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Fractures of the lateral malleolus – A follow up study of treatment and resource utilization after implementation of a structured treatment algorithm at Sahlgrenska University Hospital

Degree Project in Medicine

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Abstract

Introduction

Ankle fractures are very common. Around 350-400 patients with lateral malleolar fractures are treated at Sahlgrenska University Hospital (SU) every year (1). In this study we focused on the most common subgroup classified as AO-44B1, with a further subset into B1.1 and B1.2/3. This type of fracture can be either stable or unstable. Distinguishing between the two types is sometimes difficult due to potential injuries on adjacent ligaments, not visible on plain radiographs. Making a correct clinical assessment is crucial to elect adequate treatment and follow-up, which in turn affects the use of resources. In order to sharpen the diagnostics and simplify the assessment a structured treatment algorithm (PM) was introduced at SU in September 2017. This PM has been in use for almost two years and the possible differences in regard to treatment and utilization of resources can be compared between groups of patients treated before and after its implementation.

Aim

The first aim was to analyze the post-PM group in relation to the guidelines in order to investigate to what extent the PM had been followed. The second objective was to study the effect on a number of resource related variables since the introduction of the PM.

Methods

This study consists of two separate populations of patients treated before- and after the introduction of the PM. Consequently, referred to as the pre- and the post-PM group. Data was extracted from the Swedish Fracture Register and further information collected through a detailed review of medical records and radiographs. Comparative statistics such as Chi^2 test and Mann-Whitney non-parametric test were executed using SPSS 25.

Results

The number of operated patients with B1-fractures had been significantly reduced since the implementation of the PM. ($p < 0.001$). Regarding the patients given surgical treatment our study revealed a significant decrease in the number of days immobilized ($p < 0 .001$) and the number of days inpatient care ($p = 0.001$). We found only 2 cases where non-surgical treatment was converted to surgical at an early stage due to findings on the follow-up radiographs.

Our study shows an excessive use of radiographs and follow-up visits among patients diagnosed with a B1.1 fracture given non-surgical treatment. They were also immobilized for more days than what is recommended in the PM.

Conclusion

The compliance to the PM needs to be increased. Especially when it comes to the number of radiographic examinations, follow-up visits and immobilization time for non-surgically treated patients. The mandatory 1-week follow up with radiographs may be removed from the PM since it rarely leads to any changes of treatment. Nonetheless, we advocate further investigations to be made before doing so.

Keywords

Ankle fracture, The Swedish Fracture Register, use of resources, treatment algorithm.

Introduction

In 2015 an epidemiological study (2) of all ankle fractures treated at SU during two consecutive years was conducted. The aim of the study was to investigate the epidemiology and describe the treatment of ankle fractures in general and detailed mapping of treatment and treatment results for lateral malleolar fractures at the level of the syndesmosis. Data was extracted from The Swedish Fracture Register (SFR) including all patients registered as treated at SU with ankle fractures during 2012-04-01 to 2014-04-01. Medical records and radiographs were studied and descriptive statistics was performed on this data (2). The work contributed to the development of a structured treatment algorithm which was introduced clinically in September 2017 (3). This algorithm has to present date been in use for over two years and the possible differences in regard to findings at first examination, treatment methods and utilization of resources can be compared before and after its implementation. In this study we also investigated to what extent the new algorithm had been followed in daily practice at SU.

Anatomy of the ankle joint

The ankle joint or talocrural articulation consists of three articulating bones. The tibia, fibula and talus. The tibia and fibula together with the lower part of posterior tibiofibular ligament forms a mortise similar to a rectangular socket where the superior part of talus, the trochlea fits. The fork like shape of the distal parts of the tibia and fibula, the malleolus, can be palpated on the medial and lateral side of the ankle. They constitute the medial and lateral limitations of the mortise whilst the roof is formed by the inferior surface of tibia, the tibial plafond. Through tibia the vast majority (80-90%) of the bodyweight is transferred to the talus and depending on the position of the foot the main force is directed to different aspects of the talus (4). The ankle joint permits mainly plantar- and dorsiflexion but in its most unstable position, plantarflexion, some small movement of adduction, abduction, inversion and eversion is also possible. This position dependent stability is due to the shape of the talar trochlea. The trochlea has a slightly conic shape in transverse plane, with the wider part anteriorly, resulting in that when the foot is dorsiflexed the wider part of trochlea enters between the two malleoli and applies a separating force which tightens their grip, and on the other aspect thus loosening their grip when the foot is plantarflexed. (5, 6)

In order to prevent the tibia and fibula from being forced apart three ligaments are of importance. The interosseous tibiofibular ligament, anterior tibiofibular ligament and posterior tibiofibular ligament. This complex of ligaments is often referred to as the tibiofibular syndesmosis. The interosseous tibiofibular ligament is a distal continuation of the interosseous membrane and its mesh of fibers fills out most of the distal space between the tibia and fibula. The anterior portion of the interosseous tibiofibular ligament continues as the anterior tibiofibular ligament which runs obliquely in laterodistal direction. The posterior fibers of the interosseous ligament continue in a smooth transition into the posterior tibiofibular ligament which runs almost horizontally from the distal posterior surface of tibia to the lateral malleolus. The lower part of this ligament is by some considered a separate structure namely transverse tibiofibular ligament, whilst others advocate it should be seen as an integrated part of the posterior tibiofibular ligament (7, 8)

The stability of the ankle joint is furthermore reinforced by collateral ligaments on the medial and lateral side. The deltoid ligament on the medial side is a triangular shaped, strong structure that fans out from the medial malleolus in distal direction. It has four different insertion points and is hence subdivided into four separate units named after the structure where inserted. Biomechanical and cadaver studies has shown that the deltoid ligament in association with the medial malleolus are the primary stabilizing units of the ankle. Especially the deeper part of the deltoid ligament is considered to be of great importance (9-12). On the lateral side the ankle joint is stabilized by three separate ligaments connecting the lateral malleolus on the fibula to the talus and calcaneus respectively (13).

Classification of ankle fractures

There are several different systems enabling classification of fractures. Some examples of commonly used systems are Danis-Weber, Lauge-Hansen and Müller-AO (AO). They all use different variables and level of detail but share the same objective, to create a standardized description of each fracture. The AO classification is used in the SFR since it offers the advantage of covering all different extremity fractures with only one system. Usually the classification and reporting to the SFR is done in the accident and emergency department by doctors with different level of experience. However, the system has been proven accurate with high agreement between classifications made in the SFR compared to gold standard classification (14). When it comes to classification of ankle fractures it is either based on foot position and direction of force applied as suggested by Lauge-Hansen or by anatomical location as in the AO and Weber systems. Classifying ankle fractures help to assess the probability of simultaneous ligament injuries making the ankle unstable. The benefit of this depend on the difficulty to discover ligament injuries solely with plain radiographic imaging. Even though other imaging techniques such as computed tomography (CT), magnetic resonance imaging (MRI) and ultrasound are proven to have high sensitivity in detecting ligament injuries these methods are more expensive and often not promptly accessible in the acute phase (15).

The embryo of the AO (Arbeitsgemeinschaft für Osteosynthesfragen) was founded by a small group of Swiss surgeons in 1958 with the purpose to perform studies on bone healing, inspired by the previous work of Robert Danis. His observations had shown that diaphyseal fractures heal without external callus if rigid stability is obtained through compression. Those findings formed the basis of the continuous work of AO and development of early, basic principles of fracture treatment. Since then the AO foundation, which is a non-profit organization, has grown to cover five continents and it comprises a network of 170.000 health care professionals in 124 countries. Throughout the years AO research has not only contributed to the knowledge of healing of fractures but also to development of materials and methods for fixation as well as extensive documentation. In 1987 Müller et al presented the first AO fracture classification system. This enabled a systematic methodology for describing all types of fractures and is now widely spread and used internationally. (16)

The advantage of using the AO system is the creation of a uniform language that simplifies the sharing of information between units and individuals. It also facilitates database storage and retrospective comparisons since verbal descriptions are transformed into alphanumeric values. The basis of the AO classification is the anatomic location of the fracture and starts with two numbers. The first number is determined by which bone is affected and the second number describes where the fracture is located on the bone. In accordance tibia/fibula fractures located in the malleolar section are categorized as 44. Regarding ankle fractures a further subgrouping is applied depending on the position of the fractures in relation to the inferior syndesmosis, which follows the system of Danis-Weber, into type A, B and C. Type A fractures are located inferior to the syndesmosis, type B fractures are trans-syndesmotic and type C are located superior to the syndesmosis. In the AO system the A, B and C types are then further divided into three subgroups each, numbered 1-3 depending on the number of malleolus that are fractured. Type B1 involves only the lateral malleolus whilst B2 involves both lateral- and medial malleolus or ligament. If even posterior malleolus is injured resulting in a tri-malleolar fracture it is categorized as a B3 injury. For the types A1-3 and B1-3 even further subgrouping is made by decimals one to three. Hence a single fracture involving only the lateral malleolus, passing trans syndesmotic and without injuries to the anterior syndesmosis, will be categorized as 44-B1.1. If even the anterior syndesmosis is ruptured it is named 44-B1.2 and if the fracture is multi-fragmentary it is classified as 44-B1.3. (17)

The Swedish Fracture Register

The Swedish Fracture Register (SFR) is a national quality register collecting data on all types of fractures in extremities, back, shoulders and pelvis. The first registration was made in 2011 and ankle fractures have been registered since 2012-04-01. In 2018 the register included 45 out of 55 orthopedic clinics in Sweden (18). The SFR collects data regarding fracture type, cause of injury and given treatment, including non-surgical treatment. Moreover, reoperations and cases where primary treatment was converted to surgical are registered. Subsequent treatment results are measured by numbers of reoperations/late stage operations and patient reported outcome measures (PROM) where EQ-5D is used to measure health-related quality of life (19). For evaluation of musculoskeletal function, the patients are given a questionnaire

Short Musculoskeletal Function Assessment (SMFA) to report their function before the injury by recall (20). For those who participate an identical questionnaire is sent out one year later for assessment of post-injury function.

