

The Danish Fracture Database can monitor quality of fracture-related surgery, surgeons' experience level and extent of supervision

Morten Jon Andersen¹, Kiril Gromov^{1,3}, Michael Brix^{2,3}, Anders Troelsen^{1,3} & The Danish Fracture Database collaborators

ABSTRACT

INTRODUCTION: The importance of supervision and of surgeons' level of experience in relation to patient outcome have been demonstrated in both hip fracture and arthroplasty surgery. The aim of this study was to describe the surgeons' experience level and the extent of supervision for: 1) fracture-related surgery in general; 2) the three most frequent primary operations and reoperations; and 3) primary operations during and outside regular working hours.

MATERIAL AND METHODS: A total of 9,767 surgical procedures were identified from the Danish Fracture Database (DFDB). Procedures were grouped based on the surgeons' level of experience, extent of supervision, type (primary, planned secondary or reoperation), classification (AO Müller), and whether they were performed during or outside regular hours.

RESULTS: Interns and junior residents combined performed 46% of all procedures. A total of 90% of surgeries by interns were performed under supervision, whereas 32% of operations by junior residents were unsupervised. Supervision was absent in 14-16% and 22-33% of the three most frequent primary procedures and reoperations when performed by interns and junior residents, respectively. The proportion of unsupervised procedures by junior residents grew from 30% during to 40% ($p < 0.001$) outside regular hours.

CONCLUSION: Interns and junior residents together performed almost half of all fracture-related surgery. The extent of supervision was generally high; however, a third of the primary procedures performed by junior residents were unsupervised. The extent of unsupervised surgery performed by junior residents was significantly higher outside regular hours.

FUNDING: not relevant.

TRIAL REGISTRATION: The Danish Fracture Database ("Dansk Frakturdatabase") was approved by the Danish Data Protection Agency ID: 01321.

related procedures from the start of their training. To ensure patient safety and quality of treatment, operations done by trainees are preferably undertaken only under adequate supervision by a more experienced surgeon. The importance of supervision and the surgeons' level of experience for patient outcome have been documented for both hip fracture and arthroplasty surgery [3-5] as well as in other specialties [6-8]. For fracture-related surgery in general, the operating surgeons' level of experience and the extent of supervision are unknown. At departments participating in the Danish Fracture Database collaboration, data regarding the surgeons' experience levels and the extent of supervision are registered in DFDB by the operating surgeon.

The aim of this study was to describe the level of experience of the operating surgeons and the extent of supervision for: 1) fracture-related surgery in general; 2) the three most frequent types of primary operations and reoperations; and 3) primary operations during and outside regular working hours.

MATERIAL AND METHODS

Data were collected from the Danish Fracture Database (DFDB); an online database developed using Procordo software (Procordo Aps, Aarhus, Denmark). The DFDB was established in 2011 as a quality monitoring tool for fracture-related surgery [9]. At the time of data analysis (10 June 2013) a total of 9,767 procedures were registered at eight orthopaedic departments across Denmark. In addition to the surgeons' level of experience and the extent of supervision, data regarding patient demographics, fracture pattern (Müller AO Classification) [10] and the type of treatment are recorded in the DFDB. Both primary surgeries, planned secondary procedures and reoperations are registered. Primary surgery is defined as the first surgical procedure on a fracture. Planned secondary procedures are defined as surgical procedures that form a part of a primary treatment plan but which are performed after the primary surgery. Reoperations are defined as surgical procedures that do not form part of an initial treatment plan following primary surgery.

Postgraduate education for the orthopaedic spe-

ORIGINAL ARTICLE

- 1) Department of Orthopaedic Surgery, Hvidovre Hospital
- 2) Department of Orthopaedic Surgery, Odense University Hospital
- 3) Danish Fracture Database Administration

Dan Med J
2014;61(6):A4839

Fractures are common injuries and result in a large number of hospital admissions [1, 2]. Fracture-related surgery is therefore a common task within the orthopaedic specialty. In Denmark, doctors training to become orthopaedic surgeons are extensively exposed to fracture-



TABLE 1

Experience level of operating surgeons both in general and for the three most frequent operations and reoperations. The values are n (%).

