Journal of the Pediatric Orthopaedic Society of North America 10 (2025) 100137

Contents lists available at ScienceDirect

Journal of the Pediatric Orthopaedic Society of North America

journal homepage: www.jposna.com

Original Research

Advantages of a Dedicated Orthopaedic Trauma Room for Children With Fractures of the Femur Treated at a Pediatric Community Hospital

Jennifer A. Sheasley, MD[1]; Anna Faino, MSc[2]; Apeksha Gupta, MPH[2]; Viviana Bompadre, PhD[4]; Gregory A. Schmale, MD[3,4,*]

[1] University of Washington School of Medicine, Seattle, WA, USA
[2] Center for Clinical and Translational Research, Seattle Children's Research Institute, Seattle, WA, USA
[3] Department of Orthopaedics and Sports Medicine, University of Washington School of Medicine, Seattle, WA, USA
[4] Department of Orthopedics and Sports Medicine, Seattle Children's Hospital, Seattle, WA, USA

ARTICLE INFO

Keywords:
Femur fracture
Pediatric
Surgery timing
Surgical costs
Complications

ABSTRACT

Background: The benefits of a dedicated orthopaedic trauma room (DOTR) for patients with isolated femur fractures have not been reported from a pediatric community hospital.

Methods: Twenty-three years of skeletally immature patients treated for an isolated diaphyseal femur fracture with two flexible intramedullary nails, Pre-DOTR: 2000–2015 and Post-DOTR: 2016–2022, were reviewed for comparison of patient demographics and injury patterns, timing and durations of surgery, fellow presence, duration and cost of hospitalization, and complication rates.

Results: One hundred fifty-three patients were identified. One hundred twenty-six patients underwent surgery pre-DOTR and 27 post-DOTR. Demographics were similar between groups, except the post-DOTR patients were younger (mean age 7.4 years vs 9.0 years, $P = 0.002$). There was no significant difference in the percentage of patients undergoing surgery within 18 h of admission pre- and post-DOTR (78% vs 93%, respectively, $P = 0.53$). Post-DOTR surgeries were more frequently daytime (93%) than pre-DOTR (56%, $P < 0.001$). Fellows were present in 8% of pre-DOTR vs 44% of post-DOTR procedures ($P < 0.0001$). Average durations of surgery post-DOTR were significantly longer (118 min vs 93 min, $P = 0.031$). Lengths of stay post-DOTR were significantly shorter (3.0 days vs 3.5 days, $P = 0.016$), with substantial potential cost savings. There was no significant difference in complication rates pre- and post-DOTR (21% and 22%, $P = 0.85$).

Conclusions: Implementing a guaranteed first start for orthopaedic trauma via a DOTR at a pediatric community hospital, a pediatric non-Level I or II trauma center, allowed for daytime surgery without prolonging hospital stays for pediatric patients undergoing flexible intramedullary nailing for a femur fracture. Guaranteed morning OR block time for orthopaedic trauma decreased lengths of hospital stay and enabled a larger percentage of surgeries to be done during daytime hours. Shorter hospital stays suggest substantial cost savings, while early daytime surgery for nonemergent procedures avoided burdening families with prolonged waits to surgery.

Key Concepts:

(1) A daily dedicated orthopaedic trauma room (DOTR) for operative treatment of orthopaedic trauma in a pediatric community hospital results in the vast majority of femur fracture surgeries being performed during daytime hours.
(2) Even with a delay of many femur fracture surgeries until the next morning, a DOTR does not increase the fraction of patients treated outside the 18-h window from admission.
(3) A DOTR for operative treatment of pediatric femur fractures in a community pediatric hospital can decrease lengths of stay for patients treated for diaphyseal femur fractures.
(4) A DOTR may decrease the costs of hospitalization by decreasing lengths of stay for patients treated for diaphyseal femur fractures.

Level of Evidence: Therapeutic, Level III - Retrospective comparison study

* Corresponding author: Department of Orthopedics and Sports Medicine, Seattle Children's Hospital, m/s OA9.120, PO Box 5371 Seattle, WA 98145-5005, USA.
E-mail addresses: gschmale@uw.edu, gregory.schmale@seattlechildrens.org (G.A. Schmale).
@seattlechildren, @SchmaleGreg (G.A. Schmale)

https://doi.org/10.1016/j.jposna.2024.100137
Received 2 August 2024; Received in revised form 1 December 2024; Accepted 2 December 2024
Available online 9 December 2024

Introduction

Femur fractures in children and adolescents are common, with an annual incidence of 19.15 per 100,000 [1,2]. Typical mechanisms of injury include falls and motor-vehicle accidents [3–5]. Rates of fracture are influenced by age, sex, season, and socioeconomic conditions [6,7]. Intramedullary flexible nailing of the femur is a recognized and recommended treatment method for many fracture patterns in children and young adolescents with open physes, with high union rates and good functional results [8–12]. Flexible nailing of fractures in patients 5–11+ years of age can be performed via limited surgical exposure, allowing for early mobilization, limit the risks of osteonecrosis, growth abnormalities, or refracture [8–12]. However, reported complication rates for flexible intramedullary nailing of the femur are quite variable, from under 10% to over 75%, due to nail prominence, excessive shortening, angular and rotational malalignment, growth abnormalities, and infection, often leading to unplanned reoperation [13–18]. Prior research has demonstrated several factors influencing complications, including patient factors such as age, sex, weight, fracture pattern and cardiac comorbidity, and surgical factors such as prolonged operative time, insufficient advancement of nail ends, and nail type [19–21]. Identifying additional factors associated with decreased complication rates can provide insight into actions that may produce cost-savings for hospitals.

