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Variation in treatment of hip fractures and guideline adherence amongst surgeons with different training backgrounds in the Netherlands

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ABSTRACT

Background and Purpose: Two medical specialties, general surgery and orthopaedic surgery, with different training programs but matching trauma certification requirements, provide hip fracture surgery in the Netherlands. This study analyses treatment preferences and guideline adherence of Dutch surgeons with different surgical backgrounds.

Patients and Methods: All hip fracture patients registered in the Dutch Hip Fracture Audit in 2018 and 2019 were included in this retrospective study. Four types of surgeons were distinguished: trauma-certified general surgeons (ST+), non-trauma certified general surgeons (ST-), trauma-certified orthopaedic surgeons (OT+) and non-trauma certified orthopaedic surgeons (OT-). Differences in patient characteristics, and practice variation in treatment choices and guideline adherence per fracture type were analysed using descriptive statistics.

Results: 28,656 patients were included; 16,367 (57.1%) treated by ST+, 1,371 (4.8%) by ST-, 4,692 (16.4%) by OT+ and 6,226 (21.7%) by OT-. Few clinically relevant differences in patient characteristics and hospital processes were found between all surgeon groups. Displaced FNF were the most commonly treated fracture type for all types of surgeons. Both OT+ and OT- operated mostly (displaced) FNFs, while the fracture types treated by ST+ and ST- were more heterogeneous. For all fracture types, the orthopaedic surgeons performed THA and HA more often than general surgeons, while general surgeons more often placed SHS and IMN for specific fracture types. Guideline adherence was on average 68.4% and differed significantly per surgeon type (68.7% by ST+, 65.2% by ST-, 74.4% by OT+ and 63.6% by OT-($p<0.01$)), as well as per fracture type: >90% treatment according to the guideline for trochanteric AO-31A2 and A3 fractures, 18.8% for AO-31A1 fractures and 51.7% guideline adherence for undisplaced FNF. Guideline adherence for displaced FNF varied depending on patient characteristics.

Discussion: In the Netherlands, different surgical specialists treat different types of hip fractures and have different preferences concerning implants for hip fracture surgery in comparable patients. Guideline adherence of trauma- and non-trauma certified orthopaedics and general surgeons differs significantly. Reduction of practice variation should be strived for in order to improve hip fracture care.

Introduction

In the Netherlands, 17,500 patients with a hip fracture are treated annually. [1] The Netherlands belong to the few countries worldwide in which two medical specialties, i.e. general (trauma) surgeons and orthopaedic surgeons, with different training programs are licensed to provide musculoskeletal trauma care, including the operative treatment of hip fractures. [2]

The Dutch Trauma Society started a 2-year trauma speciality training within the general surgery training in 2010, which after fulfilment, results in a trauma certification for treating both musculoskeletal and visceral trauma for general surgeons. The Dutch Orthopaedic Association started a musculoskeletal trauma certification for orthopaedic surgeons in 2013. Since 2016 both trauma related associations matched their requirements for the musculoskeletal trauma certification. Nowadays they are working together on the implementation of a common multidisciplinary trauma unit (MTU) in every hospital. In the MTU certified trauma surgeons and orthopaedic trauma surgeons fulfil the same require-

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ments when treating musculoskeletal trauma patients. After fulfilling their trauma speciality training within the general or orthopaedic surgery, trauma-certified surgeons and trauma-certified orthopaedic surgeons meet the same generic trauma certification requirements: 1) clinical activities are related to treatment of trauma patients at least two days per week (for trauma surgeons also including visceral trauma), 2) more than 75 trauma procedures are performed annually and 3) at least 50% of the annual accredited training needs to be trauma surgery related. [3,4] A minority of general and orthopaedic surgeons still treat hip fractures without being trauma-certified. This results in four types of surgeons that treat hip fracture patients: general surgeons, trauma-certified surgeons, orthopaedic surgeons, and trauma-certified orthopaedic surgeons.

The speciality for which the patients with musculoskeletal trauma will be admitted and the type of surgeon operating on the patient depends on local agreements and hospital staffing, since there are no national regulations at present. Examples of local agreements are the implementation of specific 'orthopaedic' weekdays or weeks in which the (trauma-certified) orthopaedic surgeon is responsible for the fracture care, alternating with trauma-certified surgeons. Furthermore, specific patient or fracture characteristics may influence the assignment to one or the other speciality, again depending on local agreements.

Differences in training and the experience with specific surgical techniques may lead to preference-based treatment of certain fracture types. [5] Currently, it is not known how Dutch hip fracture patients are distributed amongst the different surgeon types. Nor do we have insight in the surgeons' preferences for treatment strategies and how these preferences relate to the current national guideline for hip fracture treatment, whilst adherence to treatment guidelines is known to be associated with better outcomes. [6]

The aim of this evaluation of the national hip fracture registry is to assess the treatment preferences in hip fracture surgery of Dutch surgeons with different training backgrounds, and to assess the guideline adherence of these surgeons in the Netherlands.