	Interns	Junior residents	Senior residents and consultants	Total
All primary operations	1,429 (18)	2,303 (29)	4,228 (53)	7,960
All planned secondary operations	234 (26)	172 (19)	486 (55)	892
All reoperations	193 (21)	200 (22)	520 (57)	913
All procedures	1,856 (19)	2,675 (27)	5,234 (54)	9,767 ^a
<i>Most frequent primary operations in adults</i>				
Proximal femoral fracture	681 (31)	776 (35)	767 (34)	2,224
Distal radius fracture	201 (19)	360 (35)	474 (46)	1,035
Malleolus fracture	164 (19)	274 (33)	402 (48)	840
<i>Most frequent reoperations in adults</i>				
Proximal femoral fracture	74 (28)	54 (20)	137 (52)	265
Malleolus fracture	41 (26)	41 (26)	75 (48)	157
Tibial shaft fracture	10 (17)	22 (38)	26 (45)	58

a) 2 registrations were missing. All data relating to these were excluded from further analysis.

cialty in Denmark takes a minimum of six years; one year of basic clinical education and five years of specialty training including one year of internship and four years of residency.

From the extracted data, surgeons were divided into three groups based on their level of experience (educational level): "Interns" (doctors in basic clinical education and orthopaedic interns), "junior residents" (first and second year residents) and "senior residents and attendings" (third year residents and attending physicians).

The extent of supervision was also divided into three groups: "Unsupervised", "Non-expert supervision" (supervision by interns and junior residents) and "Expert supervision" (supervision by senior residents and attendings).

All procedures were grouped into primary operations, planned secondary operations and reoperations. Frequencies were calculated for each type of procedure. For each of these groups, the experience level of the surgeons and the extent of supervision were determined using cross tabulation. The three most frequent primary surgeries and reoperations (based on AO fracture groups) were selected for further analysis, and experience level and extent of supervision were determined for these groups as well.

To investigate any changes in the extent of supervision during and outside regular working hours, all primary procedures were classified based on start time of the procedure as registered in the DFDB. They were grouped into "during" (8:00 AM-5:59 PM) and "outside" (6:00 PM-7:59 AM) regular working hours. Analysis of experience level and extent of supervision was done us-

ing cross tabulation. Pearson's χ^2 -test was used to determine the significance of any differences in results. The significance level was set at $p < 0.05$.

All data analysis was done using IBM, SPSS Statistics, version 20.

Trial registration: Danish Fracture Database ("Dansk Frakturdatabase") was approved by the Danish Data Protection Agency ID: 01321.

RESULTS

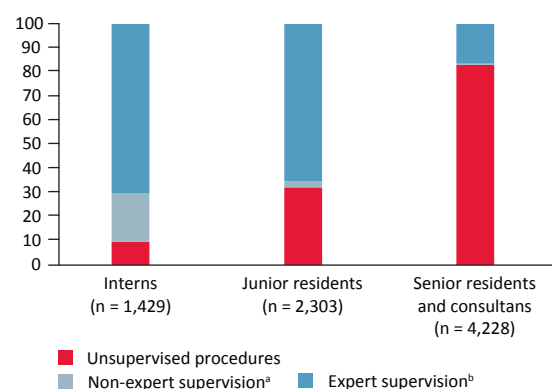
A total of 9,767 surgical procedures were identified from the DFDB. For two registrations, all data were missing, and these were excluded from the analysis. The three most frequent primary surgical procedures in adults were operations on the proximal femur (AO group 31), distal radius (AO group 23) and malleoli (AO group 44). These procedures accounted for 32% (2,224/6,823), 15% (1,035/6,823) and 12% (840/6,823) of all adult primary procedures, respectively. The proximal femur, malleoli and tibial shaft (AO group 42) were the most frequent sites of reoperations accounting for 32% (265/846), 19% (157/846) and 7% (58/846), respectively.

Table 1 displays the experience level of the surgeons performing fracture-related procedures, and **Figure 1** shows the extent of supervision in primary fracture-related surgery. A total of 90% (1,292/1,429) of surgeries by interns were supervised; and in 80% (1,006/1,292) of these cases, expert level supervision was provided. In 96% (1,499/1,565) of supervised surgeries by junior residents, expert level supervision was provided.