B1-ankle fractures

The challenge in evaluating lateral malleolar fractures passing trans-syndesmotic is they might look stable on first radiographic image (Figure 1). However, there can also be additional damages to the deltoid ligament not visible on plain radiographs (Figure 2). As the level of damage on the lateral side increases the more likely it is with simultaneous medial injury. In that case the fracture becomes unstable and benefits from surgical treatment (21). The classification descriptions and pictograms used in the treatment algorithm were released by AO in 1996. However, there is a more recent update which was released in a compendium 2018 but it had no changes regarding ankle fractures. Since the meaning is the same but with updated images, we chose to present the latest pictograms below.

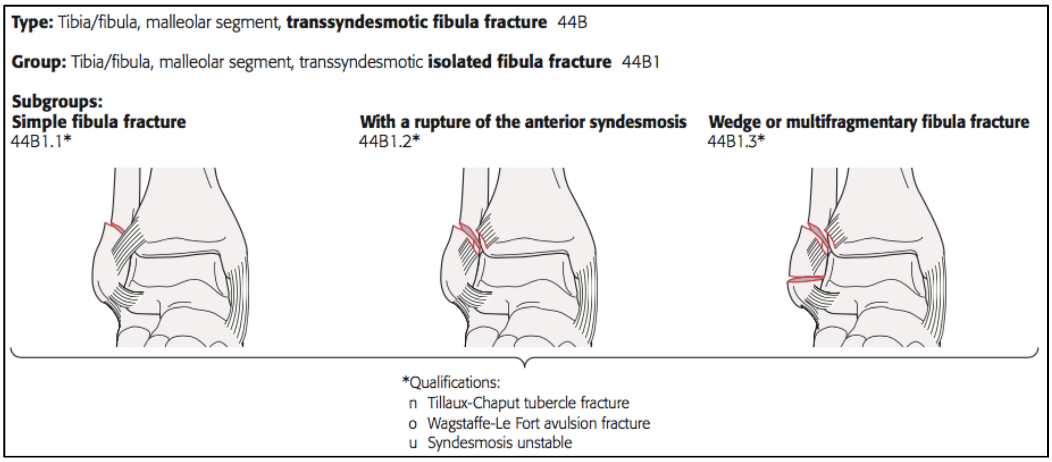


Figure 1. The AO/OTA classification of B1-fractures according to Fracture and classification compendium – 2018.

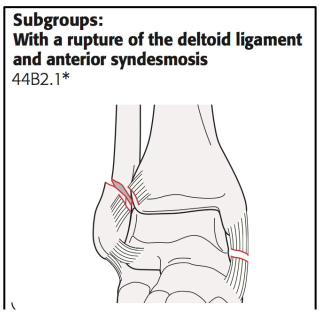


Figure 2. The AO/OTA classification of a B2.1-fracture with rupture of the deltoid ligament.

The fracture 44-B1.1 in Figure 1 is considered stable and since the lateral ligament is intact there will be only minor displacement of the distal part of the fibula. If rotation of this piece has occurred the distance of displacement may be interpreted as more severe than it actually is, which is why this should be measured on frontal- and straight sideview radiographic images.

When comparing the B1.2 fracture in Figure 1 with the B2.1 fracture as demonstrated in Figure 2, they can be confusingly similar on radiographs since injuries on the ligaments are not visible. However, the B2.1 fracture is expected to have some characteristic differences such as medial swelling and further displacement but most importantly the radiographic "fork-view" will reveal incongruency in the joint space. This comes as a consequence of a broken deltoid ligament which leads to a movement of the talus in lateral direction. Hence, the distance between the medial surface of the talus and the medial malleolus will increase and the fracture is considered unstable.

Diagnostics and treatment of B1-ankle fractures

When assessing the patient in the accident and emergency department (A&E) the combination of clinical examinations, knowledge of the injury mechanism and radiographic imaging, is important to be able to assess the most likely fracture type. Regarding B1-fractures the key is to determine whether the ankle is stable or unstable in order to choose the appropriate treatment method. The treatment methods most commonly used are either non-surgical with below knee immobilization or surgical with open reduction and internal fixation (ORIF). Unstable fractures with more than minimal displacement (> 2mm.) benefits from surgical treatment resulting in a lower risk of non-union, malunion and loss of reduction (21, 22). On the other hand, there is an increased risk of acute complications such as infection and peroneal nerve injury that has to be taken into account as well (23) . Previous studies have shown that the greatest risk factors for short term complications is high age, smoking and comorbidities such as diabetes (24, 25), which emphasizes the importance of a case by case assessment. Furthermore, surgery might also cause late side effects due to problems with internal fixation material which requires additional operations. In contrast stable fractures have the same or better outcome if treated non-surgically and the risk of adverse events like displacement has been proven very low (26, 27).

Evidence based guidelines are being used in many different fields of the health care system with the purpose to optimize patient care. Wykes P.R et al. conducted a study in the UK where guidelines for treatment of stable ankle fractures was implemented. Their results show a decreased amount of follow-up radiographs and reduced immobilization time without compromising patient safety (28). Many of the criteria for diagnosis of stable ankle fractures and subsequent treatment from their study were retained in the treatment algorithm that was introduced at SU in 2017. The first question to be answered at the Acute and Emergency department (A&E) is if there is a fracture or not. Since all ankle fractures should be examined by radiographs it is advised to use the Ottawa ankle rules as a tool to distinguish them from ankle sprains. The Ottawa rules have been proven accurate for discovering ankle fractures and comprises three questions to be answered (29). Does the patient have tenderness posterior to the lateral- or medial malleolus and 6 cm above? Was the patient unable to put load on the foot directly after the trauma? Is the patient unable to walk more than four steps in the A&E? If any of the requirements are met radiographic imaging should be performed. When analyzing these radiographs, the main purposes is to locate the fracture, assess the congruency of the joint space and secondly to check for displacement since this is not as strong a predictor of instability as the others.
According to the PM the indicators of instability are obvious malalignment of the foot or radiographs showing incongruency in the joint space. Tenderness, swelling or ecchymosis on the medial side of the ankle are considered as indicators of ligament injury and must be taken into account as well.

Besides clinical examination and plain radiographs further information about the direction of the force and position of the foot during the event is an important part of the assessment. Injuries to the ankle are often caused by rotational force which occur when an axial load is passed on to a pronated- or supinated foot (30). When translational force is applied to a supinated foot it causes the body to rotate externally in relation to the foot. This allows for structures on the lateral side of the ankle to take the first hit, namely the distal fibula and lateral syndesmosis. This mechanism is often referred to as a supination external rotation injury (SER). If excessive force is applied even more structures will be involved and eventually the deltoid ligament on the medial side will break as well. On the other hand, if an external force is applied to a pronated foot the medial malleoli and deltoid ligament will be damaged first. (31)

Guidelines according to the PM

When all information has been compiled and the fracture is classified, the suggested treatment according to the PM is as follows. For a stable B1.1 fracture the recommendation is to give the patient an orthosis for 4 weeks and permit full weight bearing promptly. No follow-up radiographs are considered necessary. If remaining pain or stiffness when dismantling the orthosis, it is advised to continue with physiotherapy. In case of remaining symptoms even after physiotherapy, additional visits to surgeon for evaluation is advocated. This means that in most favorable case, without any complications, this patient should only undergo one radiographic examination and have one follow-up visit to a doctor for dismantling the orthosis. Usually there is no need of inpatient care, but this has to be evaluated on a case by case basis.

If the fracture is classified as a potentially unstable B1.2/3 there are basically two treatment options depending on the findings and overall assessment as described in the PM. If the clinical examination reveals an obvious instability or if there is a visible joint space incongruence on the radiographs, the primary treatment will be surgical. However, if the signs are not that obvious the recommendation is to immobilize the ankle in circular plaster or orthosis, allowing full weight bearing immediately. This is followed by a radiographic control of congruency after one week. If there is no sign of displacement or incongruence on the one-week follow-up radiographs the non-surgical treatment continues with immobilization for six weeks. On the other hand, if the radiographs show a worsened displacement or increased tibiotalar clear space, the treatment is converted to surgical fixation (3). Many patients can be managed by outpatient surgery, but each case has to be evaluated individually.

Regardless of fracture type the guidelines advocate up to double the length of immobilization time for diabetic patients.

Costs and resources

Fractures of the lateral malleolus is the 5th most common fracture registered in the SFR nationwide and the 4th most common at SU. Between the years 2013 to 2018 a total of 2307 patients were registered as treated at SU which gives an average of 385 patients every year. Hence, the work of optimizing and managing the use of resources is well invested since it can lead to great savings. When assessing the total cost for treatment and rehabilitation of ankle fractures both direct health care costs and indirect costs must be taken into account. The direct costs include, among other things, physician services, diagnostic imaging and inpatient care. Previous studies on stable ankle fractures have shown that reduction in the number of follow-up appointments and radiographs are the factors with the greatest impact on direct costs (32). Follow-up radiographs are mainly used to detect changes in the configuration of the fracture but are also used to assess the degree of healing of the fracture. However, roentgenograms are proven to be relatively insensitive in evaluating clinical healing based on the fact that fracture lines are visible a considerable time after the actual healing has occurred (33).

Indirect costs, on the other hand, are affecting the patient economy and comprises expenses for transportation, medications and loss of productivity during absence from work. It has been shown that indirect costs constitute approximately 50% of the total cost (34). Among employed patients the single largest contributing factor to the indirect cost is absence from work which raises the proportion even higher.

Aim

In the first part of present study we focused on the group post-PM and the generation of descriptive statistics for the two subgroups B1.1 and B1.2/3 respectively. By analyzing the results in relation to corresponding guidelines, our aim was to investigate to what extent the new treatment algorithm was followed in daily practice at SU. The results can be used for improvements of the guidelines as well as contributions to the work of increasing the compliance.