The benefits of a dedicated orthopaedic trauma room (DOTR) at adult and pediatric Level-I trauma centers have been well described [22–30]. Having a guaranteed first start for orthopaedic trauma via a DOTR and having surgery for diaphyseal femur fractures within 18 h of admission have been a U.S. News and World Report (USNWR) quality measure for many years [31]. The positive impacts of initiation of a DOTR have been widely reported, with decreased complication rates, surgery durations, lengths of hospital stay, and, in some reports decreased times from admission to surgery [24–28,32,33]. Dedicated block time for orthopaedic trauma has also been reported to minimize the disruption of elective cases [21] and scheduled clinics [31], as well as increasing capacity without compromising patient safety, as demonstrated at one institution through the use of a part-time DOTR at an outpatient satellite surgery center to decompress a Level-1 trauma center [34].

This study intended to identify the impacts of a DOTR at one pediatric community hospital, a pediatric *non*-Level I or II trauma center, where pediatric patients with isolated femur fractures and not polytrauma were routinely treated, examining patient- and institution-related factors pre- and post-initiation of a DOTR. We hypothesized that guaranteed morning OR block time for orthopaedic trauma via a DOTR would have the following effects on pediatric patients undergoing flexible nailing surgery for their femur fracture: 1) little impact on mean times from admission to surgery, 2) more procedures completed during the daytime; 3) procedures of shorter duration; 4) decreased length of hospital stay; and 5) lower complication rates.

Materials and methods

An internally funded and IRB-approved retrospective review of medical records for 23 years of patients treated between the ages of 4 and 15 years who underwent intramedullary nailing of a diaphyseal femur fracture, AO classifications 32-D/4.1, 5.1-2 [35], CPT code 27506, at one pediatric community hospital, a pediatric non-Level I or II trauma center, was performed to ascertain the impact of a dedicated orthopaedic trauma room (DOTR) on times from admission to surgery, the rate of daytime procedures, procedure durations, lengths of stay, and complication rates by comparing two periods of time: 2000–2015, prior to the institution of the DOTR, and 2016–2022, following the institution of the DOTR. Prior to 2016, femur fractures were treated in the first available urgent but non-emergent OR, often the night of admission or following the next day's elective schedule. Beginning in 2016, the majority of night presentations of patients with orthopaedic trauma were treated with surgery early the following day by a rotating member of our pediatric orthopaedic service. A guaranteed first start for orthopaedic trauma in one OR for one-half-day was implemented in 2016. Patients were classified "pre-DOTR" if they underwent operation between January 1, 2000, and December 31, 2015, and "post-DOTR" if treated between January 1, 2016, and December 31, 2022. Included patients were skeletally immature, had sustained a closed isolated diaphyseal fracture of the femur without neurovascular injury and were treated with a pair of stainless steel or titanium flexible nails. Patients were excluded if they underwent rigid nailing, had a closed distal femoral physis, were nailed with a single flexible nail, were plated, had pathologic bone throughout the femur, sustained a peri-articular fracture, or had less than 3 months of follow-up (Fig. 1.)

Demographic data collected included sex, age, weight, race, and fracture type (fracture location and stability [36]) and were compared to assess similarities between groups. Treatment variables collected included nail type, length of time from admission to surgery, time of day of surgery, length of operation, whether a fellow was present during surgery, length of hospital stay, and complications. Complication status was categorized using the modified Clavien-Dindo classification Grades II, III, and IV, excluding the Grade I complications that "required no treatment and had no clinical relevance." [37,38] Related complications, such as nail prominence due to fracture shortening, were graded as a single complication. The designation of "daytime" surgery was given to those procedures begun between 7:00 a.m. and 5:00 p.m.

Complication rates and outcome variables were compared between the pre- and post-DOTR groups. The potential impact of patient age on complication status, length of operation, and length of stay was also assessed by dividing patients into "younger" and "older" age groups, with the split at the median age of patients and comparing groups. Wilcoxon rank sum tests and Fisher's exact tests were used to compare continuous and categorical variables between groups. All analyses were performed with R version 4.1.2, and a two-sided test *P*-value less than 0.05 was considered statistically significant. The Revised Standards for Quality Improvement Reporting Excellence (SQUIRE 2.0) served as a guide in preparation of this manuscript [39].

Results

One hundred fifty-three patients who met the inclusion criteria were identified. Forty-two patients were female, and 111 were male. Mean age at surgery was 8.7 years (range 4.1–14.4 years). The mean weight at surgery was 32.6 kg (range 17 kg–66 kg). The mean follow-up was 14.6 months (range 3–76 months).