Patients and methods

Study design and data source

Data were derived from the Dutch Hip Fracture Audit (DHFA). The DHFA is a nationwide multidisciplinary hip fracture audit in which patients suffering from a hip fracture are registered since 2016. [7] In 2018 and 2019, 60 and 65 hospitals participated respectively, covering approximately 80% of the 17,500 hip fracture patients treated in the Netherlands. [1]

Patient population

Patients aged ≥18 years, diagnosed with a hip fracture and registered in the DHFA in 2018 and 2019, were included in this study. Patients with periprosthetic fractures, pathological fractures and patients treated conservatively by a non-surgical specialist were excluded.

Surgeons

Four types of surgeons were distinguished: trauma-certified general surgeons (ST+), non-trauma certified general surgeons (ST-), trauma-certified orthopaedic surgeons (OT+) and non-trauma certified orthopaedic surgeons (OT-). Trauma-certified general and orthopaedic surgeons did complete a 2-year trauma speciality course during their training as a medical specialist, non-trauma certified finished their training without the 2-year trauma speciality course. ST+, ST-, OT+ and OT- were analysed as separate groups. No detailed information on the surgeons' characteristics (age, experience, etc.) was available.

Data and definitions

Patient and clinical characteristics included age, gender, fracture side, fracture type, American Society of Anaesthesiologists physical status classification (ASA) score, pre-fracture living situation, mobility and KATZ Index of Independence in Activities of Daily Living (KATZ-6 ADL) score, as well as pre-fracture presence of dementia or osteoporosis. [8,9] Nutritional status was measured using the short nutritional assessment questionnaire (SNAQ) or malnutrition universal screening tool (MUST) and categorized as low (SNAQ 0 or MUST 0), medium (SNAQ 1–2 or MUST 1) or high risk of malnutrition (SNAQ ≥3, MUST ≥2). [10,11] Treatment characteristics included type of surgical fixation (if any), type of anaesthesia, length of stay in the emergency department (ED) in minutes, time between presentation on the emergency ward and operation in hours, involvement of a geriatrician, and hospital length of stay (HLOS) in days until discharge or in-hospital death. Time to operation beyond two weeks, ED length of stay longer than 24 h and HLOS longer than one year were considered data entry errors and coded as missing values. Variables recorded as 'unknown' were recoded as missing.

The Dutch national hip fracture guideline

A summary of the Dutch treatment guideline for femoral neck fractures (FNF) and trochanteric fractures (TF) is shown in Fig. 1. For undisplaced FNF this guideline recommends using fixation techniques such as a sliding hip screw (SHS) or cancellous screws (CS) rather than hip replacement therapy in healthy and relatively young patients. For displaced FNF patient profile considerations are leading for the choice of therapy, in combination with shared decision making. The Dutch guideline recommends the use of a SHS in AO-31A1 TF. For AO-31A2 TF the SHS is preferred over the intramedullary nailing (IMN) techniques for no other reason than the lower cost of the SHS. For AO-31A3 TF IMN is recommended. [12]

Data analysis

Hospital variation concerning the number of operated hip fracture patients was presented graphically per hospital and surgeon type. Baseline, fracture and treatment characteristics were compared between the four surgeon groups using one-way ANOVA for normally distributed continuous variables, the Kruskal-Wallis test for non-normally distributed continuous variables, and the Chi-square test for categorical variables. Treatment preferences are presented using descriptive statistics; per surgeon group, the count and percentage of each treatment was calculated, stratified per fracture type. The guideline adherence per surgeon type is shown separately for all fracture types as percentages of a specific treatment type. For displaced FNFs an additional subdivision was made according to age and ASA-classification. Patients with a secondary girdle stone treatment or missing data on the type of treatment were excluded from the analyses of treatment preference and guideline adherence. *P*-Values <0.05 were regarded as statistically significant. Statistical analysis was performed using R Studio Version 1.1.456. [13]

Results

A total of 28,656 patients with a hip fracture were included in this study, 16,367 (57.1%) of whom were treated by ST+, 1371 (4.8%) by ST-, 4692 (16.4%) by OT+ and 6226 (21.7%) by OT- (Table 1). Patients were treated in 65 different hospitals. Fig. 2

Table 1
Patient characteristics at baseline by operating specialist.