Figure 2A displays the extent of supervision for the three most frequent primary operations. In addition, we

FIGURE 1

Level of experience for primary fracture-related surgery in general.

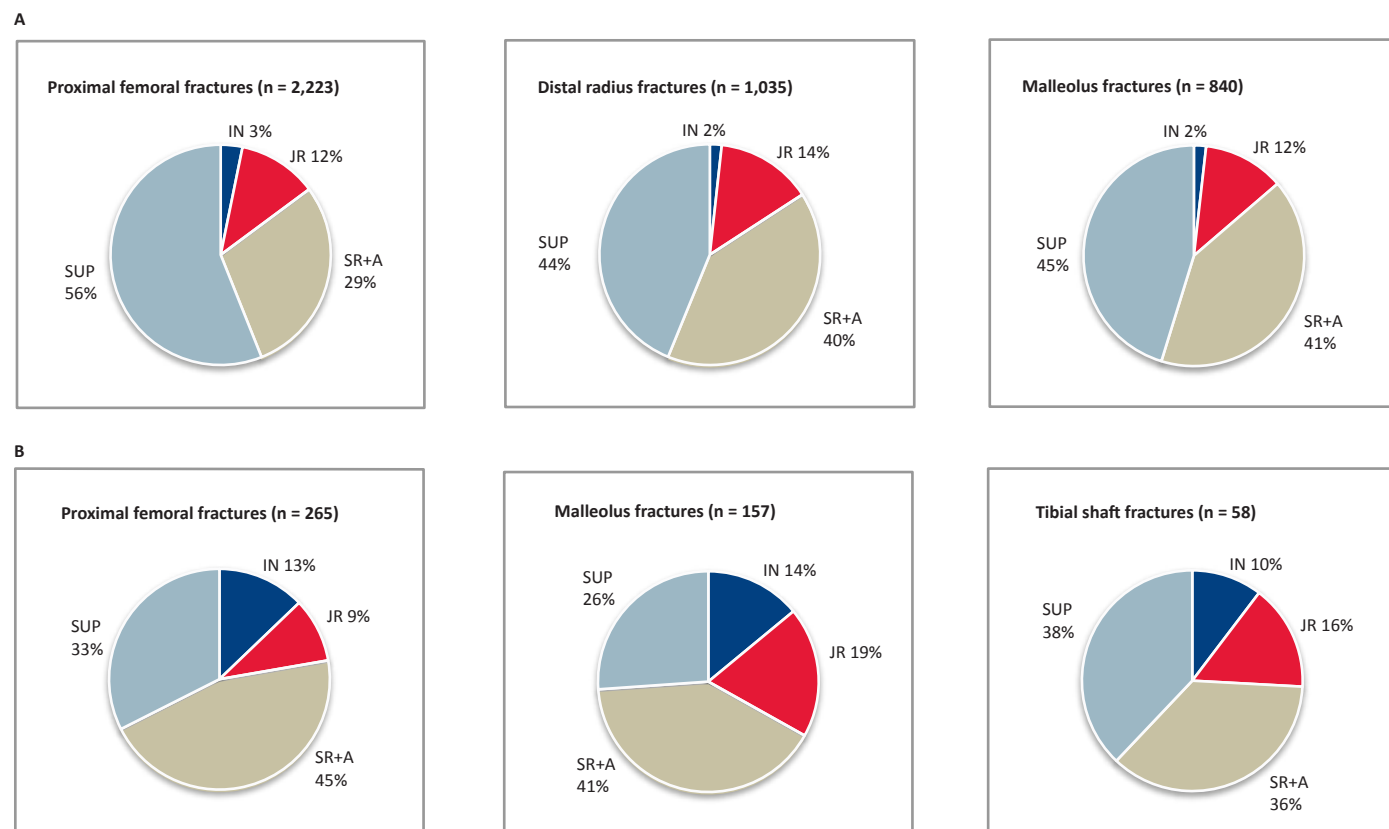


a) Supervision by interns or junior residents.

b) Supervision by senior residents or attendings.