In the second part the outcome variables related to the use of resources were compared between the two datasets pre- and post-PM. By doing this we aimed to elucidate if the use of resources in terms of number of surgically treated patients, quantity of radiographic examinations, number of visits to a doctor, time immobilized and days of inpatient care had changed since the introduction of the PM. Our hypothesis is that the numbers in above listed variables have decreased since the introduction of the PM.

Materials and methods

Data collection

In 2015 an epidemiological study of all ankle fractures treated at SU during two consecutive years was conducted. This generated a dataset with detailed information about the treatment of 439 patients diagnosed with AO-44B1 fractures. In present study this group is referred to as the pre-PM dataset and the information will be used for comparisons. In order to make these comparisons a similar database including variables, corresponding to the ones collected in 2015, was conducted. Data from the SFR for all patients with ankle fractures registered at SU between 2017-09-01 and 2019-05-31 was extracted. The collected data consisted of 1200 patients distributed on twelve different fracture subgroups. Since the main interest in the present study is lateral malleolar fractures at the level of the syndesmosis classified as AO-44B1 this subgroup was separated from the total amount and analyzed in detail. A manual review of medical records and radiographs was made of this subgroup. This generated information of the number of visits to a doctor after injury, number of plain radiographs, CTs, MRIs and ultrasound examinations, time immobilized, days of inpatient care and weight bearing advices. We also noted if investigation of the medial side of the ankle was commented in medical journals from the E&A.

During the period of interest, a total of 342 patients were registered as having B1-fractures. In total 57 patients were excluded due to the following reasons: 25 were initially treated at other hospitals or followed up elsewhere and another 21 patients had not visited health care in acute phase of injury. In 7 cases we found the registration to be inaccurate and 2 patients were excluded due to lack of follow-up information. In 1 case there was no fracture and further 1 patient had never visited the E&A (Table 2). After making the exclusions 285 patients were included and this group will hereafter be referred to as the post-PM dataset.

Table 1. Number of patients and reasons for exclusion from the post-PM group.

Reason for exclusion	N
Initially treated or follow up at other hospital	25
Not visited health care in acute phase of injury	21
Other fracture than AO-44B1	7
Missing follow up information in medical journals	2
Never visited the E&A	1
No fracture	1
Total	**57**

Statistical methods

Part 1

In part one of present study we will present descriptive statistics of the post-PM group. The results were analyzed separately for the two subgroups B1.1 and B1.2/3 with a further level of subgrouping based on primary treatment. By doing this we aimed to evaluate the results for each subgroup in relation to what could be expected if the guidelines were followed. Descriptive statistics and production of charts was performed using Microsoft Excel ver.16 and SPSS 25.

Part 2

In the second part the choice of primary treatment of B1-fractures was compared between the two groups pre-PM and post-PM. The variables surgical and non-surgical are categorical which also applies for the comparison groups pre- and post-PM. The latter are considered independent since they are separated in time and consist of different individuals. Crosstab Chi^2 testing and production of charts was executed using SPSS 25 and Microsoft Excel ver.16. (35)

In the subsequent questions of part two a comparison of numerical variables, such as the number of radiographic examinations, was made between the two categorical groups pre- and post-PM. As stated above these groups are separated in time, and consist of different participants, which makes the observations independent. Furthermore, the variables are not normally distributed, and the groups differs in size. Non-parametric Mann-Whitney testing and production of charts was performed using SPSS 25 and Microsoft Excel ver.16. (36)

Ethics

All patients included in the SFR have been informed about the registration and that it is voluntary to participate. The director of the SFR is responsible for managing all collected data in accordance with applicable Swedish laws and regulations. Since this is a register study using only already collected data from registers and medical records, we assess the risk of privacy violation as minimal. The benefits of in-depth knowledge overcome the possible disadvantages. Included patients get no benefits from participating but studies like this might contribute to improved treatment and more effective use of resources. After consolidating the data from the SFR with the data from medical journals a pseudonymization was made. All analyses were performed on pseudonymized data and the results are presented at statistical group level. In order to access and review journals of the patients extracted from the SFR a permission was approved by the head of department at the orthopedic clinic at SU. The previous study with data extraction in 2015 was approved by the Regional Ethical Review Board in Gothenburg, Sweden, Nr. 1011-15. The approval also includes present follow up study.

Results – part 1

In below section the descriptive statistics of the post-PM group will be presented. This dataset consists of patients who were registered in the SFR after the clinical implementation of the treatment algorithm.

Characteristics of the patients in the post-PM group

The following is a brief description of the main characteristics of the 285 patients included in the post-PM group. 173 (61%) were females and 112 (39%) were males. 156 patients were classified as AO-44B1.1 and all of the patients with this fracture type were primary treated non surgically. The rest of the patients in the post-PM group were consequently classified as AO-44B1.2/3 Within this group, 103 patients were given non-surgical treatment and the remaining 26 patients were operated. The age ranged from 16 to 94 years. (Table 2)

Table 2. Characteristics of the 285 patients with B1-fractures included in the post-PM group.

					Fracture type			
	Age (Years)		Gender		AO-44B1.1		AO-44B1.2/3	
Dataset	Min.	Max.	Male (N)	Female (N)	Non surgical	Surgical	Non surgical	Surgical
post-PM (N=285)	16	94	112	173	156	0	103	26

The median age was 54 years and the most common age group for occurrence of B1-ankle fracture was the 56-65 years range (Figure 3).

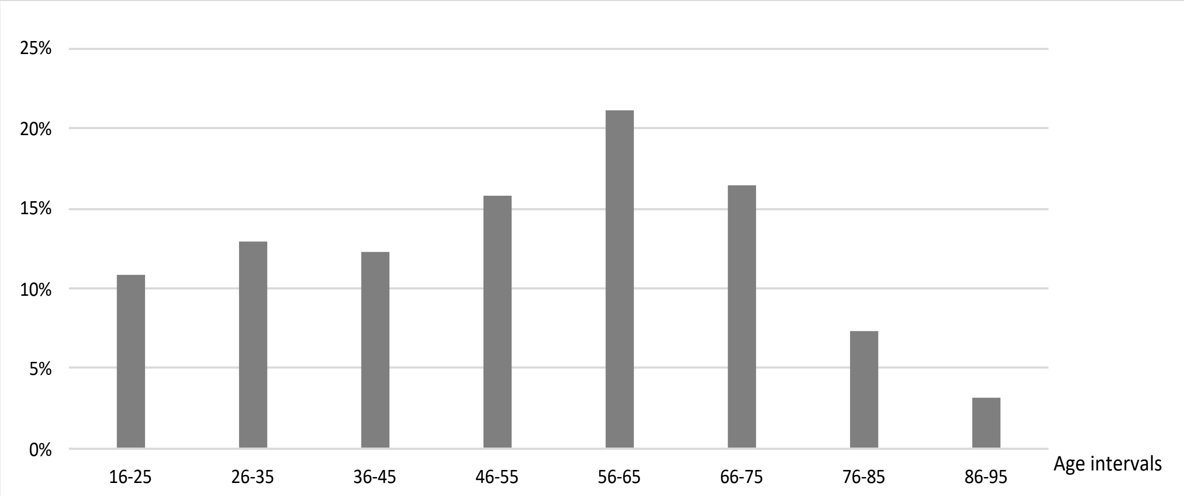


Figure 3. Age distribution of patients with B1-ankle fractures in the post-PM group.

The most common cause of a B1-fracture was a fall on the same level from slipping, tripping or stumbling which was noted in 48% of all the cases. (Table 3).

Table 3. Frequency and description of injury codes that appeared in the post-PM group

Injury code	N	%	Description
W01	136	48%	Fall on same level from slipping, tripping and stumbling
W00	57	20%	Fall due to ice and snow
W19	16	6%	Unspecified fall
V01-V99	13	5%	Transport accident
W10	13	5%	Fall on and from stairs and steps
W17-W18	9	3%	Other fall
W05, W11-W15	9	3%	Fall outdoors
W02	8	3%	Fall skiing/ice skating
W03	8	3%	Other fall on same level due to collision with another person
W50-W51, W64	7	2%	Exposure to animate mechanical forces (Mechanical forces by living beings)
ND	5	2%	No Data
Y30, Y34, X58	2	1%	Other accident
W20-W21	2	1%	Exposure to animate mechanical forces (Mechanical forces by objects)
Total	**285**		

Post-PM - B1.1 and B1.2/3 outcome variables in relation to PM

The descriptive statistics in the post-PM group is presented separately for the two subgroups B1.1 and B1.2/3 with a further level of subgrouping based on primary treatment. (Table 4-5)

Table 4. Medians of the outcome variables in relation to recommendations in the PM.

Fracture class	Primary treatment	Variables	Sum	Median	Recommendation according to PM	Deviation
AO-44-B1.1 (n=156)	**Non-surgical** (*n* =156)	Number of radiographic examinations	316	**2.0**	1.0	**1**
		Number of visits to surgeon	468	**3.0**	2.0	**1**
		Days of inpatient care	76	**0.0**	0.0	**0**
		Days immobilized	6472	**42.0**	28.0	**14**
AO-44-B1.2/3 (n=129)	**Non-surgical** (*n* =103)	Number of radiographic examinations	239	**2.0**	2.0	0
		Number of visits to surgeon	339	**3.0**	3.0	0
		Days of inpatient care	70	**0.0**	0.0	0
		Days immobilized	4424	**42.0**	42.0	0
	Surgical (*n* =26)	Number of radiographic examinations	68	**3.0**	2.0	1
		Number of visits to surgeon	106	**4.0**	4.0	0
		Days of inpatient care	27	**0.0**	Case by case	na.
		Days immobilized	1111	**42.5**	42.0	0.5

Table 5. Medians and range of the outcome variables in post-PM group for each of the two fracture classes respectively.

