

**Completeness of Proximal Humeral Fracture Reoperation
Registration in the Swedish Fracture Register at Sahlgrenska
University Hospital between 2011 and 2016**

**Degree project in Medicine
Department of Orthopaedics
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Programme in Medicine

Gothenburg, Sweden 2019

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Abstract

Background: The Swedish Fracture Register (SFR) was started in 2011 at Sahlgrenska University Hospital (SUH). Since then, proximal humeral fractures (PHF) have been consecutively registered. Reoperation is considered a complication and is an important objective quality measurement after orthopaedic surgery. The completeness of registrations in the SFR regarding reoperations/late surgery of PHF was unknown.

Aim: The aim of the study was to validate the completeness of surgical treatment for PHF with focus on reoperations.

Methods: The study design was retrospective. Patients ≥ 16 years treated at SUH were included. Data from the SFR between 2011 and 2016 was extracted. Each personal identity number was searched for in the surgery planning program. If a missed surgical procedure was found, the medical records were reviewed for further information. Missed procedures were retroactively registered in the SFR. A new extract of the SFR was then retrieved and used for completeness calculation of different variables for reoperations.

Results: Data from 3,910 PHF registrations were included in this study. The completeness of reoperation registration was 62.0 %. The completeness for registrations of all surgical procedures was 89.0 %. The highest registration rates were achieved by specialists in orthopaedics focusing on fracture care (70.8 %). Arthroscopies were the procedures with the lowest completeness (12.5 %). The completeness for registering reoperations showed higher figures during 2016 (76.9 %) than 2012 (32.4 %).

Conclusions: This study presents a high overall completeness of registrations for PHF surgery, but a lower completeness for reoperation registrations. The reoperation completeness was in line with a previous degree project of tibial fractures at SUH from 2018. Retroactive registration

of missed surgical procedures has been conducted, which will enable further studies of PHF at SUH.

Key words: proximal humeral fracture, fracture register, completeness, reoperation

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List of Abbreviations

AO/OTA	Arbeitsgemeinschaft für Osteosynthesefragen/Orthopedic Trauma Association
ICD-10	International Classification of Diseases Tenth Revision
KVÅ	Klassifikation av vårdåtgärder (Classification of Care Measures)
PHF	Proximal humeral fracture
PIN	Personal Identity Number
SFR	Swedish Fracture Register
SHAR	Swedish Hip Arthroplasty Register
SUH	Sahlgrenska University Hospital

Background

Introduction and epidemiology

Proximal humeral fractures (PHF) are common. They account for almost 5 % of all fractures and 50 % of all shoulder fractures (1). PHF are the third most common fracture after wrist and hip fractures (2). Osteoporosis is an important factor for sustaining a PHF and the majority are caused by low energy falls (1). The incidence increases from the age of 50 in both genders, with a greater increase in incidence with advancing age for women than for men. (3) Women have a higher PHF incidence than men (ratio 7:3) (4).

Both direct violence and indirect violence may result in a PHF (5). The typical cause of injury is a simple fall, with a straight or slightly abducted arm. Among younger patients, higher energy is needed for a fracture to occur. For instance a fall from one level to another or traffic accidents can cause a fracture in non-osteoporotic bone (6).

The physical examination should focus on identifying skin or neurovascular damage. Open fractures of the proximal humerus are rare. In a study by Bergdahl et al from 2016, the authors analyzed the epidemiology of 2,011 humeral fractures in Gothenburg. In that study, only 0.2 % of all PHF were open (3). Due to the proximity of the proximal humerus and the neurovascular bundle, injuries to these structures should always be suspected in the case of a dislocated proximal humeral fracture and neurologic or vascular damage are also the most common acute complications seen in these fractures (2).

If a PHF is suspected, standard radiographs of the shoulder should be obtained including antero-posterior and a trans-scapular views. An additional axillary view (from above) can be helpful (5). In the majority of cases, these plain radiographs are sufficient in defining the fracture (2).

If more complex fracture patterns occurs, a CT-scan can be used to obtain a more detailed view, especially when needed for preoperative planning (5).

Classifications of proximal humeral fractures

There are many different classification systems for PHF. The Neer classification of PHF is probably the most frequently used along with the AO/OTA classification.

The Neer system divides the proximal humerus into four parts based on the four ossification points of the proximal humerus; the greater tuberosity, the lesser tuberosity, caput humeri and the surgical neck (humeral diaphysis) (7). The fracture lines usually follow these ossification points (1) and the fractures are divided into one, two, three or four part fractures (Fig. 1). The fracture lines are not essential when classifying the fractures, but to count as a segment it has to be at least 1 cm displaced or angulated more than 45°(4). Non-displaced fractures were not included in the original Neer classification, but later a type 1, one part fracture, has been added to the classification system. These minimally displaced fractures, even if they include multiple fracture lines, constitutes a type 1, one part fracture. The classification also takes into account shoulder dislocation combined with a PHF.

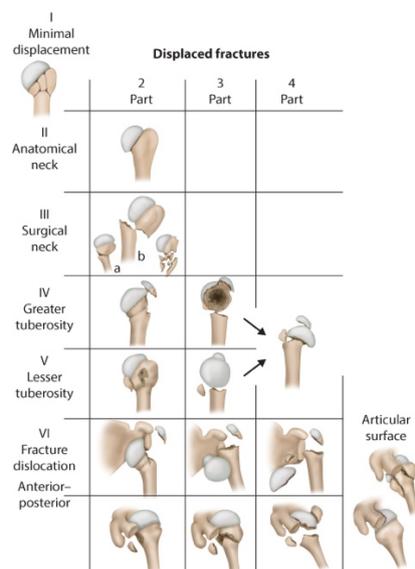


Figure 1. Different fracture types according to Neer's classification. Used with permission.