FIGURE 2

Extent of supervision for the three most frequent primary fracture-related operations (A) and reoperations (B) in adults. Unsupervised operations are subdivided by surgeons' level of experience.



IN = unsupervised procedures by interns; JR = unsupervised procedures by junior residents; SR+A = unsupervised procedures by senior residents and attendings; SUP = supervised procedures.

found that interns and junior residents received supervision from a surgeon of higher charge in 97% (745/767) and 95% (720/752) of the cases, respectively. Senior residents (not including attendings) received supervision from a physician of the same charge in 17% (30/219) and from a physician of a higher charge in 78% (179/219) of the cases.

Table 1 and Figure 2B display the surgeons' level of experience and extent of supervision for the three most frequent re-operations. For these three procedures combined, interns, junior residents and senior residents (not including attendings) received supervision from a surgeon of higher charge in 92% (58/63), 98% (52/53) and 89% (16/18) of cases, respectively.

Figure 3 displays the extent of supervision for primary fracture surgery during and outside regular working hours. The number of unsupervised operations by interns declined insignificantly outside regular working hours ($p = 0.193$). The number of unsupervised surgical procedures by junior residents grew significantly in the

same time period ($p < 0.001$). Also, the number of unsupervised operations by senior residents and attendings was significantly higher outside regular working hours ($p < 0.001$).

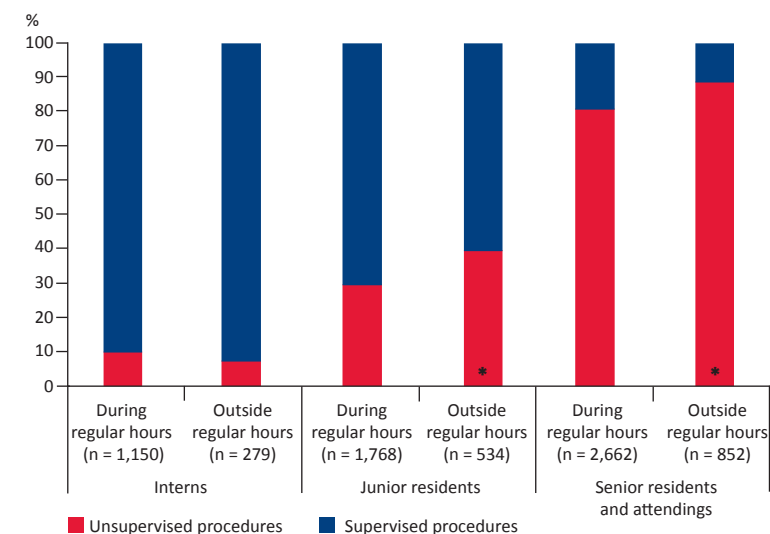
DISCUSSION

Interns and junior residents together performed 46% all fracture-related surgery. A total of 90% of surgeries by interns were supervised. Supervision was absent in 32% of procedures performed by junior residents. Approximately 15% of procedures performed by interns and junior residents on fractures of the proximal femur, distal radius and malleoli were unsupervised. Approximately half of the reoperations due to fractures of the proximal femur, the malleoli and the tibial shaft were done by interns and junior residents. A significantly lower extent of supervision was found for surgeries performed by junior residents and senior residents and attendings outside regular working hours.

This study is based on registry data from the DFDB.

FIGURE 3

Variations in extent of supervision for interns, junior resident, and senior residents and attendings; during (8:00 AM-5:59 PM) and outside (6:00 PM-7:59 AM) regular working hours.



*) $p < 0.05$

Data from the DFDB have a high completeness and validity [11]. The large sample size strengthens the findings of this study; however, data were only collected from the eight orthopaedic departments participating in the DFDB collaboration at the time. There could be significant variations in supervision and surgeons' experience level between these and other departments not taking part in the DFDB.