Fracture class	Primary treatment	Outcome measures	Sum	Median	Std. Deviation	Min.	Max.	Range
AO-44-B1.1 (n=156)	**Non-surgical** (*n* =156)	Number of radiographic examinations	316	**2.0**	0.73	1	4	3
		Number of visits to surgeon	468	**3.0**	0.73	1	5	4
		Days of inpatient care	76	**0.0**	2.26	0	16	16
		Days immobilized	6472	**42.0**	9.74	25	92	67
AO-44-B1.2/3 (n=129)	**Non-surgical** (*n* =103)	Number of radiographic examinations	239	**2.0**	0.72	1	5	4
		Number of visits to surgeon	339	**3.0**	0.72	2	6	4
		Days of inpatient care	70	**0.0**	2.80	0	16	16
		Days immobilized	4424	**42.0**	7.79	25	78	53
	Surgical (*n* =26)	Number of radiographic examinations	68	**3.0**	0.70	2	5	3
		Number of visits to surgeon	106	**4.0**	0.48	3	5	2
		Days of inpatient care	27	**0.0**	2.22	0	10	10
		Days immobilized	1111	**42.5**	2.38	40	48	8

Number of radiographic examinations

The median number of radiographic examinations for non-surgically treated patients was 2, irrespective of fracture class. Operated patients underwent in median 3 examinations. (Table 4). As demonstrated in below figure non-surgically treated patients can be found within both fracture classes B1.1 and B1.2/3 (Figure 4)

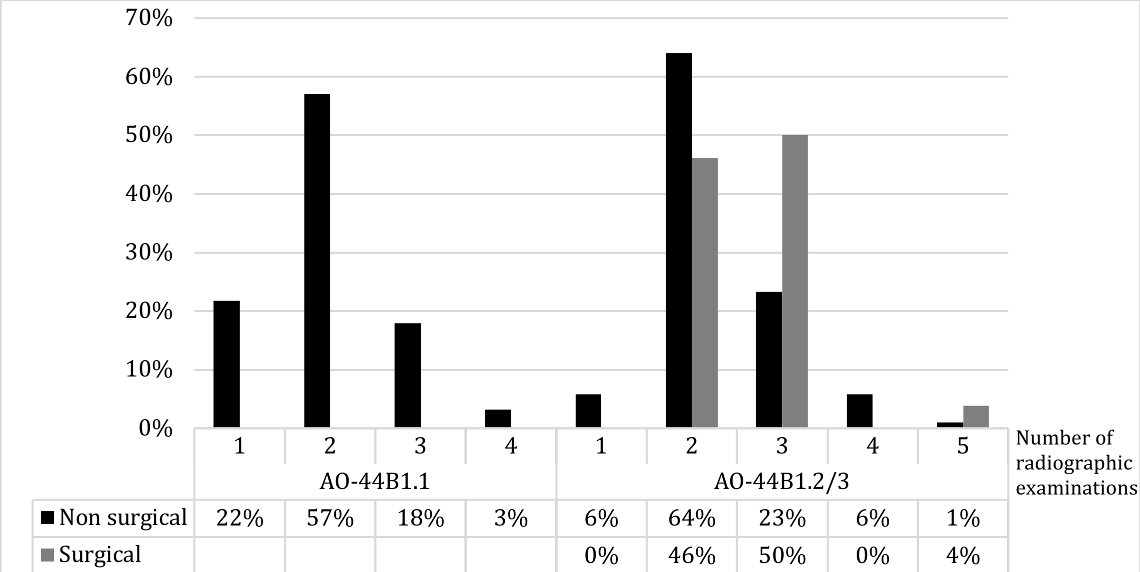
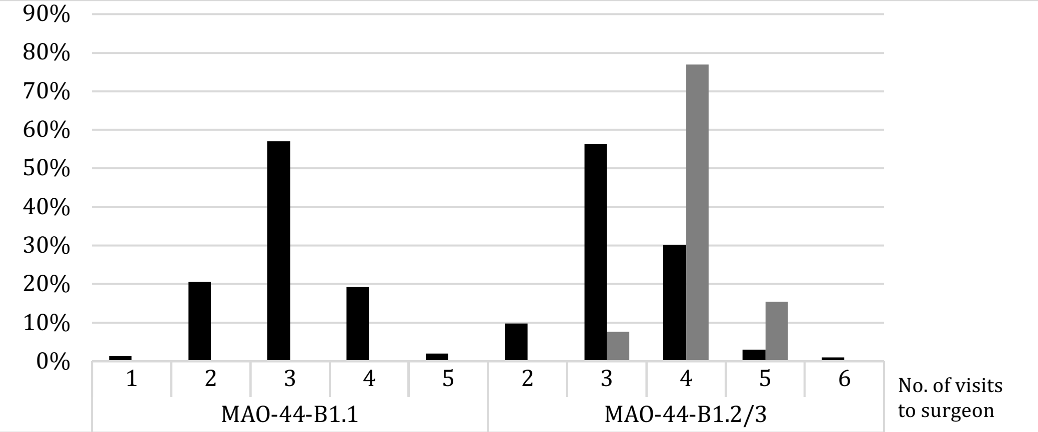


Figure 4. Number of plain radiographs executed on patients treated non-surgically respective surgically within the two fracture classes 44-B1.1 and 44-B1.2/3.

Plain radiographic imaging was the predominant examination method for all B1-fractures regardless of subtyping or treatment. It was used as single method in 282 (99%) of all the cases compared to the previous study where the proportion was 97%. CT was used as additional examination in only 3 cases why we consider this negligible and the causes will not be investigated further. MRI or ultrasound was not used in any case.

Number of visits to surgeon

The number of visits to surgeon was counted in the medical journals and consists of visits to the A&E, follow-up visits, stability testing and occasions when primary surgery was performed. Also, orthopedic consults of patients hospitalized in other departments and visits due to side effects like infections and swelling caused by primary treatment was included. Other visits related to problems with plaster, late side effects such as pain or stiffness and extraction of internal fixation material was not counted. The median number of visits in the group of patients treated non-surgically was 3, whilst surgically treated patients had made 4 visits in median (Table 5). Both fracture classes can be found among the patients treated non-surgically but the proportion of patients with four or more visits was higher in the group of patients classified as 44-B1.2/3 (Figure 5).

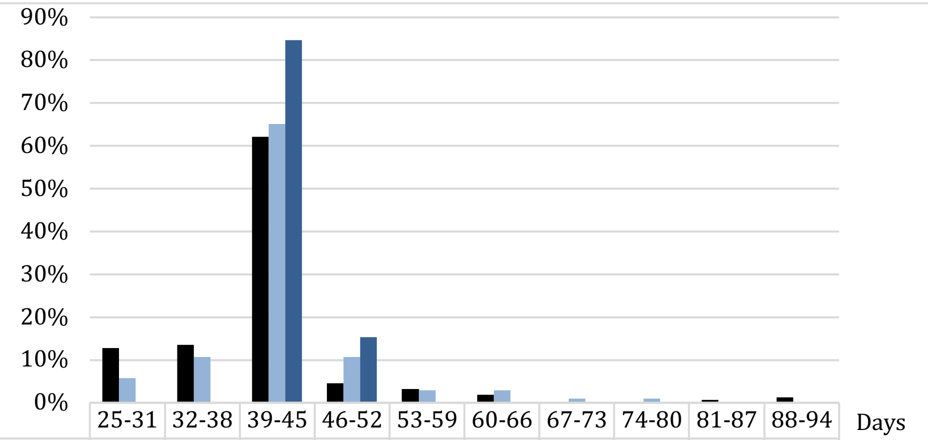


	MAO-44-B1.1					MAO-44-B1.2/3				
	1	2	3	4	5	2	3	4	5	6
Non surgical	1%	21%	57%	19%	2%	10%	56%	30%	3%	1%
Surgical						0%	8%	77%	15%	0%

Figure 5. Number of visits to surgeon for patients treated non-surgically respective surgically within the two fracture classes 44-B1.1 and 44-B1.2/3.

Number of days immobilized

The vast majority of the patients in the post-PM group were immobilized in the range of 39-45 days. Patients treated non-surgically had a predominance in the lower end of the range whilst operated patients were more frequent in the higher end of the spectrum. The diagram also demonstrates that a few patients were immobilized for more than 60 days. (Figure 6).



	25-31	32-38	39-45	46-52	53-59	60-66	67-73	74-80	81-87	88-94
44-B1.1 - Non surgical	13%	13%	62%	4%	3%	2%	0%	0%	1%	1%
44-B1.2/3 - Non surgical	6%	11%	65%	11%	3%	3%	1%	1%	0%	0%
44-B1.2/3 - Surgical	0%	0%	85%	15%	0%	0%	0%	0%	0%	0%

Figure 6. Number of days immobilized for patients receiving non-surgical respective surgical treatment in the post-PM group.

Number of days inpatient care

The median number of days inpatient care was zero for both fracture classes B1.1 and B1.2/3 regardless of primary treatment (Table 5). 93% of the patients treated non-surgically were not hospitalized for a single day whilst we found a few more cases of inpatient care among surgically treated patients.

Conversion of primary treatment at an early stage

All of the reoperations performed should be registered in the SFR which also includes cases where primary non-surgical treatment is converted to surgical at an early stage. All of the fractures classified as 44B1.1 were initially treated non-surgically. We found only one case where the treatment was changed to surgical at an early stage. A detailed review of the radiographs by a senior orthopedic surgeon revealed no medial swelling or incongruence in the ankle joint which is why the reason for operation remains unclear. This one patient also underwent a second operation due to patient experienced discomfort.

Among the fractures classified as 44B1.2/3 the treatments were distributed on 26 (20%) surgically treated and 103 (80%) non-surgically treated. Our results show that the initial treatment was converted to surgical in only 1 of the 103 patients due to findings on these radiographs. After reviewing the radiographs also this case filed suspicion to have been misinterpreted as unstable and thus unnecessarily operated.