The other often used classification system is the AO/OTA classification. It uses the same segment divisions (two, three and four part fractures) as Neer's classification, but it also takes blood supply and the risk of avascular necrosis into account by classifying the status of the surgical neck and absence/presence of dislocation (1). The system goes from A to C (two, three and four part fractures) and from 1 to 3, where 3 are the most dislocated fractures. In the SFR, proximal humeral fractures are classified according to a modified AO/OTA classification.



Figure 2. Schematic images of proximal humeral fracture classification in the Swedish Fracture Register
 From: Svenska frakturregistret/AO/OTA. Used with permission.

The most common two part fracture is the collum chirurgicum fracture, shown in Fig. 3.



Figure 3. Three different collum chirurgicum fractures. The first two are minimally displaced and the third has a major displacement of the humeral head.

Treatment of proximal humeral fractures

Most fractures of the proximal humerus are non-displaced or minimally displaced and can be treated non-surgically with good functional outcomes (8, 9). However, the treatment for displaced fractures is controversial. Randomized studies have not been able to demonstrate any significant difference regarding function or patient assessed symptoms between different treatment options, but these studies have been questioned regarding methodology and power (10-12).

The consensus of today is that the indication for surgery in displaced fractures increases by the number of fractured segments, the degree of dislocation and the age of the patient. Younger patients are more likely to be treated surgically. (5) The treatment of displaced three and four part fractures depends on a variety of underlying patient related factors, e.g. comorbidity, functional demand, the bone mineral density (osteoporosis) and the experience of the surgeon (8).

Regardless of the primary treatment, operative or non-operative, these displaced fractures result in a functional impairment of the shoulder and arm and has a major negative influence on the quality of life for the patients in the elderly population (10, 13).

Treatment modalities

Non-surgical treatment with short immobilization in a sling and early physiotherapy is recommended for non-displaced fractures or for patients with low physical demands and severe comorbidities.

If a surgical approach is selected, there are several different techniques available depending on the fracture, the patient and the surgeon. The established surgical methods for PHF are internal

fixation or joint replacement.

Isolated fractures of the tuberosities, usually a dislocated greater tuberosity (A1.3 in the SFR classification), are often surgically treated. If a tuberosity fracture heals with displacement, the mechanics of the rotator cuff is altered and might cause impingement, impaired motion and pain. These fractures can be fixed with screws, suture anchors, a small plate or a combination of these methods (14).



Figure 4. *An A1-fracture, involving the greater tuberosity, fixed with a combination of screws and a smaller plate.*

If the surgical neck is fractured (collum chirurgicum fracture) a plate or an intramedullary nail can be used. The plate is inserted laterally and fixed with screws. There are anatomically shaped plates made for the proximal humerus and they are typically used in dislocated valgus fractures or in patients with good bone quality. For dislocated varus fractures, or in patients with poor bone quality, an intramedullary nail is more commonly used. In case of a three or four part fracture, complementary sutures are used to further stabilize the tuberosities and thereby the rotator cuff (14).

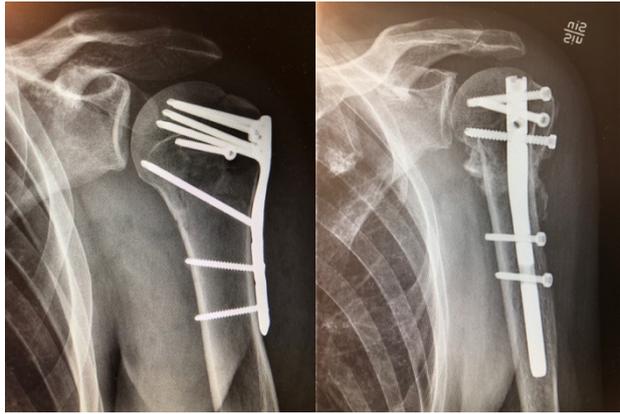


Figure 5. Fractures treated with a plate fixation (left) and an intramedullary nail (right).

Fractures in severely osteoporotic bone, or fractures with a very high risk of complications after internal fixation, shoulder arthroplasty can be a better option. The indications for a prosthesis is not clear, but the typical fracture is a dislocated four part fracture in an elderly patient. These fractures have a high risk of caput necrosis and/or tuberosity malunion, requiring further surgical procedures (14). The prosthesis can either be a hemi arthroplasty or a reverse shoulder arthroplasty. Hemi arthroplasties requires a well-functioning rotator cuff, and if that is not the case, a *reverse shoulder arthroplasty* (a non-anatomical prosthesis) is a better option (1). The reverse prosthesis can compensate for tuberosity dysfunction (2), and therefore the reverse technique may also be useful after complications like malunion or failed osteosynthesis (15, 16).



Figure 6. To the left a hemiarthroplasty and the other two are reverse shoulder arthroplasties.

Non-operative treatment has advantages such as minimal risk of infections and surgical complications. However, functional outcome is worse if non-union, malunion or avascular necrosis occurs. In addition, an observation in a study by Bosch et al shows worse outcomes with secondary surgery (> 4 weeks post injury) than with primary surgical treatment (17). It is therefore important to select the right treatment method to the right patient, in time.