The surgical volume (number and frequency of procedures performed) can vary greatly from one surgeon to another within the same educational group. Khunda et al showed one surgeon having performed no procedures and another having done 325 in the same educational group [4]. This reflects in 10% of interns not receiving supervision. Late in their internship, trainees will be able to perform simple surgeries unsupervised and in some cases supervisors are only on call if difficulties arise. Accordingly, supervision is not required for all surgeries by interns. Furthermore, junior surgeons need to train the performance of unsupervised surgery as required later in their career. The official aim for the Danish interns is the performance of at least five surgeries due to proximal femoral fractures and five other kinds of surgery due to different types of fractures [12]. However, it is likely that Danish interns will have completed more fracture surgeries than officially required at the end of their internship. Junior residents are expected to be able to perform simple fracture surgeries on their own and more complex surgeries under supervision. Senior residents are expected to be able to per-

form surgery for the most common fracture types without supervision. When completing the orthopaedic specialty, the official aim (for traumatology) is to have completed more than 100 fracture surgeries and at least ten hemiarthroplasties due to fractures [12]. The allocation of surgeons into three groups based on educational level is not optimal; however, we assumed that this was the most feasible and real-life like way of grouping them.

Data in this study were neither correlated with type or difficulty of procedure, nor with the risk of morbidity or mortality. Hence, we did not investigate whether the surgeons' level of experience or the extent of supervision had any impact on outcomes. However, previous studies have shown mortality to be directly affected by the surgeons' volume in both cardiovascular and cancer surgery [6]. In abdominal surgery, a significantly lower recurrence rate of inguinal hernia was demonstrated when open surgery was performed by a resident with four or more years of experience compared with residents with one year of experience, despite the presence of an attending surgeon [7]. In urgent colorectal surgery, it was shown that "higher surgical trainees" were in need of adequate supervision in order to achieve the same results as attendings alone [8]. We found that interns performed 19% of all fracture-related surgery. Approximately 15% of the three most frequent primary operations were performed unsupervised by interns and junior residents. Taking into account the findings in abdominal surgery, our results could be a cause for concern.

The level of experience and the extent of supervision have been shown to be equally important in hip fracture surgery. The incidence of major complications was reduced from 12.5% to 5% when a special "Hip Fracture Team" performed the operations. The reduction in complications was, in part, attributed to the surgeon's experience [13]. Khunda et al reported retro-

To ensure patient safety and quality of treatment, operations done by trainees are preferably undertaken only under adequate supervision by a more experienced surgeon.



spectively on 761 hip fracture patients and found significantly higher 6-month mortality rates for patients operated on by unsupervised trainees (29%) than among those operated on by supervised trainees or attendings (13%) [4]. We found that 15% of primary procedures on proximal femoral fractures were done by interns and junior residents without supervision. Palm et al found that unsupervised junior registrars operated on 23% of all and 15% of technically demanding proximal femoral fractures. This yielded an unacceptably high reoperation rate of 29% within six months when unsupervised junior registrars performed surgery on technically demanding hip fractures [3]. Our study does not stratify proximal femoral fractures into degree of difficulty. However, the number of unsupervised procedures by interns and junior residents might be a cause for concern. The number of unsupervised reoperations performed by interns and junior residents on fractures of the proximal femur and malleoli was remarkably higher than for the corresponding number of primary operations (Figure 2). We speculate that this might be caused by a number of unplanned implant removal procedures, which might not require supervision.

We found a significantly lower extent of supervision for surgeries performed by junior residents and senior residents and attendings outside regular working hours. The types of procedures performed in this time frame can vary much from day to day and from one hospital to another. In some cases, only complex emergency surgery is performed. In other cases, less complex surgeries not requiring the same amount of experience are planned later in the day to make room for difficult cases during the daytime. In addition, procedures might be performed by more experienced surgeons where no supervision is required. It is also possible that attendings let junior surgeons whose skills they know perform some surgeries without supervision. Chacko et al showed significantly higher mortality rates when surgery on hip-fractures was performed outside regular hours than when performed by a dedicated daytime trauma room [14]. Ricci et al found that "after-hours surgery was an independent variable associated with the need for removal of painful femoral fracture hardware" [15]. Depending on the type and difficulty of surgeries performed after hours, our findings might be of concern.