There were 126 patients pre-DOTR and 27 patients post-DOTR. The distribution of patients across demographic variables, injury types (location of fracture, fracture length-stability), and treatment variables of the two groups were similar with one exception: patients post-DOTR were younger (7.4 years vs 9.0 years, $P = 0.0019$) (Table 1).

There were no significant differences in time from admission to surgery or rate of surgeries performed within 18 h of admission when comparing groups (Table 2).

There was a greater percentage of surgeries performed during daytime hours in the post-DOTR period than the pre-DOTR period (93% vs 56%, $P < 0.001$). Average length of surgery was shorter pre-DOTR than post-DOTR (93 min vs 118 min, $P = 0.031$). Fellows were present in 8% of pre-DOTR vs 44% of post-DOTR procedures ($P < 0.0001$). Post-DOTR, average duration of surgery *with* fellows was significantly shorter than those *without* (mean durations 97 min vs 137 min, respectively, $P = 0.02$). The mean length of hospital stay pre-DOTR was longer than length of stay post-DOTR (3.5 days vs 3.0 days, $P = 0.012$). When dichotomizing age at the median of 8.4 years, we also found that there were no significant differences in length of operation or length of stay by age category (length of operation: median of 89 and 83.5 min for younger vs older age, respectively, $P = 0.73$; length of stay: median of 3 days for both younger and older patients, $P = 0.053$).

Overall, there were 32 patients with complications. Twenty-one of the complications were Grade 3, resulting in an unplanned return to the OR, while 11 were Grade 2 (Table 3).

The most common complications were 1) implant prominence and 2) acute shortening, though abnormal growth and development of the femur was also noted in two patients with long-standing retained flexible nails (Fig. 2).

There was no difference in complication rates comparing the pre- and post-DOTR periods. There was no difference in complication rates comparing length-stable to length-unstable fractures in either time period. Though the mean age of patients differed when comparing the pre- and post-DOTR periods, patient age was not significantly associated with complication status (median of 8.4 years for both complication and noncomplication, $P = 0.31$).

Discussion

This study compared 153 pediatric patients with an isolated femur fracture who underwent flexible intramedullary nailing before or after the implementation of a DOTR at a pediatric non-Level I or II trauma center and revealed its benefits: a majority of surgeries performed within 18 h of patients' admission, nearly all surgeries for urgent but not-emergent femur fractures being performed during daytime hours, and decreased lengths of stay. A similar significant decrease in nighttime surgeries for femur fractures after instituting a DOTR was also found by Bhattacharyya et al. [22], Beebe et al. [24], Brusalis et al. [23], Wixted et al. [30], reporting on care of orthopaedic injuries at Level-I trauma centers.

We did not see a decrease in overall complication rates from the pre- to post-DOTR periods. Similarly, Brusalis did not find a difference in complication rates in their treatment of femur fractures [23]. However, they did find that complications in the treatment of supracondylar fractures of the humerus dropped significantly after the institution of a trauma room. Lower complication rates for daytime surgeries have been consistently reported in the orthopaedic literature [22,25,29,40,41]. Reasons for increased complication rates for surgeries performed at night may relate to hospital staffing issues, including delays in treatment due to mandatory operating room closures as evenings progress, the possibility that operating room staff on after-hours shifts may not be appropriately trained in orthopaedic trauma implants or surgical techniques, or a lack of specialized equipment for urgent nighttime use [25]. Fatigue may also lead to increased complications during overnight surgeries, as surgeons and medical care providers may be extending their work hours beyond their routine with prolonged hours of work overnight. Sleep deprivation is well-known to impair attention and ability to focus: in studies of clinicians, less than five hours of sleep per night reduced ability to perform previously learned tasks, impaired decision-making ability, lowered concentration; and sleep deprivation has also been shown to decrease overall performance in an arthroscopy simulator task [42,43]. Furthermore, late-night procedures may require surgeons to work with smaller teams, potentially without the ideal number of assistants [38]. Disruptions in circadian rhythms caused by overnight work may also have deleterious effects [44]. The implementation of a DOTR serves as a benefit for both surgeons and staff, as fewer nighttime procedures may be preferred by on-call providers [33].

Table 1.
Patient demographics for patients pre- and post-implementation of DOTR.

Demographics	Pre-DOTR	Post-DOTR	*P*-Value
Male sex	71.4%	77.8%	0.5023
Patient age (years) median (IQR)	9.0 8.7 (3.50)	7.4 6.7 (2.64)	0.0019*
Patient weight (kg) median (IQR)	32.6 30.0 (16.0)	28.7 25.9 (14.1)	0.0892

* *Indicates statistically significant.*

Table 2.
Surgical demographics and complication rates for patients who had surgery during pre- and post-implementation of the DOTR.