Present literature of complications after PHF treatment

Several studies regarding different treatments and the result after treatment for proximal humeral fractures have been published. Most of these studies focuses on either one or two specific treatments in a selected population and often in one type of fracture. Only two studies were found that focused on reoperations after proximal humeral fracture treatment. They were either small in sample size (18) or only included in-patients (19). The latter study by Petrigliano et al only included reoperations following non-arthroplasty fixation. To the best of our knowledge there are no studies reporting on reoperation rates in a large, consecutive series of patients with a PHF including all treatments modalities.

The Swedish Fracture Register (SFR)

The Swedish Fracture Register (SFR) was started in 2011 by orthopaedic surgeons at Sahlgrenska University Hospital (SUH) with the purpose to improve fracture care. The registration in the SFR is made by the physician at the accident and emergency department, and after fracture treatment (20). Registration is web-based.

The registration is linked to the Swedish Population Register. Therefore, refugees and foreign citizens cannot be registered (21). The physician register the injury date, the injury cause and classifies the fracture according to ICD-10 and the AO/OTA classification. Additional variables

registered are treatment date, open or closed fracture, pathological fracture and the surgeons experience. The different treatment types are non-surgical, surgical or surgical after non-surgical treatment was abandoned early. Planned secondary surgery is distinguished from reoperations or late surgery after non-surgical treatment. In the case of a reoperation/late surgery, the reason for the procedure is registered (22).

The treatment code is registered according to KVA, which stands for classification of care measures (21). KVA is a national standardized system with codes of non-surgical and surgical healthcare that are mandatory for the hospitals to report to the Board of health and welfare (Socialstyrelsen) (23).

Based on the fracture registration in the SFR, all patients receive surveys right after the injury. They are asked to report their function the week before the fracture occurred, with a so called recall technique. Patients answering the questionnaires are sent the same surveys one year after the fracture. These patient reported outcome measures (PROM) are used to evaluate the patients' health related quality of life and their functional status before and after the fracture (21).

The SFR is a national quality register with the aim to use the collected information it generates to be able to select the best possible treatment for each individual patient. Every department can also compare their fracture treatment results with other departments and to the national average. If a department has inferior values, new routines can be created to improve the medical care (20).

The SFR differentiates the concepts “coverage” and “completeness”. The coverage is the number of participating hospitals in relation to the number of hospitals treating fractures in the country. The completeness is the number of fractures registered in relation to the number of fractures that has occurred (24).

The coverage 2017 was 70-80 % (25) and has 2019 increased to 85% (personal communication, Möller M). It has been shown that it is possible to register fractures with a high completeness. When the data from the SFR is compared to official health databases as the Patient register at the Board of health and welfare (Patientregistret hos Socialstyrelsen) a completeness of 70-95% has been detected for fracture registrations (26). Data from the SFR has to be reliable if research of high quality is the goal. Therefore validation studies of the register is required. A previous degree project in 2018 with a validation of tibial fractures between 2011 and 2015 has been performed (27). To be able to make further studies of humeral fracture treatment, a similar validation study was needed.

Validation of the SFR

Several validation studies focusing on different aspects of the SFR, both degree projects and published studies, have been reported. For humeral fractures, there is one study on epidemiology of humeral fractures between 2011 and 2013 (3), and one investigating the validity of humeral fracture classification (28). There is also one study evaluating ankle fracture classification (29). Two other studies are focusing on a description of the register (22), and an implementation of the SFR during its first seven years, with the register’s opportunities and limitations (30).

Two degree projects focusing on the validation of the SFR have been performed, one by Kapetanovic 2015 and one by Selse 2018 (27, 31). Kapetanovic investigated all humeral and tibial fracture reoperations registered during 2011. The completeness for all humeral fractures, PHF included, was 54.2 % (n reoperations=59). Selse validated the SFR between 2011 and 2015 regarding tibial fractures and the results in her study showed a completeness for reoperations of 63.0 %.

Hypothesis

The registration of reoperations after treatment for PHF was expected to be incomplete. Since the registration of tibial and humeral fractures started at the same time at SUH, a similar completeness for registering reoperations after PHF as in the study by Selse (27) of tibial fractures was expected.

Aim

The aim of the study was to validate the completeness of surgical treatment registrations with focus on reoperations. Humeral fractures registered in the SFR at SUH between 2011 and 2016 were evaluated. The validation will serve as a foundation for the analysis of reasons for reoperations in a planned research project.

Methods

The study design was retrospective and based on available registrations in the SFR. All registered proximal humeral fractures (ICD-10 S42.20), in patients 16 years and older at injury, treated at SUH between January 1st. 2011 and December 31st, 2016 was extracted from the SFR.

Included patients were either primary treated at SUH or sent from other hospitals in Sweden for surgical care. The extraction of data was made in 2018 using SPSS statistics software.

The data consisted of 3,831 registrations. Because a fracture can be treated sequentially there can exist various registered treatments for one single fracture. Some patients appear more than once because of repeated fractures or bilateral fractures during the study period.

The exclusion criteria were: patients treated at other hospitals or injured abroad. Patients injured abroad were excluded from the study and deleted from the SFR since the aim of the register is to include only fractures that have occurred in Sweden. Patients primarily treated at other hospitals were excluded because it was judged not possible to obtain these hospitals data from medical charts and operation planning systems. In addition, those patients were most likely difficult cases, which could distort the results. In total, 13 reoperations on 9 patients were excluded.