		(General) Surgeons		Orthopaedic surgeons		
		Trauma-certified (ST+)	Non-trauma certified (ST-)	Trauma-certified (OT+)	Non-trauma certified (OT-)	*p*-value*
Total number of patients, n (%)		16,367 (57.1)	1371 (4.8)	4692 (16.4)	6226 (21.7)	
Age, mean (SD)		79.06 (12.59)	78.65 (12.78)	79.30 (11.51)	79.13 (11.45)	0.33
	Missing	48 (0.3)	4 (0.3)	10 (0.2)	14 (0.2)	
Sex, n (%)	Male	5477 (33.5)	504 (36.8)	1585 (33.8)	1968 (31.6)	<0.01
	Female	10,864 (66.4)	863 (62.9)	3104 (66.2)	4246 (68.2)	
	Missing	26 (0.2)	4 (0.3)	3 (0.1)	12 (0.2)	
ASA-score, n (%)	1–2	6366 (38.9)	514 (37.5)	1857 (39.6)	2333 (37.5)	<0.01
	3–5	8833 (54.0)	652 (47.6)	2561 (54.6)	3160 (50.8)	
	Missing	1168 (7.1)	205 (15.0)	274 (5.8)	733 (11.8)	
Pre-fracture living situation, n (%)	At home, independent	8648 (52.8)	820 (59.8)	2568 (54.7)	3110 (50.0)	<0.01
	At home, with care	2866 (17.5)	221 (16.1)	816 (17.4)	749 (12.0)	
	Elderly home	1257 (7.7)	142 (10.4)	302 (6.4)	373 (6.0)	
	Nursing home	1724 (10.5)	111 (8.1)	541 (11.5)	505 (8.1)	
	Nursing home for revalidation	158 (1.0)	10 (0.7)	43 (0.9)	46 (0.7)	
	Other	413 (2.5)	29 (2.1)	94 (2.0)	172 (2.8)	
	Missing	1301 (7.9)	38 (2.8)	328 (7.0)	1271 (20.4)	
Dementia, n (%)	No	12,279 (75.0)	979 (71.4)	3351 (71.4)	3728 (59.9)	<0.01
	Yes	2934 (17.9)	242 (17.7)	732 (15.6)	827 (13.3)	
	Missing	1154 (7.1)	150 (10.9)	609 (13.0)	1671 (26.8)	
Osteoporosis, n (%)	No	12,963 (79.2)	1067 (77.8)	3592 (76.6)	3809 (61.2)	<0.01
	Yes	1778 (10.9)	157 (11.5)	433 (9.2)	520 (8.4)	
	Missing	1626 (9.9)	147 (10.7)	667 (14.2)	1897 (30.5)	
Pre-fracture mobility, n (%)	Mobile without mobility aid	7294 (44.6)	598 (43.6)	2275 (48.5)	2302 (37.0)	<0.01
	Mobile using 1 mobility aid	977 (6.0)	68 (5.0)	219 (4.7)	292 (4.7)	
	Mobile using 2 mobility aids (e.g. walker)	5005 (30.6)	404 (29.5)	1543 (32.9)	1324 (21.3)	
	Not mobile outside without help	1332 (8.1)	105 (7.7)	327 (7.0)	356 (5.7)	
	No functional use of lower extremities	471 (2.9)	22 (1.6)	67 (1.4)	219 (3.5)	
	Missing	1288 (7.9)	174 (12.7)	261 (5.6)	1733 (27.8)	
KATZ-6 ADL score, n (%)	0	8542 (52.2)	701 (51.1)	2480 (52.9)	3012 (48.4)	<0.01
	1–3	3778 (23.1)	283 (20.6)	1096 (23.4)	1356 (21.8)	
	4–6	3257 (19.9)	282 (20.6)	930 (19.8)	1137 (18.3)	
	Missing	790 (4.8)	105 (7.7)	186 (4.0)	721 (11.6)	
Risk of malnutrition, n (%)	No risk	11,597 (70.9)	972 (70.9)	3536 (75.4)	4286 (68.8)	<0.01
	Medium risk	1757 (10.7)	125 (9.1)	513 (10.9)	605 (9.7)	
	High-risk	1623 (9.9)	162 (11.8)	438 (9.3)	530 (8.5)	
	Missing	1390 (8.5)	112 (8.2)	205 (4.4)	805 (12.9)	

*p-values are calculated for non-missing categories.

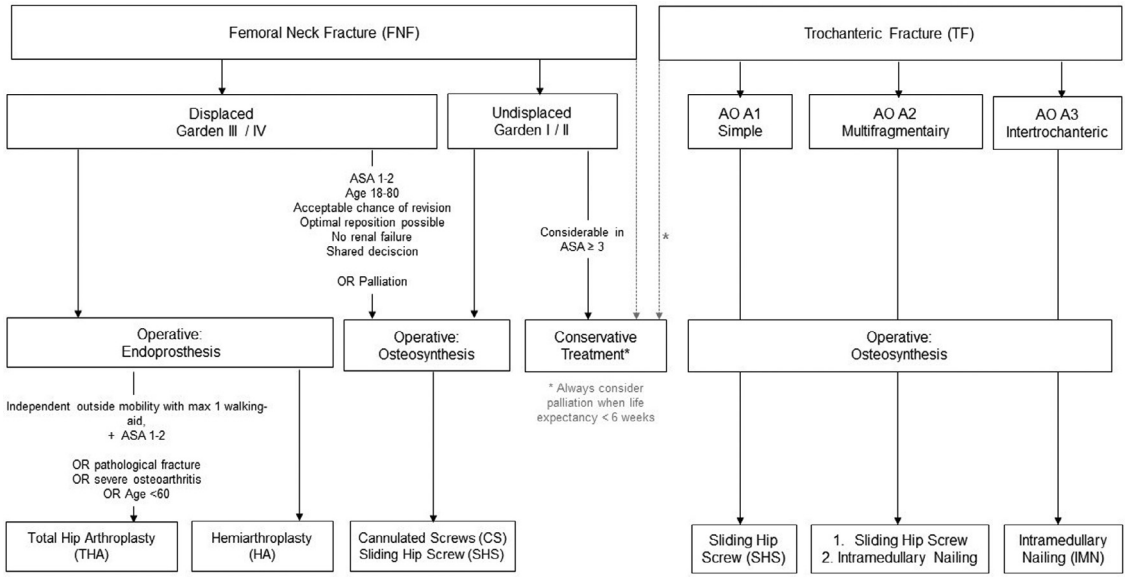

Fig. 1. Summary of the Dutch National Hip Fracture Guideline [12].