Surgery details	Pre-DOTR	Post-DOTR	*P*-Value
Surgery within 18 hours of admission	77.8%	92.6%	0.5292
Surgery performed on weekday	64.3%	74.1%	0.3298
Surgery performed during daytime hours	56.3%	92.6%	0.0003*
Rate of fellow attendance	8%	48%	<0.0001*
Length of operation (minutes)	93.3	117.8	0.0314*
Length of hospital stay (days)	3.5	3.0	0.0123*
Length of follow-up (months)	15.8	8.9	0.0967
Complication rate	21%	22%	0.85

* *Indicates statistically significant.*

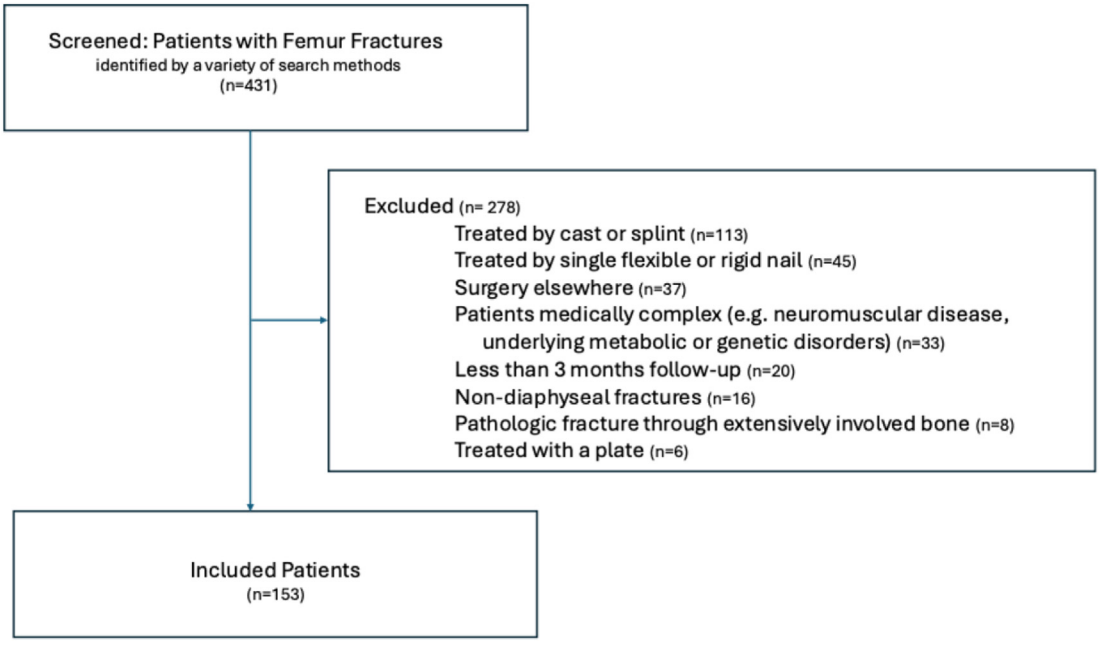

Figure 1. Strobe flow diagram. The numbers of screened and included patients are shown.

Table 3.
Complications by the modified Clavien and Dindo scale [36].

Primary complication	Pre-DOTR		Post-DOTR	
	Grade 2	Grade 3	Grade 2	Grade 3
Re-fracture	1	0		
Fracture instability		1		
Infection	3	1		
Loss of alignment greater than 5° varus/valgus or 10° Procurvatum/ recurvatum	1	1		
Limb overgrowth or acute shortening greater than 1 cm	3	1		3
Implant related issues (nail or screw prominence)	2	10	1	2
Abnormal growth of femur		2		
Totals	**10**	**16**	**1**	**5**
Overall complication rates	**26/125**	**or 21%**	**6/27**	**or 22%**

Prior to the institution of our DOTR, surgery for patients with a femur fracture was often performed the evening of patient admission or, less frequently, late the following day. Despite postponing surgeries to the following morning, we found no significant difference in the rates of surgery performed within 18 h of admission when comparing pre- and post-DOTR periods, indicating that delaying potentially overnight surgeries until morning did not lead to a greater percentage of femur fracture surgeries falling outside of the 18-h benchmark at our institution. The DOTR effectively facilitated daytime surgeries within 18 h, as over 90% of surgeries were performed during the day.

The rates of complications reported in the literature for intramedullary fixation of femur fractures vary widely, depending on the criteria used. Our complication rate of 21% (32/152) was similar to that described by others [13,16,45]. Flynn reported on 58 patients treated with intramedullary fixation of femur fractures and found only "satisfactory" results in 18 of 58, or 31%, with "satisfactory" being a down-grade from excellent due to 5–10° of malalignment, 1 cm–2 cm leg length inequality, soft-tissue irritation by the prominent nail, refracture after hardware removal, and backing-out of the nail, and one poor result (20° varus malalignment) [13]. Sink et al. reported complications in 24 of 39, or 62% of patients treated with flexible titanium nails for femur fractures [32]. Eight returned to the OR prior to complete fracture healing (21%), and six of these were length unstable. As this study revealed no increased rate of complications with length unstable fractures, the rate of unplanned return to the OR, not surprisingly, was substantially lower at 14% (21/152). Baghdadi reported on 841 femur fractures in 832 patients treated via a variety of methods with a rate of unplanned return to the operating room of 5.3% within the first 6 months postsurgery, lower than the rate reported in this study, though we included all unplanned returns to OR at any time in patients with a minimum 3 months of follow-up [16].