The validation of data from the SFR was performed between January and April 2019. Each personal identity number (PIN) in the SPSS-file was checked in the operation planning program “Operätt”, which was used for all surgeries at SUH during the study period. The search in “Operätt” was done for surgery performed at all three hospitals that forms SUH. The included departments in “Operätt” were “Dagkir MS-ORT”, “COP MS-ORT”, “Ortop SS” and “Ortop ÖS”.

Each registration in the SFR was compared to the available information in “Operätt” regarding number of surgeries, dates and codes. If the SFR and “Operätt” were not consistent, the medical record “Melior” was also checked. All missed registrations of primary surgeries and

reoperations/late surgery were noted in a separate SPSS file and retroactively registered in the SFR to make it complete.

A new data extraction from the SFR was made in April 2019, when all missed registrations had been registered in the SFR. The completed SPSS-file was then merged together with the SPSS-file of missed surgical procedures for further analysis including calculation of the completeness in the SFR. Data analysis was performed by using IBM SPSS Statistics 25.

The completeness was analyzed for primary procedures, early changed treatment from non-operative to operative treatment, planned secondary surgery (rare for PHF) and reoperations/late surgery. The completeness was calculated by dividing the number of all procedures (missed and registered) minus all missed procedures by all procedures. If no missed procedures occurred, the completeness was 100 %. The number of missed registrations per patient was calculated using the SPSS software. For reoperations/late surgery completeness in correlation to gender, age, the type of procedure, the complication causing the reoperation, the experience of the main surgeon was analyzed. Completeness per year and month was also investigated.

Ethical considerations

This study is a register study based on data from the SFR and the surgery planning program “Operätt”. When they were not consistent, the medical records in “Melior” were used and in selected cases x-rays of the fractures in order to classify or to evaluate the type of surgery performed.

The study does not involve any risk or inconvenience for the patients. It is a retrospective study, and it is not interfering with the patients' treatment. The patients do not directly benefit, nor do they harm, from the study. The knowledge the study might generate can be of high value since the SFR adds a new type of information about fracture treatment. In the future, this can lead to improved care for humeral fracture patients and better use of public resources.

This validation study is part of a larger study on humeral fractures at SUH and the Sahlgrenska academy, Gothenburg University and a prerequisite for it to take place. Ethical approval exists from the Regional Ethics Review Board (Dnr: 1042-17).

Patients may withdraw their consent to be in the SFR, with withdrawal of their data, at any time (32).

Results

The study involved 3,910 registrations on 3,426 patients (after retroactive registration of missed procedures). 1,095 surgical procedures (28.0 %) and 2,814 non-operative treatments (72.0 %) were registered. One treatment was missing in the register. Only 3 out of 677 primary procedures were missed, which gives a completeness of 99.6 %. 23 out of 167 registrations for early change of treatment – initial non-surgical treatment changed to surgical treatment within 30 days from injury – were registered, which gives a completeness of 86.2 %. The reoperations and late surgery (post 30 days from injury date) had a lower completeness with 93 registrations out of 245 missed which gives a completeness of 62.0 %. For primary surgery, performed within a month from injury, the completeness was 96.9 % (n=844). The overall completeness for all surgical procedures was 89.0 %.

Table 1. *Completeness for surgical treatments based on treatment type.*

	N, missed reoperations	N, all procedures	Completeness (%)
Primary surgical treatment	3	677	99.6
Early change to surgical treatment	23	167	86.2
Planned secondary surgery	0	6	100.0
Reoperation	93	245	62.0
Total	119	1095	89.0

N, frequency

The majority of all patients in the study had no missed procedures (n=3325, 97.0 %). Most patients with missed registrations had only one missed procedure (n=88, 2.6 %). The highest number of missed registrations for one patient was four.

Table 2. Numbers of missed registrations per patient.

Numbers of registrations	N	Percent
0	3325	97.0
1	88	2.6
2	9	0.3
3	3	0.1
4	1	<0.1
Total	3426	100.0

N, frequency

The following tables are describing different variables in the SFR when comparisons are made between missed and registered reoperations and late surgery. Reoperations and late surgery are presented as reoperations in the remaining part of this report.

Patient characteristics

The majority of reoperations were seen in patients between 41 and 80 years of age (n=204, 83.3 %). Within these age groups, the completeness was higher among the older population. It was 50.0 % among the 41-50-year-old patients and 71.7 % among the 71-80-year-olds (Table 3).

Most reoperations were performed on women and the completeness was also slightly lower among women than men (Table 4).

Table 3. Numbers of missed reoperations based on age at time of injury.

Injury age	N, missed (%)	N, all	Completeness (%)
16-20	0	2	100.0 %
21-31	1	4	75.0 %
31-40	5	11	54.5 %
41-50	12	24	50.0 %
51-60	27	62	56.5 %
61-70	28	72	61.1 %
71-80	13	46	71.7 %
81-90	6	22	72.7 %
>90	1	2	50.0 %
Total	93	245	62.0 %

N, frequency

Table 4. Distribution of missed reoperations based on gender.