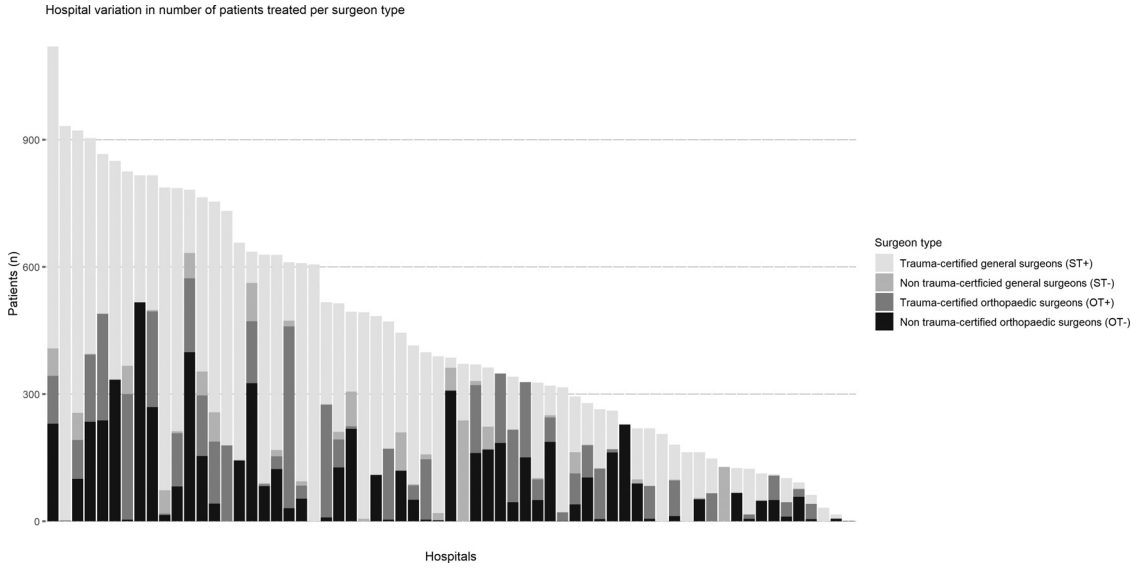

Fig. 2. Hospital variation in the number of hip fracture patients treated per surgeon type.

shows a wide between-hospital variation in the numbers of patients treated by the four surgeon types.

Patient, fracture and surgical treatment characteristics

There were some small but statistically significant differences in the distribution of patient characteristics per surgeon type (Table 1). Displaced FNF were the most commonly treated fracture type for all types of surgeons (Table 2). The heterogeneity in fracture types treated per surgeon type was most evident for ST+ and ST-. Both OT+ and OT- operated mostly (displaced) FNFs. Regarding treatment characteristics, there was a slight but statistically significant difference in the use of anaesthetic techniques between general surgeons or orthopaedic surgeons (Table 2). Both OT+ and OT- operated under spinal or regional anaesthesia more frequently. All types of surgeons operated their patients at a median of 20 h after presentation on the Emergency Department. The median length of hospital stay of a hip fracture patient in the Netherlands was 5 days; this was 1 day longer for patients treated by ST-. For 88.3% of the 23,275 patients aged 70 or older, a geriatrician was consulted. The timing and type of geriatric specialist involvement were significantly different between the patients treated by different surgeon types. For patients treated by ST- a geriatrician was often not consulted or only consulted after surgery, while patients treated by ST+ were more often admitted to a specialized geriatric trauma ward. The majority of patients was discharged to a facility (n = 16,483, 57.5%, Table 2).

Variation in treatment practice

The treatment choices per fracture type and operating specialist are shown in Table 3. Small numbers of (mainly simple) fractures were conservatively treated, while the vast majority of all fractures was treated surgically. For all fracture types, the orthopaedic surgeons performed THA and HA more often than general surgeons, while general surgeons more often placed SHS and IMN for specific fracture types.

Table 2
Treatment characteristics by operating specialist.