In the group treated primarily surgical 2 patients were also registered as having planned follow-up surgery with extraction of internal fixation material. Further one was re-operated in later stage due to displacement or malunion of the fracture. (Figure 7)

Figure 7. Initial treatment and subsequent number of reoperations in the post-PM group.

Examination of the medial side of the ankle

There is a common agreement that medial status is important to examine since it is considered an indicator of injury to the deltoid ligament. As a consequence of such injuries, the ankle becomes unstable. Hence, the occurrence of medial status is one of the key factors to examine according to the guidelines in the PM. Therefore, the proportion of cases where medial status has been commented on, can be used as one parameter to evaluate if the PM was followed. However, during our review we found a great variety of linguistic wording in the medical records leaving a lot of room for interpretation. This makes it difficult to draw any conclusions or to make comparisons with previous study. Consequently, the table should only be considered a rough indication of the degree to which the PM is being followed in clinical practice. As presented below, the number of cases where medial status was commented on appears to have increased with around 14-19 percentage points in comparison to the pre-PM group. (Table 6)

Table 6. Proportion of cases where medial status was commented on in medical journals.

			Medial status commented	
Primary treatment	Dataset	N	Yes	No
Non surgical	pre-PM	309	75%	25%
	post-PM	259	89%	11%
Surgical	pre-PM	130	66%	34%
	post-PM	26	85%	15%

Weight bearing advices

When reviewing the medical records regarding weight bearing advice, we noted a wide variety of linguistic wording also for this variable. Based on the same conclusions as with medial status, we do not consider this parameter suitable for comparison.

Results – part 2

The dataset collected before the introduction of the PM, named pre-PM, did not include any subdivisions of B1-fractures. Hence, they were all called only B1 but with a subgrouping based on primary treatment, surgical or non-surgical. To enable comparisons, the two fracture classes B1.1 and B1.2/3 from the dataset post-PM, were merged into one group with a subgrouping based on primary treatment. Accordingly, surgically treated patients in the pre-PM group were compared to surgically treated patients in the post-PM group. The same comparisons were also made between patients given non-surgical treatment. In the following section the results will be presented separately for each of the two treatment types. (Table 7)

Table 7. Medians of outcome variables for surgically treated patients in the two comparison groups pre- and post-PM.

Primary treatment: Surgical	N (pre-PM) = 130 N (post-PM) = 26					
Variable	Dataset	**Median**	Std. Deviation	Min.	Max.	Range
Number of visits to surgeon	pre-PM	4,0	1,62	1	9	8
	post-PM	4,0	0,48	3	5	2
Number of radiographic examinations	pre-PM	2,0	1,27	2	9	7
	post-PM	3,0	0,70	2	5	3
Number of days immobilized	pre-PM	45,0	7,07	16	75	59
	post-PM	42,5	2,38	40	48	8
Number of days inpatient care	pre-PM	2,0	3,83	0	35	35
	post-PM	0,0	2,22	0	10	10

Primary treatment: Surgical

Comparison of the number of surgically treated B1-fractures

In the pre-PM group almost 30% of the patients with B1-fractures were treated surgically whilst the proportion of surgical treatment in the post-PM group was only 9%. (Table 8)

Table 8. Number of B1-fractures treated non-surgically respective surgically in the two comparison groups pre-PM and post-PM.

Dataset	N Non surgical	N Surgical	Total
pre-PM	309 (70.4%)	130 (29.6%)	439
post-PM	259 (90.9%)	26 (9.1%)	285

Chi^2 testing confirmed there was a significant difference in primary treatment with fewer operations being performed on patients with AO-44B1 fractures in the post-PM group compared with the pre-PM group. ($p < 0.001$)

Number of visits to surgeon

The median number of 4 visits to surgeon in the pre-PM group was the same as in the post-PM group (Table 7). However, the range of counts was wider in the pre-PM group with a maximum of 9 visits compared to 5 in the post-PM group. (Figure 8)

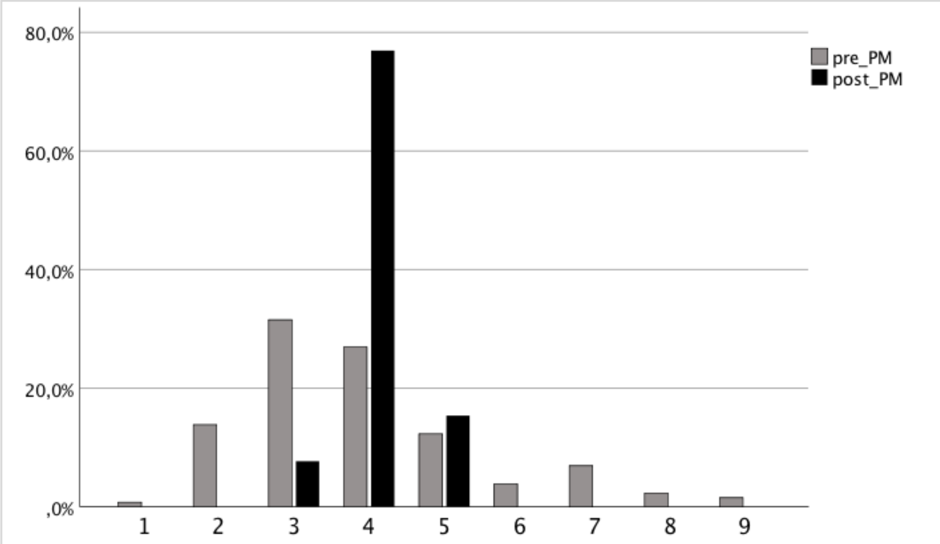


Figure 8. Number of visits to surgeon among surgically treated patients in the two comparison groups pre-PM and post-PM respectively.

There was no significant difference in number of visits to surgeon comparing the period before with the period after the PM was introduced. (*p* = 0.084 two-tailed)

Number of radiographic examinations

Our data shows that the median number of radiographic examinations performed in the pre-PM group was 2 compared to 3 in the post-PM group (Table 7). Also, for this variable there was a wider range in the pre-PM group with a maximum of 9 examinations compared to 5 in the post-PM group. (Figure 9).

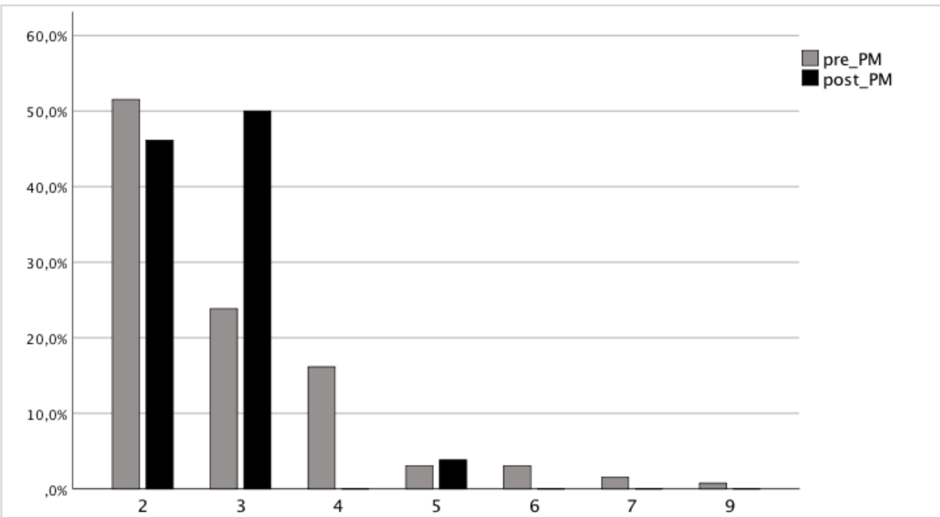


Figure 9. Number of radiographic examinations performed on surgically treated patients in the two comparison groups pre-PM and post-PM respectively.

Mann-Whitney test showed no significant difference in the number of radiographic examinations performed on surgically treated patients comparing the periods before- and after the introduction of the PM ($p = 0.625$ two-tailed).

Number of days immobilized

All forms of immobilization in lower leg cast, ankle orthosis or plaster splint have been included. The median number of days immobilized was 45 in the pre-PM group and 42.5 in the post-PM group (Table 7). There were several cases in the pre-PM group where the immobilization time exceeded 50 days with a maximum of 75 days. All of the patients in the post-PM group were immobilized in the range of 40 to 48 days (Figure 10).

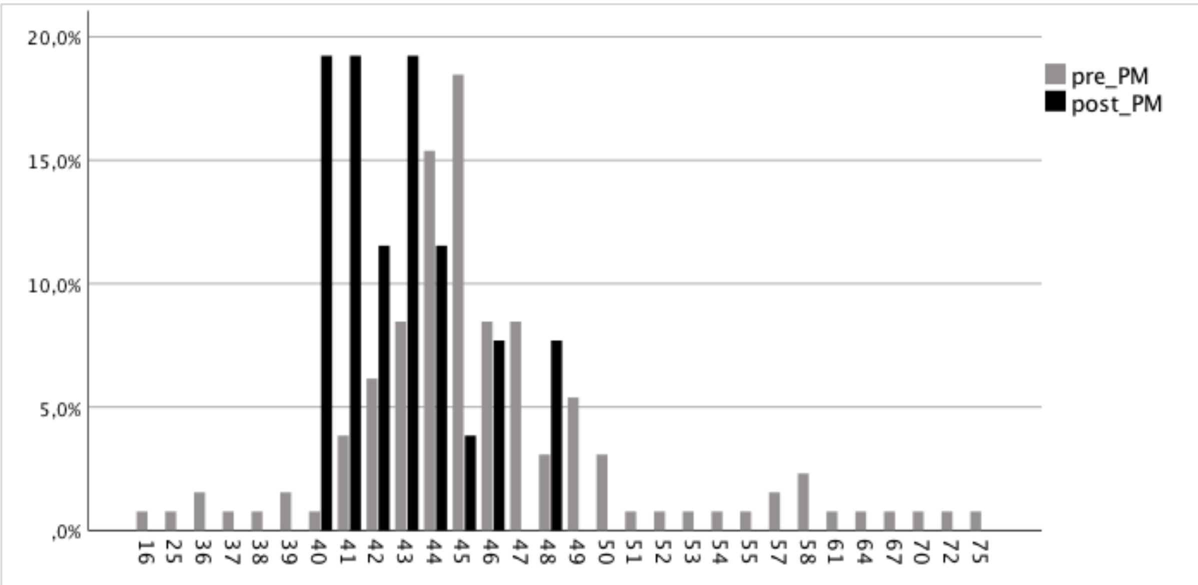


Figure 10. Number of days immobilized for surgically treated patients in the two comparison groups pre-PM and post-PM.