Gender	N, missed reoperations	N, all reoperations	Completeness (%)
Female	66	165	60.0 %
Male	27	80	66.0 %
Total	93	245	62.0 %

N, frequency

Missed reoperation registrations

In total, there were 93 reoperations with missing registrations in the SFR (Table 1). Two-thirds (67.8 %) of these missed procedures were performed due to patient related discomfort or implant failure (e.g. screw penetration into the joint or improperly placed implants causing fracture displacement, impingement or pain). These two groups also had the lowest completeness (25.6 % and 42.4 % respectively). The highest completeness was found among reoperations due to non-union and malunion (82.6 % and 86.8 %).

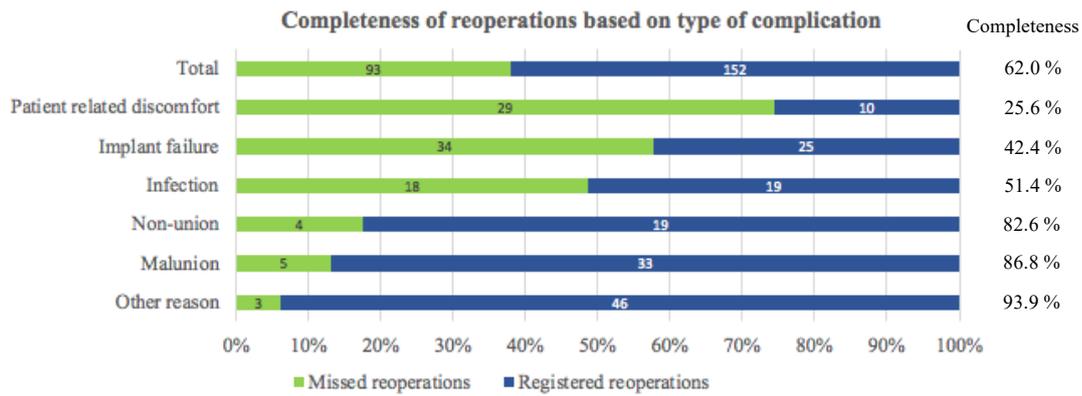


Figure 7. Bar chart representing the completeness of reoperations based on type of complication. The frequency of missed and registered reoperations is seen in the bars.

Fig. 8 shows reoperations based on type of procedure. Arthroscopies had, by far, the lowest completeness with 12.5 %. Only 4 out of 32 procedures were registered. The highest registration rates were among procedures like plate fixation and intramedullary nailing (87.5 % and 90.0 %), even though those procedures were few in numbers (n=8 and n=10). The most common reoperation was extraction of internal fixation material (n=95), which accounted for almost 40 % of all reoperations.

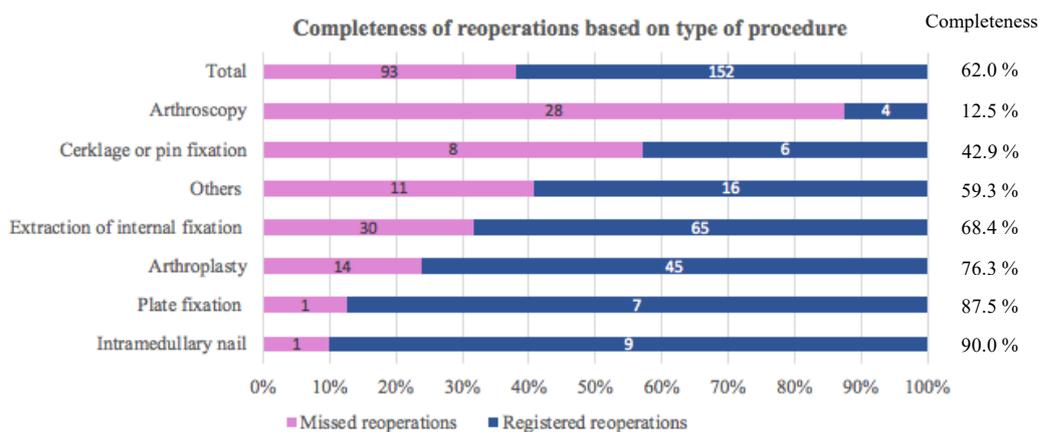


Figure 8. Bar chart representing the completeness of reoperations based on type of procedure. The frequency of missed and registered reoperations is seen in the bars.

When analyzing the experience of the main surgeon, specialists in orthopaedics with more than 50 % fracture surgery performed most of the surgeries, 79.6 % of all procedures, and they also

had the highest completeness, 70.8 %. The lowest completeness (9.6%) was seen among the specialists in orthopaedics.

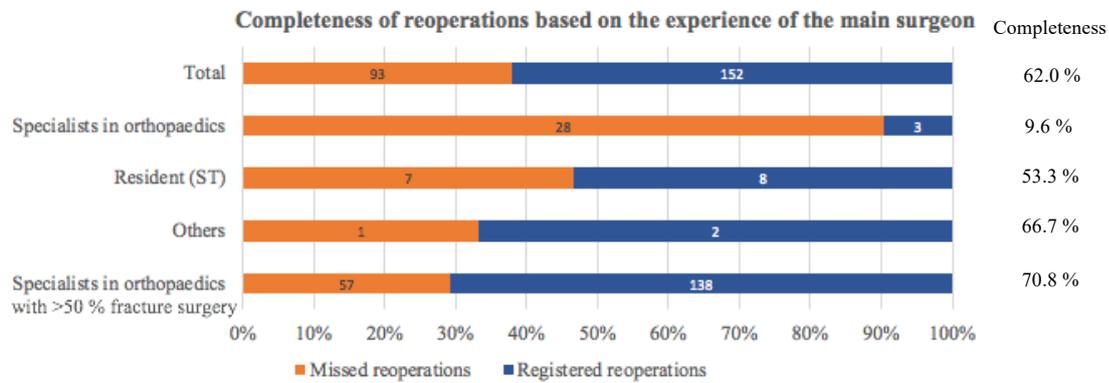


Figure 9. Bar chart representing the completeness of reoperations based on the experience of the main surgeon. The frequency of missed and registered reoperations is seen in the bars.