		(General) Surgeons		Orthopaedic surgeons		
		Trauma-certified (ST+)	Non-trauma certified (ST-)	Trauma-certified (OT+)	Non-trauma certified (OT-)	*p*-value*
Total number of patients, n (%)		16,367 (57.1)	1371 (4.8)	4692 (16.4)	6226 (21.7)	
Fracture type, n (%)	Femoral neck, undisplaced	2907 (17.8)	234 (17.1)	715 (15.2)	983 (15.8)	<0.01
	Femoral neck, displaced	4726 (28.9)	352 (25.7)	2349 (50.1)	2882 (46.3)	
	Trochanteric, type AO-31A1	2573 (15.7)	248 (18.1)	475 (10.1)	527 (8.5)	
	Trochanteric, type AO-31A2	3743 (22.9)	317 (23.1)	669 (14.3)	512 (8.2)	
	Trochanteric, type AO-31A3	1063 (6.5)	75 (5.5)	202 (4.3)	286 (4.6)	
	Sub trochanteric	684 (4.2)	58 (4.2)	137 (2.9)	148 (2.4)	
	Not specified	108 (0.7)	33 (2.4)	52 (1.1)	515 (8.3)	
	Missing	563 (3.4)	54 (3.9)	93 (2.0)	373 (6.0)	
Type of anaesthesia, n (%)**	General	5599 (35.6)	500 (39.5)	1491 (32.9)	1463 (24.4)	<0.01
	Combination	482 (3.1)	39 (3.1)	164 (3.6)	273 (4.6)	
	Regional (incl. spinal)	8271 (52.6)	684 (54.1)	2401 (53.0)	2974 (49.7)	
	Missing	1361 (8.7)	42 (3.3)	472 (10.4)	1278 (21.3)	
Duration of ED stay in minutes, median [IQR]	162 [0, 1403]	151 [0, 864]	150 [0, 1380]	160 [0, 1391]	<0.01	
	Missing	1457 (8.9)	117 (8.5)	602 (12.8)	941 (15.1)	
Time to surgery in hours, median [IQR]**	20.2 [0, 334.4]	20.1 [0, 317.4]	19.6 [0, 334.1]	19.8 [0, 331.8]	0.08	
	Missing	314 (2.0)	18 (1.4)	88 (1.9)	343 (5.7)	
Hospital stay in days, median [IQR]	5 [, 278]	6 [0, 59]	5 [0, 286]	5 [0, 280]	<0.01	
	Missing	1340 (8.2)	80 (5.8)	471 (10.0)	863 (13.9)	
Involvement of geriatrician in ≥70-year-old patients, n (%)	None	1348 (10.2)	181 (16.8)	477 (12.3)	730 (14.3)	<0.01
	Post-operative consultation	1190 (9.0)	146 (13.5)	272 (7.0)	586 (11.5)	
	Shared treatment on surgical ward	6454 (48.8)	569 (52.7)	2047 (52.9)	2552 (50.0)	
	Specialized geriatric trauma ward	3750 (28.4)	156 (14.4)	1037 (26.8)	726 (14.2)	
	Geriatrician in charge, surgical consultant.	242 (1.8)	15 (1.4)	12 (0.3)	126 (2.5)	
	Missing	244 (1.8)	13 (1.2)	28 (0.7)	417 (8.2)	
Discharge destination, n (%)	Home	4159 (25.4)	376 (27.4)	1464 (31.2)	1702 (27.3)	<0.01
	Institution	10,110 (61.8)	859 (62.7)	2479 (52.8)	3035 (48.7)	
	Unknown	560 (3.4)	35 (2.6)	201 (4.3)	184 (3.0)	
	Missing	1538 (9.4)	101 (7.4)	548 (11.7)	1305 (21.0)	

*p-values are calculated for non-missing categories.
** Percentages shown are of patients operatively treated.
ED: emergency department; IQR: interquartile range.

Table 3
Fracture treatment characteristics per fracture type by operating specialist.