This study shows that junior residents in orthopaedic departments participating in the DFDB Collaboration performed surgery without supervision in 32% of cases. This warrants further investigation into the types of unsupervised procedures performed by these surgeons. Also, a study of the correlation between unsupervised operations and the rates of complications as well as mortality is called for. The significant rise in unsupervised procedures outside regular working hours

calls for further study of the types of procedures done in this time period. This study has shown that the use of the DFDB is a feasible way of monitoring the quality of fracture-related surgery in regard to surgeons' experience level and the extent of supervision.

CORRESPONDENCE: Morten Jon Andersen, Ortopædkirurgisk Afdeling, Hvidovre Hospital, Kettegård Allé 30, 2650 Hvidovre, Denmark. E-mail: mortenjonandersen@dadlnet.dk.

ACCEPTED: 4 March 2014

CONFLICTS OF INTEREST: Disclosure forms provided by the authors are available with the full text of this article at www.danmedj.dk.

ACKNOWLEDGEMENTS: Contributors from The Danish Fracture Database Collaborators: Anders Jordy, Department of Orthopaedic Surgery, Kolding Hospital; Anders Wallin Paulsen, Department of Orthopaedic Surgery, Rigshospitalet; John Kloth Petersen, Department of Orthopaedic Surgery, Køge Hospital; Kim Stentzer, Department of Orthopaedic Surgery, Herlev Hospital; Lasse Birke-lund, Department of Orthopaedic Surgery, Aabenraa Hospital; Thomas Brandt Bloch, Department of Orthopaedic Surgery, Slagelse Hospital.

LITERATURE

1. Donaldson LJ, Reckless IP, Scholes S et al. The epidemiology of fractures in England. *J Epidemiol Community Health* 2008;62:174-80.
2. Singer BR, McLauchlan GJ, Robinson CM et al. Epidemiology of fractures in 15 000 adults: The influence of age and gender. *J Bone Joint Surg (Br)* 1998;80:243-8.
3. Palm H, Jacobsen S, Krashennikoff M et al. Influence of surgeon's experience and supervision on re-operation rate after hip fracture surgery. *Int J Care Injured* 2007;38:775-9.
4. Khunda A, Jafari M, Alazzawi S et al. Mortality and re-operation rate after proximal femoral fracture surgery by trainees. *J Orthop Surg (Hong Kong)* 2013;21:87-91.
5. Shervin N, Rubash HE, Katz JN. Orthopaedic procedure volume and patient outcomes: a systematic literature review. *Clin Orthop Relat Res* 2007;457:35-41.
6. Birkmeyer JD, Stukel TA, Siewers AE et al. Surgeon volume and operative mortality in the United States. *N Engl J Med* 2003;349:2117-27.
7. Wilkiemeyer M, Pappas TN, Giobbie-Hurder A et al. Does resident post graduate year influence the outcomes of inguinal hernia repair? *Ann Surg* 2005;241:879-82.
8. Hawkins WJ, Moorthy KM, Tighe D et al. With adequate supervision, the grade of the operating surgeon is not a determinant of outcome for patients undergoing urgent colorectal surgery. *Ann R Coll Surg Engl* 2007;89:760-5.
9. Brix M, Gromov K, Troelsen A. The Danish Fracture Database. 2011.
10. Müller ME. The comprehensive classification of fractures. Berlin: Springer-Verlag, 1990.
11. Gromov K, Fristed JV, Brix M et al. Completeness and data validity for the Danish Fracture Database. *Dan Med J* 2013;60(10):A4712.
12. Målbekrivelse for Speciallægeuddannelsen i Ortopædisk Kirurgi. Copenhagen: Sundhedsstyrelsen og Dansk Ortopædisk Selskab, 2011.
13. Parker MJ, Pryor GA, Myles JW. The value of a special surgical team in preventing complications in the treatment of hip fractures. *Int Orthop* 1994;18:184-8.
14. Chacko AT, Ramirez MA, Ramappa AJ et al. Does late night hip surgery affect outcome? *J Trauma* 2011;71:447-53.
15. Ricci WM, Gallagher B, Brandt A et al. Is after-hours orthopaedic surgery associated with adverse outcomes? A prospective comparative study. *J Bone Joint Surg Am* 2009;91:2067-72.