The registration over time shows an increasing trend of higher completeness for reoperations in the SFR (Fig. 10). The high number (81.6 %) for 2011 is due to a previous study by Kapetanovic, where missed registrations were retroactively registered in the SFR when the study was completed (31). During 2015 and 2016, the completeness regarding reoperations had reached a level of almost 80 %.

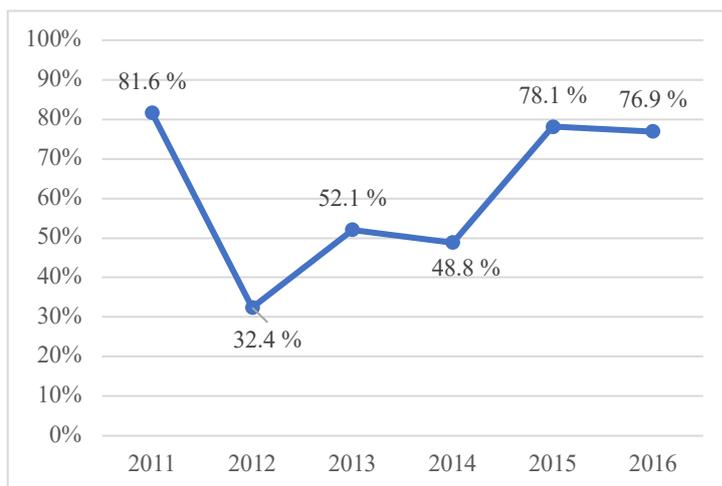


Figure 10. Line chart illustrating the completeness for reoperations per year from 2011 to 2016.

The distribution of missed reoperations per month varied from 42.9 % (May) to 90.0 % (April). Most reoperations were performed in the winter. The completeness was higher during the summer months than in the winter (Table 5).

Table 5. *Distribution of missed reoperations per month during 2011-2016.*

Month	N, missed reoperations	N, all reoperations	Completeness (%)
January	11	24	54.1 %
February	11	26	57.7 %
March	13	27	51.9 %
April	2	20	90.0 %
May	8	14	42.9 %
June	7	25	72.0 %
July	5	16	68.9 %
August	3	17	82.3 %
September	9	19	52.6 %
October	11	21	47.6 %
November	6	22	72.7 %
December	7	14	50.0 %
Total	93	245	62.0 %

N, frequency

Discussion

This study was based on data from 3,910 PHF treatments from the SFR at SUH. The main result shows a completeness of reoperation registrations at SUH between 2011 and 2016 of 62.0 %. The completeness for reoperations was lower than for primary surgery (99.6 %) and for registrations of early change from non-operative to surgical treatment (86.2 %). The lowest completeness was seen among specialists in orthopaedics. When comparing different surgical procedures, arthroscopies had the lowest completeness. The missed reoperations that were due to patient related discomfort and implant failure showed the lowest completeness. The completeness for reoperations has a higher figure during 2016 than 2012.

The results show variations when analyzing patient-, time-, implant-, surgeon and method-related factors. The highest completeness was seen among specialist with more than 50 % fracture surgery, eg specialists in orthopaedics with fracture care as their main interest. Their high completeness when registering reoperations might be due to them treating fractures on a daily basis and they are therefore used to register in the SFR. They also perform most of the reoperations and use the SFR as a part of their daily activity. The graph illustrating the completeness based on type of complication (Fig. 7) displays a higher completeness for non-union and malunion. This could be because the trauma specialists perform the majority of these surgeries and they have a higher registration rate. These procedures are also strongly linked to the fracture, which could have a positive effect on the willingness to register in the SFR. The reoperations due to infections, patient related discomfort and implant failure can be performed by physicians with minor experience and specialists in orthopaedics that do not primarily treat fractures. Since they do not work with the SFR on a daily basis, they probably forget registering and therefore the lower completeness among these procedures could be explained by the experience of the main surgeon. In addition, the surgeon might not always connect a late surgery to a previous fracture.

The distribution of missed reoperations per month showed a variation between 42.9 % in May and 90.0 % in April. During the autumn, the completeness rates also varied a lot (52.6-72.7 %). These figures may be due to chance. However, it could be a seasonal correlation since the completeness was lower during December to March (50.0-57.7 %) than during June-August (72.0-82.3 %). One can speculate if the reason was due to a higher workload during the winter months. There is a higher fracture occurrence during the winter, as shown in the study by Bergdahl et al (3), why also primary surgery should be higher during this period of time. Elective arthroscopies, which had a low completeness, are not performed during the summer,

which could also increase the completeness during these months since arthroscopies showed a low completeness in this study.