There was a significant difference in the number of days immobilized for surgically treated patients in the two comparison groups. ($p < 0.001$ two-tailed)

Number of days inpatient care

Days of inpatient care was calculated as the date discharged from the hospital subtracted with the date admitted to the hospital. In median the patients in the pre-PM group were hospitalized for 2 days, compared to 0 days in the post-PM group (Table 7).

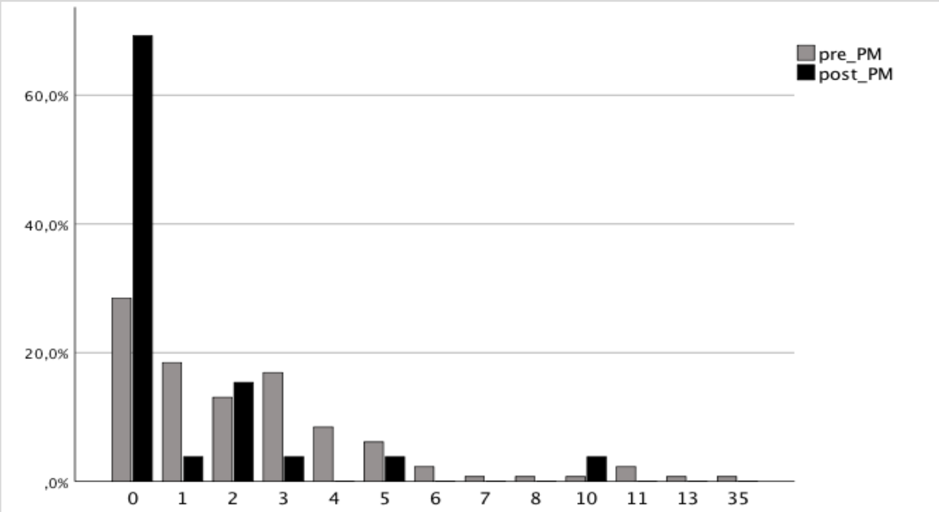


Figure 11. Number of days inpatient care for surgically treated patients in the comparison groups pre-PM and post-PM respectively.

There was a significant difference in the number of days hospitalized for surgically treated patients in the two comparison groups. (p = 0.001 two-tailed)

Primary treatment: Non-surgical

Table 9. Medians of outcome variables for non-surgically treated patients in the two comparison groups pre- and post-PM.

Primary treatment: Non Surgical	N (pre-PM) = 309 N (post-PM) = 259					
Variable	Dataset	**Median**	Std. Deviation	Min.	Max.	Range
Number of visits to surgeon	pre-PM post-PM	3,0 3,0	1,19 0,74	1 1	11 6	10 5
Number of radiographic examinations	pre-PM post-PM	2,0 2,0	0,87 0,74	1 1	7 5	6 4
Number of days immobilized	pre-PM post-PM	42,0 42,0	10,86 9,03	0 25	108 92	108 67
Number of days inpatient care	pre-PM post-PM	0,0 0,0	1,34 2,49	0 0	15 16	15 16

Number of visits to surgeon

The median number of visits to surgeon was 3 in both the comparison groups (Table 9). The range in the pre-PM group was wider with a maximum of 11 visits (Figure 12).

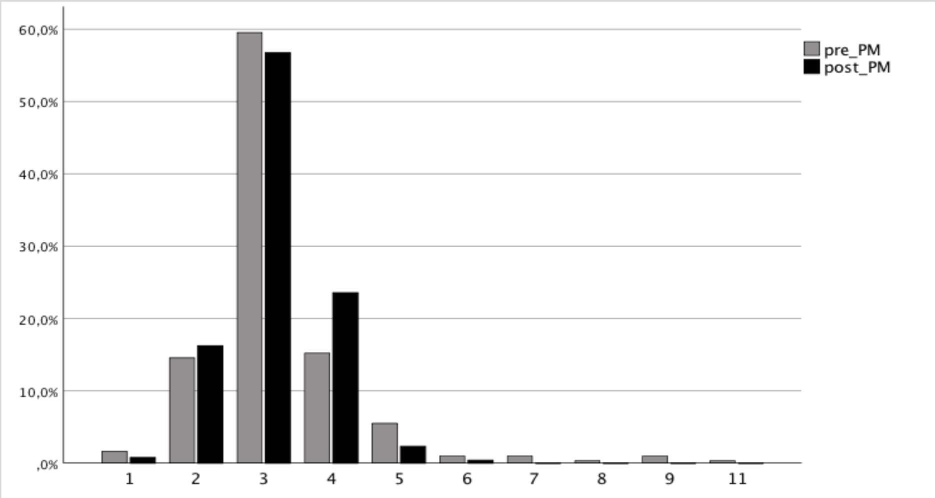


Figure 12. Number of visits to surgeon for patients treated non-surgically in the two comparison groups pre-PM and post-PM.

There was no significant difference in number of visits to surgeon for patients receiving non-surgical treatment between the groups. (p = 0.891 two-tailed)

Number of radiographic examinations

Counted was plain radiographic examinations. CT's and MRI's were not included. In both comparison groups the median number of examinations was 2 (Table 9). There was a wider range in the pre-PM group with a maximum of 7 occasions (Figure 13).

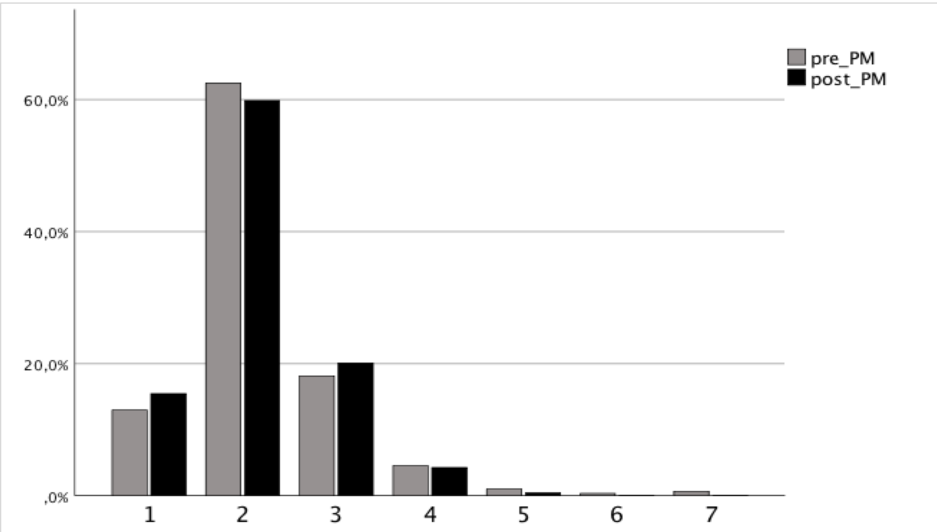


Figure 13. Number of radiographic examinations performed on patients treated non-surgically in the two comparison groups pre-PM and post-PM.

We were not able to show any significant difference in the number of radiographic examinations performed on non-surgically treated patients between the pre- and post-PM groups. (p = 0.586 two-tailed)

Number of days immobilized

The median number of days immobilized was 42 in both groups. The range in the pre-PM group was wider with a maximum of 108 days compared with the post-PM group where maximum was 92 days (Table 9). The majority of the patients in both groups were immobilized in the range of 40-44 days. Noteworthy, is also that a larger proportion of the patients in the post-PM group were immobilized in the range of 25-29 days compared with the pre-PM group. (Figure 14)

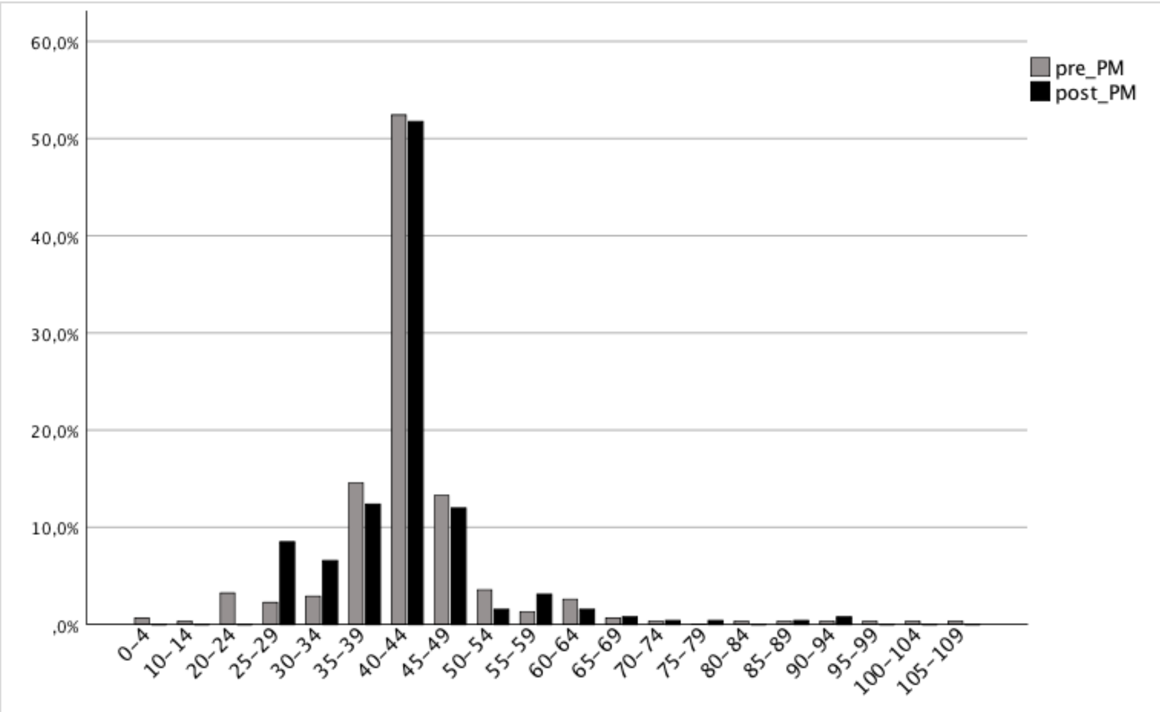


Figure 14. Number of days immobilized for patients treated non-surgically in the two comparison groups pre-PM and post-PM.