The increased mean duration of surgery found in the post-DOTR period has not been demonstrated in recent literature; Brusalis found no change in duration of surgery or time in operating room [23], while Bhattacharyya found closed femoral nailing took significantly longer after-hours [22]. One might hypothesize longer procedure duration during the post-DOTR period to be due to increased teaching, as a fellow was present significantly more often during post-DOTR procedures, where their role would be to lead a resident through the procedure once comfortable with the technique; however, we found the exact opposite to be true: procedures performed with fellows in the post-DOTR periodwere of significantly shorter duration than those without.

The mean length of hospital stay was significantly shorter in the post-DOTR period. Shorter hospital stays were also reported by Brusalis following their DOTR implementation. They reported a mean duration of inpatient hospitalization decreased by 5.6 h across all orthopaedic procedures and resulted in a mean cost reduction of $1251 per patient [23]. Considering that *value* equals *quality* divided by *cost*, decreasing lengths of stay, ie lowering costs without compromising quality, would be a positive "value-increasing" change [46]. Though Grauberger et al. and others argue that maintaining quality despite prolonged times from admission to surgery justifies the increased wait times to surgery [47,48], Blakemore et al. point out that the added value of decreased wait times to surgery and thereby shorter lengths of hospital stay would be appreciated not only by hospitals but families as well [49].

Limitations

A major limitation of this study was its retrospective nature. Procedures were completed by multiple surgeons, and documentation of

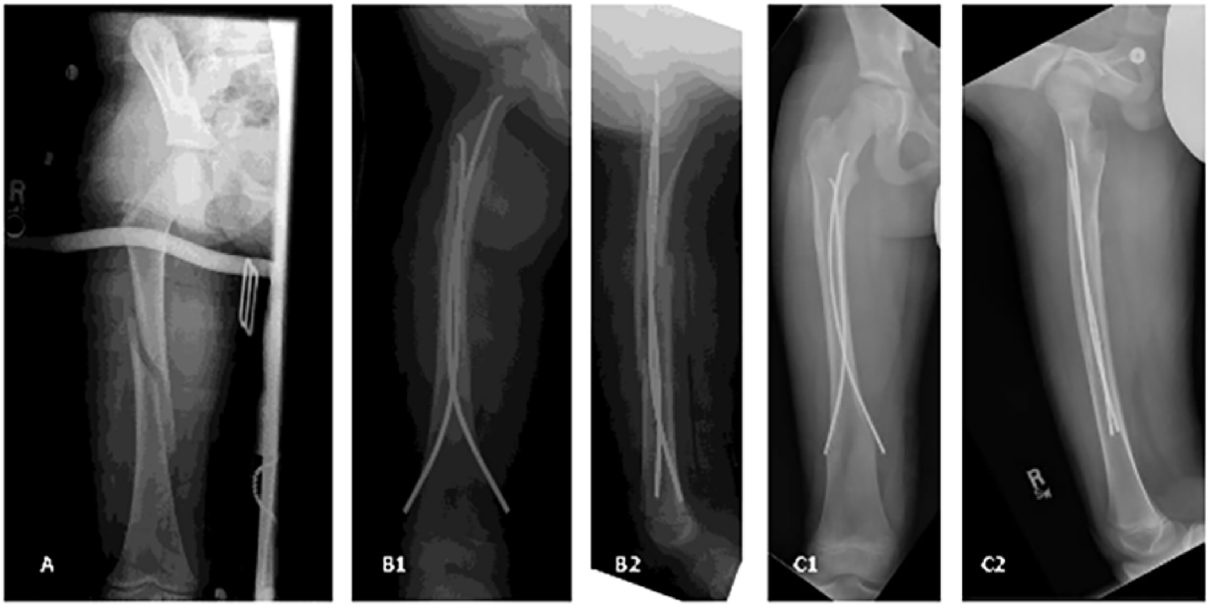

Figure 2. Demonstration of abnormal growth of the femoral metaphysis with an Erlenmeyer flask appearance of the distal femur in a 9-year-old patient 3-1/2 years after intramedullary fixation of their femur fracture with flexible nails. A: injury; B1 and B2: early postoperative; C1 and C2: 3-1/2 years postoperative.

patient exams and function were not standardized prior to data collection. Information on patient pain pre-and post-operatively and patient and parent satisfaction surveys were not routinely collected. Surveys of surgeon fatigue were not performed. With the 23-year span of data collection, practice patterns have shifted: fewer length unstable fractures are being treated with flexible nails, given the advantages of submuscular plating [50], and broader indications for rigid nailing with the introduction of trochanteric entry nails also means fewer flexible nailings being performed [51]. Of note, we found no greater rate of complications in the length-unstable fractures across the whole study period, typically treated in the pre-DOTR period with flexible nailing, now more often treated with submuscular plating or rigid nailing. Given these changes in practice patterns, it is not surprising that the mean age of those treated with flexible intramedullary nailing of the femur was significantly younger in the post-DOTR period. However, we did not find that the difference in age between groups had a significant impact on complication rates, lengths of surgery, or lengths of stay. We suspect that the lack of a decrease in complication rates overall post-DOTR may have, in part, been due to smaller post-DOTR numbers, resulting in inadequate power to detect a difference between groups, should one have existed, with only 7 years of data included in the post-DOTR period (2016–2022; 27 patients), compared to 16 years in the pre-DOTR period (2000–2015; 126 patients).