Even though it is not investigated further in this study, many of the arthroscopies are probably due to patient related discomfort. All fracture surgeons do not perform arthroscopies, but specialists in orthopaedics do. This category showed the lowest completeness. Another explanation why arthroscopies and reoperations due to patient related discomfort had a low completeness might be that these procedures were often performed long time after the fracture, why these registrations demand extra awareness of the surgeon to remember registering in the SFR.

The number of reoperations between 2011 and 2016 varied from 32 to 49 per year. Except the high completeness during 2011, which was due to the retroactive registration done by Kapetanovic (31), the completeness of reoperations per year shows higher figures over time. It is almost 80 % during 2015 and 2016. Using the SFR has become part of the daily work at the department at SUH and it seems the register data becomes more reliable over time.

There are different ways of validating register data. In this study, the surgery planning program “Operätt” and the medical records “Melior” was used for validation. They were considered the “truth”. In the Danish Fracture Database, a validation study was published 2013 (33). They also used the surgery planning program as gold standard. The study included all surgical procedures (322 patients, 387 procedures) at two departments in Denmark during a one month-period. For primary procedures, the completeness was 88 %, for reoperations 77 % and the total completeness was 83 %. The figures are comparable to this study, with a higher number for

reoperations. The Danish Fracture Database includes both in-patients and out-patients, but not non-operative treatments, as in the SFR.

In Finland, the Finnish National Hospital Discharge Register has been investigated. There is a validation study from 2014 focusing on hip fractures, where the medical records and radiographs were used for validation (34). The completeness was high regarding diagnosis (96 %) and accuracy (88 %). However, reoperations and late surgery are not recorded in the register.

There are also other types of orthopaedic registers than fracture registers. In Sweden, there is for example the Swedish Hip Arthroplasty Register (SHAR), started in 1979. That register does not include all reoperations, only revisions are included and defined as the failure endpoint. SHAR was validated by Söderman et al 2000 by comparing the register with the National Discharge Register (from the Swedish National Board of Health and Welfare, “Socialstyrelsen”) and the National Death Register. The completeness was >95 % for both primary surgery and revision (35).

The Swedish Knee Arthroplasty Register has been validated by sending a questionnaire to all living patients who had been operated between 1975 and 1995. It included a total of 30,796 knees and 93 % of the patients answered. The results showed that one fifth of all revisions were not registered (36). As with the SHAR, The Swedish Knee Arthroplasty Register does not include all reoperations, only revisions, defined as reoperations during which one or more components are removed, exchanged or added, including also amputation and arthrodesis.

A degree project by Selse during 2018 on tibial fractures had a similar method and aim as the present study. Her study included all tibial fractures at SUH between 2011 and 2015. The

material consisted of 1,371 fractures treated with 2,160 surgical procedures (27). Her completeness rates were almost the same as in this study. For primary procedures, the completeness for tibial fractures was 99.1 %, compared to 99.6 % for humeral fractures. Regarding reoperations the completeness was 63.0 % for tibial fractures and 62.0 % for humeral fractures. The overall completeness for all surgical procedures was 90.0 % for tibial fractures and humeral 89.0 % for humeral fractures (Table 1). Planned secondary surgery is more common for tibial fractures than humeral fractures, and those results are therefore not comparable.

When regarding treatment methods, arthroscopies had the lowest completeness among both fracture types (18.2 % for tibia and 12.5 % for humerus), strengthening the conclusion that completeness is depending on type of procedure and surgeon. Regarding the type of complication, Selse also showed that the lowest completeness was found among reoperations due to patient related discomfort (33.1 % for tibial fractures and 25.6 % for humeral fractures). However, reoperations due to implant failure had a higher completeness among tibial fractures (78.9 %) than humeral fractures (42.4 %). The highest registration rates when comparing the experience of the main surgeon was also seen among the trauma specialists for tibial fractures (68.7 % for tibial fractures vs 70.8 % for humeral fractures). Specialists in orthopaedics had a far better registration completeness for tibial fractures than for humeral fractures (53.3 % and 9.6 % respectively). Selse's study also showed an increasing trend of reoperation registrations over time, with the highest rates during the last two years of the study. The completeness was 42.1 % 2012 and 70.8 % 2015 for tibial fractures and the figures for PHF these years were 32.4 % and 78.1 %).

A degree project by Kapetanovic from 2015 was also focusing on reoperations. It included both humeral and tibial fractures in the SFR during 2011. The results during that first year of the SFR showed a completeness for humeral fracture reoperations of 54.2 % (31). The study included all humeral fractures, both proximal, shaft and distal. However, since most humeral fractures are proximal, 79 % according to Bergdahl et al from 2016 (3), the completeness found by Kapetanovic is most likely transferrable to only PHF. The completeness during 2011 in this study was 81.6 %, which is comparable to Selse's degree project about tibial fractures with a completeness of 87.2 % during 2011 (27). The high number that year was due to retroactive registration of missed procedures. Why the completeness is not 100 % could be explained by reoperations performed later than 2015.

Strengths and limitations

This study includes a large number of consecutively registered treatments of PHF from a population based register. All treatment modalities and both in- and out patients are included in the study. Since SUH is the only hospital in the catchment area treating fractures, all patients with suspected fractures of the proximal humerus are referred to SUH. This means all patients that received any type of treatment for a PHF in the catchment area during the study period, was most likely treated at SUH. A possible limitation is that only PHF treatments registered in the SFR are included in the study. Primarily missed registrations cannot be controlled with the current study method. However, the completeness of registration for all PHF fractures at SUH, based on partly the same cohort (2011-2012) as the current study, has been investigated by Nilsson et al. They showed that around 90 % of all primary registrations (non-operative and surgically treated PHF) were registered in the SFR (unpublished manuscript, May 2019). The risk of a fracture being missed at least twice, which is the lowest number of registrations for a

reoperation/late surgery, is therefore considered low, and therefore most fractures that have undergone reoperations during the actual period of time should be included in this study.