		(General) Surgeons		Orthopaedic surgeons	
		Trauma-certified (ST+)	Non-trauma certified (ST-)	Trauma-certified (OT+)	Non-trauma certified (OT-)
Femoral Neck, Undisplaced, n		2906	233	715	982
	Conservative	152 (5.2)	11 (4.7)	58 (8.1)	46 (4.7)
	Hemiarthroplasty	890 (30.6)	52 (22.3)	253 (35.4)	495 (50.4)
	Total Hip Arthroplasty	0 (0.0)	0 (0.0)	120 (16.8)	142 (14.5)
	Cannulated Screws *	629 (21.6)	77 (33.0)	148 (20.7)	167 (17.0)
	Sliding Hip Screw *	1176 (40.5)	82 (35.2)	109 (15.2)	114 (11.6)
	Intramedullary Nailing	59 (2.0)	11 (4.7)	27 (3.8)	18 (1.8)
**Femoral Neck, Displaced, n ** **		4718	352	2349	2877
	Conservative	142 (3.0)	25 (7.1)	42 (1.8)	47 (1.6)
	Hemiarthroplasty *	3497 (74.1)	238 (67.6)	1627 (69.3)	1998 (69.4)
	Total Hip Arthroplasty *	0 (0.0)	0 (0.0)	550 (23.4)	651 (22.6)
	Cannulated Screws *	294 (6.2)	21 (6.0)	60 (2.6)	68 (2.4)
	Sliding Hip Screw *	732 (15.5)	62 (17.6)	59 (2.5)	93 (3.2)
	Intramedullary Nailing	53 (1.1)	6 (1.7)	11 (0.5)	20 (0.7)
Trochanteric, type AO-31A1, n		2570	247	475	527
	Conservative	41 (1.6)	11 (4.5)	12 (2.5)	13 (2.5)
	Hemiarthroplasty	21 (0.8)	2 (0.8)	9 (1.9)	13 (2.5)
	Total Hip Arthroplasty	0 (0.0)	0 (0.0)	8 (1.7)	10 (1.9)
	Cannulated Screws	18 (0.7)	3 (1.2)	5 (1.1)	11 (2.1)
	Sliding Hip Screw *	447 (17.4)	37 (15.0)	129 (27.2)	104 (19.7)
	Intramedullary Nailing	2043 (79.5)	194 (78.5)	312 (65.7)	376 (71.3)
Trochanteric, type AO-31A2, n		3742	317	669	511
	Conservative	59 (1.6)	7 (2.2)	13 (1.9)	5 (1.0)
	Hemiarthroplasty	12 (0.3)	1 (0.3)	7 (1.0)	11 (2.2)
	Total Hip Arthroplasty	0 (0.0)	0 (0.0)	6 (0.9)	5 (1.0)
	Cannulated Screws	13 (0.3)	1 (0.3)	6 (0.9)	2 (0.4)
	Sliding Hip Screw *	177 (4.7)	11 (3.5)	73 (10.9)	44 (8.6)
	Intramedullary Nailing *	3482 (93.0)	297 (93.7)	564 (84.3)	444 (86.9)
Trochanteric, type AO-31A3, n		1060	74	202	286
	Conservative	15 (1.4)	0 (0.0)	4 (2.0)	2 (0.7)
	Hemiarthroplasty	0 (0.0)	0 (0.0)	1 (0.5)	4 (1.4)
	Total Hip Arthroplasty	0 (0.0)	0 (0.0)	1 (0.5)	4 (1.4)
	Cannulated Screws	1 (0.1)	0 (0.0)	2 (1.0)	2 (0.7)
	Sliding Hip Screw	30 (2.8)	3 (4.1)	6 (3.0)	18 (6.3)
	Intramedullary Nailing *	1014 (95.7)	71 (95.9)	188 (93.1)	256 (89.5)

* Treatment recommended in the Dutch guideline: 'Richtlijn Proximale Femurfracturen 2016' [12].
** Guideline recommends osteosynthesis in patients with ASA 1–2, aged < 80 and Total Hip Arthroplasty or Hemiarthroplasty in all other patients.
Girdle stone treatments and missing treatment values were excluded.

Table 4
Guideline adherence (%) per fracture type and operating specialist.

	(General) Surgeons		Orthopaedic surgeons			Overall adherence per fracture type
	Trauma-certified (ST+)	Non-trauma certified (ST-	Trauma-certified (OT+)	TNon-trauma certified (OT-)	*p*-value	
Femoral Neck, Undisplaced						
Guideline followed: Osteosynthesis (SHS/Cannulated screws)	62.1	68.2	35.9	28.6	<0.01	51.7
Femoral Neck, Displaced **						
Guideline followed: Osteosyntheses in patients with ASA class 1–2 and aged < 80	14.3	14.8	3.7	3.7	<0.01	8.9
Guideline followed: THA or HA	74.1	67.6	92.7	92.1	<0.01	83.1
Trochanteric, type AO-31A1						
Guideline followed: SHS	17.4	15.0	27.2	19.7	<0.01	18.8
Trochanteric, type AO-31A2						
Guideline followed: SHS or IMN	97.8	97.2	95.2	95.5	<0.01	97.2
Trochanteric, type AO-31A3						
Guideline followed: IMN	95.7	95.9	93.1	89.5	<0.01	94.3
Overall adherence% per operating specialist	68.7	65.2	74.4	63.6	<0.01	

** Guideline recommends osteosynthesis in patients with ASA 1–2 and aged < 80 and THA or HA in all other patients.
Secondary girdle stone treatments and missing treatment values were excluded.
SHS: Sliding Hip Screw; THA: total hip arthroplasty; HA:hemi arthroplasty; IMN: intramedullary nailing.

Surgeon type and guideline adherence

Guideline adherence is shown in Table 4. Five patients secondarily treated with a girdle stone and 396 patients with missing treatment data were excluded from the analysis. Conservatively treated patients ($n = 767$) were scored as not being treated according to the guideline, since ASA classification had been documented for none of these patients. The Dutch treatment guidelines were followed in 19,322 of 28,256 patients (68.4%). On average general surgeons (ST+ and ST-) were compliant to the guidelines for *undisplaced* FNF in 65.2% (ST- and ST+), orthopaedic surgeons (OT+ and OT-) on average in 32.3%. The overall guideline adherence in *displaced* FNF for patients with ASA-class 1–2 aged <80 was 8.9%. For these patients the guideline advises osteosynthesis, this was adhered to in 14.6% on average by general surgeons (ST+ and ST-), and in 3.7% by orthopaedic surgeons (OT+ and OT-). According to the guideline, all other patients should receive THA or HA. Adherence to this choice of treatment was 83.1% overall and 70.9 by general surgeon (ST+ and ST-) and 92.4% by orthopaedic surgeons (OT+ and OT-).