No analysis of factors contributing to lengths of stay of 3–3.5 days was performed for these patients, though we suspect that both patient-related factors, such as challenges in achieving adequate independence in mobilization and adequate pain control postoperatively, as well as institutional factors, such as the limited availability of physical therapy services on the weekends, contributed to these lengths of stay following surgery.

An additional limitation of the study would be the lack of analysis on the impact of reserving an operating room as a DOTR for a half day every Monday through Friday throughout the year, as reported here, including the opportunity cost of not booking elective cases during that time. The DOTR was typically reserved until 6 a.m. each day, at which point unbooked time was released to other surgical services, though undoubtedly there were days in which the block went unfilled. Allowing inclusion of patients with only 3 months of follow-up likely underestimated true complication rates, though doing so for both the pre- and post-DOTR groups likely limited the impact of such broad inclusion criteria on overall comparisons.

Conclusion

Implementing a guaranteed first start for orthopaedic trauma via a DOTR at a pediatric community hospital, a pediatric non-Level I or II trauma center, allowed for daytime surgery without prolonging hospital stays for pediatric patients undergoing flexible intramedullary nailing for a femur fracture. Guaranteed morning OR block time for orthopaedic trauma decreased lengths of hospital stay and enabled a larger percentage of surgeries to be done during daytime hours. Shorter hospital stays suggest substantial cost savings, while early daytime surgery for non-emergent procedures avoided burdening families with prolonged waits to surgery.

Author contribution

Jennifer A. Sheasley: Writing – review & editing, Writing – original draft, Formal analysis, Data curation. **Anna Faino:** Writing – review & editing, Methodology, Formal analysis. **Apeksha Gupta:** Writing – review & editing, Methodology, Formal analysis. **Viviana Bompadre:** Writing – review & editing, Supervision, Project administration, Data curation, Conceptualization. **Gregory A. Schmale:** Writing – review & editing, Supervision, Resources, Project administration, Methodology, Investigation, Formal analysis, Conceptualization.

Consent for publication

The author(s) declare that no patient consent was necessary as no images or identifying information are included in the article.

Ethics approval and consent

This study was approved by Seattle Children's IRB, PIROSTUDY15609.

Funding

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest. Dr. Schmale is a member of the Pediatric Orthopaedic Working Group for the U.S. News & World Report 2024-25 Best Children's Hospitals Survey.

This work was supported by the L.T. Staheli Endowment and the Faculty Research Support Fund, Center for Clinical and Translational Research, Seattle Children's Research Institute, Seattle, Washington.

Declaration of competing interests

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Dr. Schmale is a member of the Pediatric Orthopaedic Working Group for the US News and World Report's Best Children's Hospitals Survey. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

We would like to acknowledge Tressa Mattioli Lewis for their assistance with this study.

References

[1] Hinton RY, Lincoln A, Crockett MM, Sponseller P, Smith G. Fractures of the femoral shaft in children. Incidence, mechanisms, and sociodemographic risk factors. J Bone Joint Surg Am 1999;81(4):500–9.
[2] Loder RT, O'Donnell PW, Feinberg JR. Epidemiology and mechanisms of femur fractures in children. J Pediatr Orthop 2006;26(5):561–6.
[3] Heideken JV, Svensson T, Blomqvist P, Haglund-Akerlind Y, Janary P-M. Incidence and trends in femur shaft fractures in Swedish children between 1987 and 2005. J Pediatr Orthop 2011;31(5):512–9.
[4] Hoffmann CR, Traldi EF, Posser A. Epidemiological study of children diaphyseal femoral fractures. Rev Bras Ortop. 2015;47(2):186–90.
[5] Engström Z, Wolf O, Hailer YD. Epidemiology of pediatric femur fractures in children: the Swedish Fracture Register. BMC Musculoskelet Disord 2020;21(1):796.
[6] Bakhsh K, Zimri FK, Mohammad E, Rehman A-U, Saaiq M. Presentation and outcome of femoral infected non-unions in children and adolescents. Pak J Med Sci 2021;37(1):201–5.
[7] Valaikaite R, Tabard-Fougère A, Steiger C, Samara E, Dayer R, Ceroni D. A retrospective epidemiological study of paediatric femoral fractures. Swiss Med Wkly 2020;150:w20360.
[8] Hosalkar HS, Pandya NK, Cho RH, Glaser DA, Moor MA, Herman MJ. Intramedullary nailing of pediatric femoral shaft fracture. J Am Acad Orthop Surg 2011;19(8):472–81.
[9] Khan JA, Singh GP, Pandey A. Outcome of titanium elastic intramedullary nail in the treatment of shaft of femur fracture in children. Kathmandu Univ Med J 2015;13(51):195–9.
[10] Memeo A, Panuccio E, D'Amato RD, Colombo M, Boero S, Andreacchio A, et al. Retrospective, multicenter evaluation of complications in the treatment of diaphyseal femur fractures in pediatric patients. Injury 2019;50(Suppl 4):S60–3.
[11] Pogorelić Z, Vodopić T, Jukić M, Furlan D. Elastic stable intramedullary nailing for treatment of pediatric femoral fractures; A 15-year single centre experience. Bull Emerg Trauma 2019;7(2):169–75.
[12] Wang W, Zheng X, Sun Z. Comparison of efficacy between internal fixation of minimally invasive elastic stable intramedullary nail and plate in the treatment of pediatric femoral shaft fracture. Pak J Med Sci 2019;35(5):1417–21.
[13] Flynn JM, Hresko T, Reynolds RA, Blasier RD, Davidson R, Kasser J. Titanium elastic nails for pediatric femur fractures: a multicenter study of early results with analysis of complications. J Pediatr Orthop 2001;21(1):4–8.