Non-parametric testing showed no significant difference in number of days immobilized for non-surgically treated patients in the two comparison groups pre- and post-PM. (p = 0 .401 two-tailed)

Number of days inpatient care

Usually the patients given non-surgical treatment are not hospitalized. As demonstrated in our study the median number of days hospitalized in both pre- and post-PM group was zero. The range was similar in both groups with a maximum of 15-16 days inpatient care. (Table 9) However, more than 90% of the patients in both groups were not hospitalized for a single day.

Non-parametric testing showed no significant difference in number of days hospitalized for non-surgically treated patients comparing the two groups pre- and post-PM. ($p = 0.926$ two-tailed)

Discussion

The main focus in the first part of this study was the post-PM group. Outcome variables for each of the two subgroups B1.1 and B1.2/3 were compared in relation to what could be expected if the treatment algorithm was followed. Since the instructions in the PM differ depending on primary treatment, which is surgical or non-surgical, they have been analyzed separately in relation to corresponding tract in the algorithm.

The treatment algorithm can be said to have guidelines for each phase of the handling of ankle fractures, starting with the diagnostics at the A&E, moving on to treatment and ending with recommendations regarding follow-up and dismantling of the immobilization material.
As demonstrated in present study the number of operations of B1-fractures has been significantly reduced since the introduction of the PM. Moreover, we also reviewed medical journals to register if medial status was commented on. This examination is commonly used to detect potential injuries to the deltoid ligament which affects the choice of treatment. As a consequence of a great variety of linguistic wording within the two study groups, we found this parameter to be difficult to delineate. With lots of room for interpretation we concluded this parameter was not suitable for comparison. However, our data indicates that the proportion of cases where medial status has been commented on lies in the range of 80-90%. Based on this and the fact that fewer patients with B1-fractures were operated, our conclusion is that first part of the PM providing guidelines for initial examination to sort out the patients in need of surgery, is widely followed.

The algorithm also includes recommendations of what weight bearing advices should be given to the patient. Our review revealed the use of a wide range of linguistic wording, as well as contradicting opinions on how to interpret the different expressions among physicians. Considering this we believe there is room for improvement of this aspect of the algorithm.

Moving on to the part of the PM related to treatment we assess the compliance to be good since our results show that none of the patients classified as B1.1 were operated and the total number of surgically treated patients has been reduced.
According to current guidelines, none of the stable B1.1-fractures treated non-surgically at SU should have any follow-up radiographs. However, our study shows that non-surgically treated patients with B1.1-fractures underwent in median 2 radiographic examinations. This is one too many per patient considering what is advocated in the PM. We interpret the excessive use of radiographs as if the guidelines are not being followed. By increasing the compliance to the PM, the number of examinations performed can be reduced by approximately 50%. This corresponds to a decrease of about 100-200 examinations per year. As demonstrated by Jain et al (32) follow-up radiographs and follow-up visits are the two factors contributing the most to direct costs. Radiographic examinations are closely linked to the number of visits to surgeon which makes it reasonable to think that a reduction of one will also affect the other. By this, we conclude that one of the easiest ways to be more cost efficient, without compromising patient safety, is to decrease the number of radiographs executed on patients diagnosed with a B1.1 fracture.

Patients given non-surgical treatment within the group B1.2/3, also underwent in median 2 radiographic examinations. However, the difference is that for this group, the number is in line with what can be expected since the algorithm advocates a mandatory 1-week follow up with plain radiographs. After reviewing the images, we have addressed the question if this mandatory examination is justified, which will be discussed further down.

Plain radiographs were used as single imaging method in 99% of the cases compared to 97% in previous study. CT was used in only 3 cases which we consider negligible. MRI and ultrasound were not used in any case. All of which signals good compliance to the PM, except for the number of plain radiographic examinations being performed.

In median the patients treated non-surgically within the two groups B1.1 and B1.2/3 made 3 visits to a physician. Analyzed in relation to the algorithm this indicates an excessive number of visits in the first group. Patients with stable fractures who are treated non-surgically should in most cases only have 2 visits to the surgeon. One at the A&E and one follow-up for dismantling the orthosis. This assumes no complication has occurred. One possible cause of extra visits is that the patients express concern due to remaining stiffness or tenderness. In order to prevent such worries, we believe it is important to ensure that every treating physician is careful to inform the patient about the normal healing process. This could also include access to easily understandable information material about symptoms and their expected timeframe. As suggested in the PM this type of residual symptoms should primarily be handled by a physiotherapist. Hence, we see potential for improvements of this parameter by increasing the compliance to the treatment algorithm, as well as development of printed information material that can be distributed to the patients. In order to save resources, we see an opportunity to change the guidelines so that even the follow-up visit for plaster removal is handled by a physiotherapist. The surgically treated patients visited a surgeon in median 4 times which is in line with what can be expected if the PM is being followed. This includes the initial examination at the A&E, the occasion when surgery is performed, one visit for changing the plaster and one final visit for dismantling the immobilization material.

Our study shows that non-surgically treated patients, regardless of fracture class, were rarely hospitalized. 93% were not hospitalized at all which is in accordance with the treatment algorithm. The majority of the few cases found were elderly with inpatient care due to unsustainable home situation or similar. Among the surgically treated patients the proportion of inpatient care was slightly higher, but still 63% were managed by outpatient surgery. There are no guidelines for this described in the PM since this parameter is assessed on case by case basis. Many factors besides only the fracture classification such as age, co-morbidity and social situation have to be taken into account. Consequently, this variable is difficult to evaluate in relation to the PM but according to our assessment the numbers are reasonable and the compliance to the guidelines is acceptable in this matter.

The median number of days immobilized in the post-PM group was almost the same irrespective of treatment or fracture class. The median ranged from 42 to 42.5 days. Regarding the non-surgically treated patients it is considered too many days since the guidelines advocate 4 weeks of immobilization. One possible reason for this might be as simple as tradition and customary patterns. The standard procedure was for many years, to immobilize ankle fractures for six weeks and this attitude may still be alive, thus making it difficult to incorporate new routines. Noteworthy in this context is that the 285 patients in the post-PM group were immobilized for a total of 12.007 days which corresponds to almost 33 years of immobilization. As demonstrated by Eekman D. A. et al (34) the largest contributing factor to the indirect cost for employed patients is absence from work. Even though that study focused on osteoporosis fractures we assume the distribution of costs is approximately the same for employed patients regardless of what caused the fracture. This highlights the importance of dismantling the immobilization device within recommended time frame to avoid unnecessary absence from work. However, similar to what was discussed in terms of inpatient care even this variable is more affected by surrounding factors than for example the selected number of radiographs. A case by case evaluation has to be made with respect to any co-morbidities like diabetes which in turn prolong the recommended immobilization time. Furthermore, the patient might either remove the orthosis earlier than planned or request to keep it for longer time than necessary which will also affect the actual counts.

We found only two cases where the initial non-surgical treatment was changed at an early stage due to findings on follow-up radiographs. One case in each fracture class B1.1 and B1.2/3 respectively. After reviewing the radiographs both cases seem to have been misinterpreted as unstable and hence unnecessarily operated. The most interesting case is the one occurring in the B1.2/3 fracture class since the PM advocates a 1-week follow-up with radiographs. This raises the question if the examination is justified since it rarely leads to any change of initial treatment. We believe this question should be investigated further before changing the guidelines considering that some cases of reoperations may not have been registered.

In the following section we will discuss the variables where non-parametric testing was executed in order to investigate the effects on resource related variables. In the thesis presented by Zorko T. et al (2) the fractures of interest were only categorized as one group namely 44-B1 whilst present dataset has subdivisions into B1.1 and B1.2/3. Therefore, it is not possible to compare if the algorithm has contributed to a shift of classifications into one or the other type. What we do have compared, is if the number of operations has changed since its implementation. In order to do so the two subgroups 44-B1.1 and 44-B1.2/3 were merged into one group. We hypothesized that fewer patients were operated after the introduction of the PM. In the pre-PM group 130 (29,6%) of the patients were treated surgically compared to 26 (9,1%) in the post-PM group. Our study confirms a significant difference in primary treatment since the introduction of the PM with fewer patients being operated ($p < 0.001$). From this we conclude that current guidelines are very helpful in distinguishing between stable and unstable fractures, facilitating the election of patients who benefit from surgery.

