the bone volume at the fracture site decreases compared to adults. In addition, children’s small physical condition makes the radius smaller, making it more difficult to perform CRPP compared to adults. This makes the surgery take longer than expected and requires frequent C-arm scans. As a result, it is thought to be one of the causes of increased reoperation rate. However, these risks are not reflected in the surgery cost. In Korea, surgery cost is determined depending on whether it is intra-articular or extra-articular. In the case of distal radius fractures in adults, there is a report that intra-articular fractures account for 21.3%. However, distal radius fractures in children involve the physis in 12.5% of cases [2]. In another study, among 157 distal radius fractures involving the physis, only 10 were intra-articular fractures [17]. This results in a difference in surgery costs between adults and children in distal radius fractures (Fig. 2). We believe that there is a need to increase surgery costs when there is damage to the physis in pediatric distal radius fractures.

This study has several limitations. First, it was conducted at a single institution, limiting the generalizability of the results to other settings or populations. Further research involving multiple hospitals and regions is necessary. Second, the study duration was too narrow, resulting in a small sample size. It may impact the statistical power and reliability of the findings. Larger-scale studies are therefore needed to verify these results. Third, the study did not fully account for various clinical characteristics of patients or their postoperative rehabilitation processes. Factors such as patients’ overall health, activity levels, and pre- and postoperative care can significantly impact cost analysis and outcomes. The lack of control over these variables may limit the interpretation of the study results. Lastly, this study is retrospective in nature, introducing potential biases such as selection bias and information bias. To minimize these biases, strict patient selection criteria and consistent data collection procedures were employed. However, the inherent limitations of a retrospective study cannot be entirely eliminated. Despite these limitations, this study has several strengths. To the best of our knowledge, it is the first study in Korea to compare and analyze the costs of surgical treatment for distal radial fractures in pediatric and adult patients. The study provides valuable insights into the economic aspects of fracture care in different age groups. Additionally, all surgeries were performed by a single surgeon, thus enhancing the comparability of the results by minimizing variations in surgical technique and decision-making processes. This consistency allows for a clearer analysis of cost differences and outcomes between the two patient groups.

In conclusion, the inpatient cost of surgical treatment for pediatric patients with distal radius fractures is lower than for adults, and the biggest reason is the difference in the cost of surgical materials. However, the reoperation rate was higher in the pediatric group, and radiation exposure was also greater. Policy adjustments may be necessary to address these unique challenges in the treatment of pediatric wrist fractures adequately.

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Conflicts of interest

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References