[14] Flynn JM, Schwend RM. Management of pediatric femoral shaft fractures. J Am Acad Orthop Surg 2004;12(5):347–59.
[15] Beaty JH. Fractures of the hip in children. Orthop Clin North Am. 2006;37(2):223–vii.
[16] Baghdadi S, Mahmoud MAH, Flynn JJM, Arkader A. Unplanned return to the operating room (UpROR) after pediatric diaphyseal femoral fractures. J Pediatr Orthop 2022;42(2):e120–5.
[17] Duffy S, Gelfer Y, Trompeter A, Clarke A, Monsell F. The clinical features, management options and complications of paediatric femoral fractures [published correction appears in. Eur J Orthop Surg Traumatol 2021;31(5):883–92.
[18] Ramo BA, Martus JE, Tareen N, Hooe BS, Snoddy MC, Jo C-H. Intramedullary nailing compared with spica casts for isolated femoral fractures in four and five-year-old children. J Bone Joint Surg Am 2016;98(4):267–75.
[19] Narayanan UG, Hyman JE, Wainwright AM, Rang M, Alman BA. Complications of elastic stable intramedullary nail fixation of pediatric femoral fractures, and how to avoid them. J Pediatr Orthop 2004;24(4):363–9.
[20] Momaya A, Baker D, Gilbert S, Ponce B. Risk factors for complications and readmission after operative fixation of pediatric femur fractures. J Child Orthop 2015;9(4):307–11.
[21] Canavese F, Marengo L, Andreacchio A, Mansour M, Paonessa M, Rousset M, et al. Complications of elastic stable intramedullary nailing of femoral shaft fractures in children weighing fifty kilograms (one hundred and ten pounds) and more. Int Orthop 2016;40(12):2627–34.
[22] Bhattacharyya T, Vrahas MS, Morrison SM, Kim E, Wicklund RA, Smith M, et al. The value of the dedicated orthopaedic trauma operating room. J Trauma 2006;60(6):1336–41.
[23] Brusalis CM, Shah AS, Luan X, Lutts MK, Sankar WN. A dedicated orthopaedic trauma operating room improves efficiency at a pediatric center. J Bone Joint Surg Am 2017;99(1):42–7.
[24] Beebe AC, Arnott L, Klamar JE, Kean JR, Klingele KE, Samora WP. Utilization of orthopaedic trauma surgical time: an evaluation of three different models at a level I pediatric trauma center. Orthop Surg 2015;7:333–7.
[25] Roberts TT, Vanushkina M, Khasnavis S, Snyder J, Papaliodis DN, Rosenbaum AJ, et al. Dedicated orthopaedic operating rooms: beneficial to patients and providers alike. J Orthop Trauma 2015;29(1):e18–23.
[26] Cloud C, Fong B, Bloise C, Leonardi C, Krause PC, Lee OC. Advantages of a dedicated orthopaedic trauma operating room for diaphyseal femur fractures. J Orthop Trauma 2022;36(7):321–5.
[27] Denisiuk M, Layson JT, Bandovic DO, Waldron J, Diedring B, Frisch NB, et al. Implementation of a dedicated orthopaedic trauma room in hip and femur fracture care: a 17-year analysis. J Orthop Trauma 2022;36(11):579–84.
[28] Chen V, Hara R, Siddiqui AA, Omar HN, Nazareth A, Lightdale-Miric N, et al. Dedicated early morning orthopaedic trauma operating room is associated with shorter time to surgery and decreased length of hospital stay for children undergoing surgical treatment of supracondylar humerus fractures: a retrospective cohort study. J Am Acad Orthop Surg 2023;00:1–7.
[29] Elder GM, Harvey EJ, Vaidya R, Guy P, Meek RN, Aebi M. The effectiveness of orthopaedic trauma theatres in decreasing morbidity and mortality: a study of 701 displaced subcapital hip fractures in two trauma centres. Injury 2005;36(9):1060–6.
[30] Wixted JJ, Reed M, Eskander MS, Millar B, Anderson RC, Bagchi K, et al. The effect of an orthopedic trauma room on afterhours surgery at a level one trauma center. J Orthop Trauma 2008;22(4):234–6.
[31] Olmsted MG, Lessem S, Powell R, Murphy J, Bell D, Blackburn K, et al. Methodology: U.S. News & World Report Best Children's Hospitals 2023–2024. RTI International 2023 June;15. https://health.usnews.com/media/best-hospitals/BCH_Methodology_2023-2024.pdf.