When comparing the variables related to use of resources for non-surgically treated patients between the groups pre- and post-PM our study shows no significant difference in any of the variables. One can only speculate in the reason for this, but one possible cause is that the PM is not being followed. However, our results show a wider range of numbers in the pre-PM group with a higher frequency of extreme values. This applies for all variables except the number of days inpatient care where the post-PM group had a slightly wider range. As demonstrated in Figure 14 the proportion of patients within the range of recommended immobilization time (25-29 days) is slightly higher in the post-PM group. We interpret this as if the introduction of the treatment algorithm has contributed to a more unified diagnostics- and treatment procedure in many aspects, but it has not led to any significant changes.

In the comparison of surgically treated patients between the groups pre- and post-PM there was no significant change in number of visits to a doctor or number of radiographic examinations. However, our study shows a significant decrease in both time immobilized ($p < 0.001$) and number of days inpatient care ($p = 0.001$) after the implementation of the algorithm. Before, these patients were immobilized in a median of 45 days and spent 2 days hospitalized compared to 42.5 days immobilized and zero days inpatient care in most recent group. This study is designed to evaluate the effect of the treatment algorithm but there may also be other contributing factors to the differences. However, there has not been any changes in operation techniques that can explain the changes and the surgeons performing the operations are considered equally experienced.

Methodological considerations

This study only included patients treated at Sahlgrenska University Hospital which brings both strengths and weaknesses. Since it is a highly specialized clinic the results might not be representative for other clinics around Sweden. Registrations in the SFR have been made for many years which makes it a well incorporated system and as demonstrated by Wennergren D et al (37) there is a substantial degree of accuracy in the classification of tibial fractures at SU. The conclusion is that data from the SFR is reliable and well suitable for scientific analysis.

The two subgroups B1.1 and B1.2/3 from the dataset post-PM have been compiled into one group to be able to make comparisons with the pre-PM group. This has to be taken into account when analysing the results, especially for the patients treated non-surgically since this treatment can be found within both fracture classes but with different expected numbers.

In present study we have not taken any comorbidities into account. This may have contributed to an overestimation of the time immobilized considering that the guidelines advocate up to double the length of immobilization for diabetic patients.

When reviewing medical journals, the numerical values such as number of radiographs or visits to surgeon are more accurate and thus better suited for comparisons than parameters described in linguistic wording, like medial status and weight bearing advise. However, even the numerical values can sometimes be difficult to define since there is room for interpretation if individual examinations are related to the specific injury of interest or not. This leads to a certain amount of uncertainty which has to be taken into account when analyzing the results.

Due to the characteristics of the data, non-parametric tests were performed using Mann-Whitney. This has some limitations and is not as sensitive in finding small differences as independent sample T-test.

Since the implementation of a new system Orbit in August 2018 the registration process of re-operations has become more cumbersome. As a consequence, some re-operations might be missing in the register leading to an underestimation in present study.

Clinical implications and future research

In this study we have compared the results of the variables related to the use of resources in relation to its respective guideline in the treatment algorithm. Furthermore, comparisons between the two groups treated before and after introduction of the PM has been made. These data can be used to evaluate to what extent the algorithm is being followed but also to enlighten if certain aspects of it has better compliance than others. In this way the algorithm can be improved. Therefore, we advocate further investigations on how this can be done. This is especially true for the number of follow-up radiographs and re-visits to surgeon since we believe these numbers can be reduced by relatively small means and little risk. As part of reducing the excessive number of re-visits we also see potential in the information process towards the patient regarding the normal course of healing and what symptoms to expect.
It would be desirable to have more studies on the extent to which patients are informed and what information material is being used. This also includes the development of a printed

information material that could be handled out to the patient in conjunction with the first treatment occasion.

Our results show that primary treatment was changed in very few cases due to findings on the mandatory follow-up radiographs performed on patients with potentially unstable fractures. After reviewing the radiographs in the two cases found, we came to the conclusion they seem to have been misinterpreted and thus unnecessarily operated. However, since we suspect there might be some re-operations missing in the register further studies needs to be made before removing the mandatory 1-week radiographs from the treatment algorithm.

This study only included patients with B1-fractures why further studies of the other fracture classes would contribute to a comprehensive picture.

Conclusion

The reduced number of operations indicates that the PM works well in separating stable- from unstable fractures and elect the patients who benefit from surgery. The treatment algorithm seems to be quite well followed when it comes to diagnostics and examinations in the A&E since we see an increased frequency of cases where medial status has been commented on. Also, the choice of primary treatment method was in good agreement with the guidelines. However, the compliance appears to be lower in other areas, which is demonstrated by an excessive use of radiographic examinations and follow-up visits among patients with stable B1.1-fractures. These fractures were also immobilized for more days than recommended. From this we conclude the compliance to the PM needs to be increased in this aspect.
We found only one case among the B1.2/3 fractures where the initial non-surgical treatment was changed to surgical at an early stage due to findings on the 1-week follow-up radiographs. After-reviewing the radiographs this case seems to have been misinterpreted as unstable and hence unnecessarily operated. Based on this the mandatory 1-week follow up with radiographs may be removed from the PM since it rarely changes treatment. Nonetheless, we advocate further investigations to be made before doing so.
A conceivable explanation to the significant decrease of immobilization time and days inpatient care among surgically treated patients, could be that the time from injury to surgery had decreased. Between the non-surgically treated patients there were no significant changes in any of the variables which reinforces the suspicion that the PM was not followed.

Abbreviations

SFR – Swedish Fracture Register

SU – Sahlgrenska University Hospital

PM – Promemoria, in this report used as synonym for a structured treatment algorithm

A&E – Acute and Emergency department

AO - Arbeitsgemeinschaft für Osteosynthesfragen

ORIF – Open Reduction Internal Fixation

CT – Computed Tomography

MRI – Magnetic Resonance Imaging

SER – Supination External Rotation injury

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Populärvetenskaplig sammanfattning på svenska

Fotledsfrakturer – en uppföljande studie av behandling och resursutnyttjande efter införandet av en strukturerad behandlingsalgoritm.

Fotledsfrakturer är mycket vanliga och på Sahlgrenska Universitetssjukhuset (SU) i Göteborg registreras årligen ca: 350–400 fall av frakturer som involverar den yttre fotknölen. Vi har valt att fokusera på den vanligaste typen vilken benämns AO-44B1, med en ytterligare undergruppering i B1.1 och B1.2/3. De sistnämnda kan vara antingen stabila eller instabila och vilket som är fallet är ofta svårt att avgöra, då man på slätröntgen inte ser eventuella skador på närliggande ligament. Att särskilja mellan dem är dock helt avgörande för val av kirurgisk eller icke-kirurgisk behandling. Som ett led i att underlätta diagnostik, behandling och uppföljning av dessa frakturer infördes under 2017 en strukturerad behandlingsalgoritm (PM) vid SU. Detta PM har idag använts på kliniken i snart två år och jämförelser kan därför göras mellan patienter som behandlats före- respektive efter dess införande.

Ett datauttag gjordes från Svenska Fraktur Registret och uppgifterna kompletterades därefter med information som inhämtades genom detaljerad granskning av journaler och röntgen-bilder. Första målet med studien var att analysera resultaten från post-PM gruppen i relation till riktlinjerna för att undersöka i vilken omfattning som PM:et följts. Det andra syftet var att undersöka effekten på ett antal resurs-relaterade variabler mellan de båda grupperna pre- och post-PM. De variabler vi valde att jämföra som ett mått på resursutnyttjande var: antal opererade frakturer, antal röntgenundersökningar, antal läkarbesök, immobiliseringstid samt antal dagar inneliggande vård. Vi undersökte även i vilken utsträckning som status gällande den inre fotknölen fanns angivet i journaler som en indikation på att frakturen kunde vara instabil, samt vilken belastningsregim som hade ordinerats patienterna.

Våra resultat visar en signifikant minskning av antalet opererade frakturer sedan införandet av behandlingsalgoritmen. Vid jämförelser av resursrelaterade variabler mellan de båda grupperna pre- och post-PM konstaterades en signifikant minskning av immobiliseringstid och antal inneliggande vårddagar för kirurgiskt behandlade patienter. För icke-kirurgiskt behandlade patienter kunde vi inte påvisa några skillnader mellan grupperna. Patienter med stabila B1-frakturer som behandlades icke-kirurgiskt hade genomgått för många röntgen-undersökningar, haft onödigt många återbesök samt varit immobiliserade alltför länge i förhållande till vad som anges i PM:et. Inom gruppen post-PM återfann vi endast 2 fall där primärt icke-kirurgisk behandling hade ändrats till kirurgisk på grund av fynd vid vecko-kontroll med röntgen. I samråd med en erfaren ortopedspecialist eftergranskades dessa röntgenbilder och vi kunde då konstatera att de troligen misstolkats som instabila och således inte borde ha opererats.

Vi tolkar det minskade antalet operationer av B1-frakturer som att algoritmen har underlättat arbetet med att särskilja stabila från instabila frakturer och därigenom bidragit till ett mer korrekt urval av patienter som bör opereras. Detta indikerar att de delar av PM:et som berör initial handläggning och behandling följs i stor utsträckning. Följsamheten till andra delar av PM:et behöver dock förbättras. Särskilt påtagligt är detta för icke-kirurgiskt behandlade B1.1-frakturer och de riktlinjer som gäller antal röntgenundersökningar, antal återbesök samt föreslagen immobiliseringstid. Den obligatoriska veckouppföljningen med röntgen av icke-kirurgiskt behandlade B1.2/3 frakturer kan sannolikt plockas bort från PM:et eftersom den sällan leder till några förändringar av behandlingsmetod. Vi förordar dock ytterligare studier innan detta genomförs.

Våra resultat kan användas till förbättringar av algoritmen samt utgöra underlag för vidare diskussioner om hur man kan säkerställa att PM:et följs. Vår förhoppning är att detta kan bidra till förbättrad vård och ett mer effektivt resursutnyttjande vid behandling och uppföljning av fotledsfrakturer.

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