As mentioned, SUH is the only hospital treating fractures in Gothenburg. The routine at the orthopaedic department at SUH is to follow all the patients surgically treated at the department. At SUH there is a possibility to perform all types of surgical interventions and therefore the majority of all reoperations should have been performed at SUH. However, it cannot be excluded that patients have undergone reoperations/late surgeries after a PHF at private hospitals. It could possibly be some arthroscopies and perhaps plate extractions that are missing in this study. However, that number should be negligible.

The results can only be interpreted for PHF treatment at SUH. However, the results regarding overall surgical completeness and the completeness for reoperations are almost the same as for tibial fractures (27). Therefore, the degree of reoperation registrations at SUH might be interpreted more generally, at least for fractures of the long bones as tibia and humerus. However, the registrations in the SFR of other fractures than humeral and tibial fractures started later than 2011, why the completeness rates for registration of reoperations could be different. Hopefully, other fractures show the same positive registration trend over time as tibial- and PHF. Therefore, they might have a better overall completeness rate for reoperation registration than tibial- and PHF.

Recommendations

The validation of the SFR reflects the actual time frame at SUH. Further validation studies are needed to validate other fracture types. There could also be a variation between different centers in Sweden that needs to be further investigated. During the coming years, a new validation

study on reoperations following PHF at SUH is recommended, since the register is still under development and this study demonstrated higher registration rates during the later years of the study.

Conclusions and implications

This study shows a high overall completeness of registrations for proximal humeral fracture surgery and a lower completeness for reoperation registrations. Compared to Selse's degree project of tibial fractures in 2018, the overall completeness and the completeness for reoperation registrations were almost the same (27). The difference in registration completeness dependent on the experience of the treating orthopaedic surgeon, is a fact that could be addressed in order to achieve more reliable data in the SFR at SUH. Retroactive registration of missed surgical procedures has been conducted which will enable further studies of humeral fracture treatment at SUH. They will hopefully lead to a deeper understanding of fracture treatment and improved care for the patients in the future.

Populärvetenskaplig sammanfattning

Validering av reoperationer på överarmsfrakturer i Svenska frakturregistret mellan 2011 och 2016

Svenska frakturregistret (SFR) startades 2011 på Sahlgrenska Universitetssjukhuset (SU). I början registrerades bara överarms- och underbensfrakturer, men idag registreras alla frakturer på drygt 80 % av alla sjukhus i Sverige. Alla frakturer och behandlingar, både operationer och behandlingar utan kirurgi, registreras. För att ett register ska kunna anses tillförlitligt och kunna användas i forskningsstudier krävs valideringsstudier, som utvärderar registrets data.

Den här studien har undersökt axelnära överarmsfrakturer, vilka oftast drabbar personer över 50 år med benskörhet. Studien har tittat på hur många operationer av dessa frakturer, utförda på SU, som har registrerats i SFR 2011-2016 genom att jämföra datan från registret med en annan databas där alla utförda operationer finns med. Syftet med studien var att studera registreringsfrekvensen av reoperationer och sen kirurgi. Reoperationer innebär att man opererar en fraktur minst två gånger, då den första operationen inte givit önskat resultat. Exempel på orsaker till reoperationer är en infektion, att materialet man har opererat in i överarmen har flyttat på sig eller för att patienten har ont. Sen kirurgi kan genomföras om läkningen inte har gått som förväntat eller om patienten har ont och man bedömer att chansen är god till att man kan ge patienten mindre besvär genom en operation.

Totalt kontrollerades 3910 olika behandlingar hos 3421 olika patienter. Resultaten visade att läkarna var bättre på att registrera tidig kirurgisk behandling, inom en månad från skadan, än sena operationer och reoperationer. 97% av de tidiga operationerna registrerades i SFR, medan 62% av sena operationer och reoperationer var registrerade. Reoperationer pga

patientupplevda besvär eller besvär med inopererat material hade lägst andel registreringar (26 % respektive 42 %). Tithålsoperationer hade lägst registreringsfrekvens på 13 %, medan frakturstabiliserande ingrepp med inopererat material registrerades i högst grad. De läkare som är specialister inom frakturkirurgi utförde flest reoperationer och var också bäst på att registrera dem (71 %). Studien visade glädjande nog att siffrorna för antalet registreringar av reoperationer är högre under 2016 (77 %) jämfört med 2012 (32 %). Kunskapen från studiens resultat kan användas för att motivera läkarna på SU att komma ihåg att registrera reoperationer, så att tillförlitligheten i registret ökar.

Under studiens gång har alla 119 missade operationer efterregistrerats i SFR, varför registret under den aktuella tidsperioden nu kan anses komplett. I dagsläget vet man inte vilka behandlingsmetoder som är bäst och det finns inte några studier på ett så stort material med reoperationer som inkluderar alla frakturer och behandlingar. Resultatet av den aktuella valideringsstudien är därför viktigt för framtida forskning inom området, vilket i förlängningen kan förbättra vården för patienter med dessa typer av frakturer.

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