[32] Min W, Wolinsky PR. The dedicated orthopedic trauma operating room. J Trauma Inj Infect Crit Care 2011;71(2):513–5.
[33] Featherall J, Bhattacharyya T. The dedicated orthopaedic trauma room Model: adopting a new standard of care. J Bone Joint Surg Am. 2019;101(22):e120.
[34] Waters PM, Yang BW, White D, Barth E, Chiang V, Mizrahi-Arnaud A, et al. A dedicated satellite trauma orthopaedic program operating room safely increases capacity. J Bone Joint Surg Am 2018;100(10):e70.
[35] Slongo TF, Audige L, on behalf of the AO Pediatric Classification Group. Fracture and dislocation classification compendium for children; the AO pediatric comprehensive classification of long bone fractures (PCCF). J Orthop Trauma 2007;21(10):S135–60.
[36] Sink EL, Gralla J, Repine M. Complications of pediatric femur fractures treated with titanium elastic nails. J Pediatr Orthop 2005;25(5):577–80.
[37] Dodwell ER, Pathy R, Widmann RF, Green DW, Scher DM, Blanco JS, et al. Reliability of the modified Clavien-Dindo-Sink complication classification system in pediatric orthopaedic surgery. JB JS Open Access 2018;3(4):e0020.
[38] Clavien PA, Barkun J, de Oliveira ML, Vauthey JN, Dindo D, Schulick RD, et al. The Clavien-Dindo classification of surgical complications: five-year experience. Ann Surg 2009;250(2):187–96.
[39] Ogrinc G, Davies L, Goodman D, Batalden PB, Davidoff F, Stevens D. SQUIRE 2.0 (*Standards for QUality Improvement Reporting Excellence)*: revised publication guidelines from a detailed consensus process. BMJ Qual Saf 2016;25:986–92.
[40] Chacko AT, Ramirez MA, Ramappa AJ, Richardson LC, Appleton PT, Rodriguez EK. Does late night hip surgery affect outcome? J Trauma 2011;71(2):447–53.
[41] Ricci WM, Gallagher B, Brandt A, Schwappach J, Tucker M, Leighton R. Is after-hours orthopaedic surgery associated with adverse outcomes? A prospective comparative study. J Bone Joint Surg Am 2009;91(9):2067–72.
[42] Sanches I, Teixeira F, dos Santos JM, Ferreira AJ. Effects of acute sleep deprivation resulting from night shift work on young doctors. Acta Med Port 2015;28:457–62.
[43] Baumann Q, Bulaid Y, Van Vliet A, Gabrion A, Klein C, Mertl P. Sleep deprivation adversely impacts resident performance for simulated arthroscopy. Arthrosc Sports Med Rehabil 2021;3(4):e1125–32.
[44] Amirian I. The impact of sleep deprivation on surgeons' performance during night shifts. Dan Med J 2014;61(9):B4912.
[45] Wall EJ, Jain V, Vora V, Mehlman CT, Crawford AH. Complications of titanium and stainless steel elastic nail fixation of pediatric femoral fractures. J Bone Joint Surg Am 2008;90:1305–13.
[46] Lee KHK, Austin MJ, Pronovost PJ. Developing a measure of value in health care. Value Health 2016;19(4):323–5.
[47] Grauberger J, O'Byrne M, Stans AA, Shaughnessy WJ, Larson AN, Milbrandt TA. Does shorter time to treatment of pediatric femur shaft fractures impact clinical outcomes? J Pediatr Orthop 2020;40:e435–9.
[48] Sullivan MH, Wahlig BD, Broida SE, Larson AN, Shaughnessy WJ, Stans AA, et al. Does shorter time to treatment of pediatric supracondylar humerus fractures impact clinical outcomes? J Pediatr Orthop 2023;43:350–4.
[49] Blakemore L, Garg S, Goodwin R, Gordon JE, Hahn G, Mehlman CT, et al. Letter to the Editor: Grauberger et al, J Pediatr Orthop 2020 and Sullivan et al, J Pediatr Orthop, 2020. J Pediatr Orthop 2023;43(10):e828.
[50] Sutphen SA, Mendoza JD, Mundy AC, Yang JG, Beebe AC, Samora WP, et al. Pediatric diaphyseal femur fractures: submuscular plating compared with intramedullary nailing. Orthopedics 2016;39(6):353–8.
[51] Ricci WM, Schwappach J, Tucker M, Coupe K, Brandt A, Sanders R, et al. Trochanteric versus piriformis entry portal for the treatment of femoral shaft fractures. J Orthop Trauma 2006;20(10):663–7.