All four types of surgeons treated most AO-31A2 and AO-31A3 TF (97.2% and 94.3%) consistent with the Dutch treatment guidelines. This was not the case for AO-31A1 TF, for which all types of surgeons frequently chose fixation with IMN instead of SHS (Table 3), resulting in a maximum guideline adherence of 27.2% for OT+ and 18.8% on average. The guideline adherence for all fracture types differed significantly between surgeon groups ($p<0.01$): 68.7% (ST+), 65,2% (ST-), 74.4% (OT+) and 63.6% (OT-). Trauma certified surgeons (ST+ and OT+) treated 71.6% of the hip fractures in agreement with the guidelines, while non-trauma certified surgeons (ST- and OT-) showed 64.4% overall adherence.

Discussion

This study shows that different surgical specialists in the Netherlands treat different types of hip fractures and have varying preferences concerning implants for hip fracture surgery in comparable patients. This is the first study that provides insight into the treatment preferences and guideline adherence of hip fracture surgeons with different surgical backgrounds, as well as insight in the allocation of Dutch hip fracture patients amongst these types of surgeons.

Trauma-certified general surgeons (ST+) treated the majority of all hip fracture patients (57.1%). Within the group of patients treated by general surgeons, surgeons with a trauma certification (ST+) operated the majority of the hip fracture patients (92.3%), whereas most of the orthopaedic surgeons treating hip fracture patients were not trauma-certified (57.0%). Differences in outcome for patients with proximal femoral fractures operated by trauma-certified surgeons versus non-trauma certified general surgeons have been studied before and presented various results. Some studies suggested trauma certification to be associated with shorter time to operation but apart from one study that indicated certification to be associated with fewer reoperations and surgical site infections [14], no direct relation with better outcomes has been established so far. [15,16].

Guideline adherence may be seen as a proxy for better outcomes. [6] This study showed that guideline adherence of trauma- and non-trauma certified orthopaedic and general surgeon groups differed with statistical significance (p-value <0.01). Trauma-certified surgeons and trauma certified orthopaedic surgeons demonstrated a higher treatment adherence to the guideline than their non-trauma certified colleagues. In undisplaced FNF surgeons (ST+ and ST-) were more guideline adherent, whilst in displaced FNF the orthopaedic surgeons were more adherent. The presented orthopaedic treatment strategy; choosing for arthro-

plasty in undisplaced fractures is more in line with international guidelines rather than with the Dutch guideline; The ESTES, NICE and AAST guidelines favour hip replacement therapy over fixation techniques for displaced FNF due to better outcomes in terms of lower reoperation rates, pain scores and better functional status. [17–19] The high numbers of arthroplasties placed by orthopaedic surgeons may be explained by several factors. Local allocation regulations may direct most FNF to orthopaedic surgeons because they may require hip replacement based on their age or pre-existing osteoarthritis. As information on individual hospital care pathways was not available, the number of hospitals using this specific allocation strategy is unknown. Another good reason for orthopaedic surgeons to choose hip replacement surgery over fracture fixation techniques may be their overall expertise in arthroplasty surgery. Experience in primary and revision hip arthroplasty is described to positively affect patient outcomes after HA for FNF. [20] Orthopaedic surgeons may be more specialized in elective surgery of the hip region, whilst general surgeons do not perform elective prosthetic hip replacements in the Netherlands.

For trochanteric fractures ST+ and ST- applied more often IMN techniques compared to orthopaedic surgeons (OT+ and OT-). This preference may originate from the long-time experience of ST+ with IMN for fractures other than the hip. It may also reflect the relatively short period of equal involvement of orthopaedic surgeons in the full scope of orthopaedic trauma care; Historically, 80% of all fractures were treated by general surgeons. Over the past decades, collaboration between general and orthopaedic surgeons have led to a common training programme and a redistribution of fracture care.

Obviously, there also was a wide variation in the number of patients with specific fracture type treated per surgeon type. ST+ operated on a wide variety of hip fracture types whilst their orthopaedic colleagues, both OT+ and OT- mostly treated FNF. Similar to the explanation for their preference for arthroplasty, there are several possible reasons for this difference, of which local care pathways probably again are the main factor. Patients suffering a FNF are more likely to be treated by an orthopaedic surgeon, mainly for the reason that the placement of a THA is an operation in the niche of the orthopaedic surgeons in the Netherlands. Therefore, patients presented to a general surgeon with an indication for a THA are usually referred to the orthopaedic department. Similarly, a probable reason why ST- treated a high number of patients conservatively (3.9%), is that no specific orthopaedic or trauma surgical experience is assumed to be required for non-operative treatment of hip fracture patients.

Although the DHFA database does not include information on pre-existent osteoarthritis, the role of pre-existent osteoarthritis in guideline adherence and the choice for THA seems evident. The absence of information on this factor of influence may explain the seemingly low guideline adherence of orthopaedic surgeons (3.7% for both OT+ and OT-) and general surgeons (14.5%) in FNF patients with ASA class 1–2 aged <80 years old. For these fracture types, guideline adherence probably is underestimated because treatments will have unjustly be scored as non-adherent in the case of THA or HA treatment in patients aged <80 with ASA 1–2 and osteoarthritis.

There was a wide variation between hospitals regarding the volumes of hip fractures treated by the different surgeon types (Fig. 2). The fact that there are no national regulations to allocate hip fracture patients to specific surgeon types attributes to this hospital variation. A recent review on volume-outcome effect showed increased hip-fracture hospital-volume to be correlated with better outcomes, and similar analysis can be done on DHFA data in the near future. [21] However, the wide between-hospital variation in the number of patients treated by different surgeon types, combined with the differences in preferred surgical techniques and guideline adherence found in this study may complicate the interpretation of hospital-volume outcome comparisons within the DHFA: Are we truly looking at the hospital-volume effect or is it effectively the influence of the surgeon(group)-volume, their personal choice and experience with a specific treatment type that we analyse? Several studies point out a volume-outcome relation for both hospitals and surgeons, especially affecting complication rates in arthroplasty placements. [20,22,23] Hence, analysis of a volume threshold, which is currently not implemented in the Netherlands, seems a next step to consider for improvement of hip fracture care. Setting a threshold for both hospital and surgeon volume, and additional volume requirements per fracture or type of surgical treatment should be considered. However, a volume-outcome relation should first be demonstrated with the DHFA data, before implementation of a threshold is justified.

Overall, the average guideline adherence of all surgeon types was high in AO-31A2 and A3 TF (97.2% and 94.3%), but low in undisplaced FNF (51.7%) and specifically low in AO-31A1 TF (18.8%). Due to the missing information on arthrosis, the true guideline adherence in displaced FNF remains unsure. The adherence to guidelines was already identified as problematic in 2013 when Dutch colleagues reported the adherence to the former (2007) guidelines for hip fracture treatment to be variable. The mean reason then was the lack of scientific substantiation. [24] Our results show guideline adherence currently to be lower than the average 76% reported in 2013. Again, scientific substantiation may be questionable as especially recommendations on treatment in displaced FNF were based on low grade evidence. [12] Recently, new and higher graded evidence has been published and should be taken into account in a future update of the Dutch guidelines on the treatment of hip fractures. Substantiation of a guideline by higher grades of evidence may help improve guideline adherence. [25,26]

The main limitation that should be kept in mind when interpreting the results of this study, is the fact that the data from the DHFA are hospital derived and neither validated by the research team. Furthermore, there was a considerable number of missing data, which differed between the surgeon types. The percentage of overall complete cases were 63.1% (ST+), 58.9% (ST-), 66.7% (OT+) and 44.7% (OT-); however, the missing data predominantly concerned parameters that were not relevant to guideline adherence and treatment choices. Only OT- had high numbers of missing values in patient characteristics, but missing data on provided treatment were low for all surgeon groups with 3.2% as a maximum percentage (ST). We therefore feel that the influence of the missing data for the current research question was limited.

The only incomplete parameter documentation that influenced the results in our opinion was the ASA-score. This score was missing in 8.3% of the patients, amongst which all conservatively treated hip fracture patients. It may have influenced specifically the adherences scores in FNF treatment, but also those of conservatively treated patients ($n = 767$), who all were scored as not being treated according to the guideline.

Furthermore, we do realize that the availability of outcome parameters would have increased the clinical relevance of the findings of this study. Further research on the effect of treatment of similar fractures by four surgeon types with different backgrounds on patient outcomes is indicated.

Conclusion

Altogether, we found a wide between-hospital variation in allocation of patients to different types of hip fracture treating surgeons and in preferred surgical techniques, resulting in a variable guideline adherence amongst the four surgeon groups in the Netherlands. Choices in hip fracture treatment seem to be guided by surgical background and experience rather than by the na-

tional guideline. Trauma-certified surgeons and trauma certified orthopaedic surgeons demonstrated a higher treatment adherence to the guideline than their non-trauma certified colleagues. Several quality of care registries use the between-hospital variability as a starting point for improvement of care. It may be assumed that the variability in treatment strategies and treatment volume have an effect on outcomes. Therefore, professional bodies for orthopaedic and trauma surgeons should strive for a reduction of the practice variation and concentration of hip fracture treatment to improve the care for hip fracture patients in the Netherlands.

Authors Contribution:

FW, SV, PK, IS made the study design, FW and SV wrote the manuscript. FW performed statistical analysis. PK and IS contributed to all of the above.

Ethical approval

Permission for the use of pseudonymized patient data for research purposes is assured within the Dutch Hip Fracture Audit. Due to the nature of this study no patient informed consent or approval of the medical ethical commission was required. **Funding and potential conflicts**: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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