Unchanged incidence but change in treatment trends from 1996 to 2018: 23,718 humeral shaft fractures from the Danish National Patient Registry

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Background and purpose — Humeral shaft fractures (HSF) can be treated surgically or non-surgically. National trends and distributions are sparsely reported. We present the temporal trends in epidemiology of adult HSF in Denmark, with the primary aim of reporting HSF incidences, and the secondary aim of reporting on the primary treatment management.

Patients and methods — The diagnosis (International Classification of Diseases Version 10 [ICD-10]: S42.3) and surgical procedure codes for HSF were obtained from the Danish National Patient Registry (DNPR) covering 1996–2018. The diagnosis code for HSF is validated in the DNPR with a positive predictive value of 89%. Patients aged 18 years and above were included. Surgical treatment was defined as a diagnosis of HSF combined with a surgical procedure within 3 weeks of injury. Cases without relevant registered procedures within 3 weeks were defined as non-surgical treatment cases.

Results — 23,718 HSF (62% female) were identified in the DNPR. The overall mean incidence was 25/100,000/year and was stable over 23 years. The population above 50 years accounted for 78% of all HSF. Non-surgical treatment accounted for 87% of treatments and was stable during the study period. Temporal changes were observed regarding surgical procedures; intramedullary nailing decreased from 57% to 26% and plate osteosynthesis increased from 12% to 69%.

Conclusion — The overall incidence for HSF remained stable from 1996 to 2018. Most cases were females aged 50 years and above. The preferred primary treatment for HSF was non-surgical for all ages. Plate osteosynthesis became more popular than intramedullary nailing over the study period.

Humeral shaft fractures (HSF) are commonly managed either through non-surgical treatment with a functional brace or surgical intervention utilizing plate osteosynthesis or intramedullary nailing [1]. However, high-quality data comparing the treatments is sparse and is limited by high risk of bias due to unclear treatment indications in observational studies and the relatively younger age of participants in the randomized trials compared with the population mean age [2,3].

The management of adult HSF is debated, and only a few register-based studies have reported on treatment [4,5]. These studies have reported a high and increasing proportion of surgical treatment. In contrast to Scandinavian countries, the reported prevalence of surgical treatment elsewhere appears to be higher [6,7].

Recent epidemiological research consistently indicates that the HSF population predominantly comprises patients with fragility fractures, which is likely associated with a growing prevalence of osteoporosis [4,5,7-12]. However, these studies are hampered by low completeness, which is why there is lack of good quality national register studies.

Therefore, a nationwide overview of the epidemiology and management of adult HSF is required to describe temporal trends. The primary aim was to report the overall and age-specific incidence of HSF and the secondary aim was to estimate the distribution of primary non-surgical and surgical treatment.

Patients and methods

Design

This is a national register-based study on HSF in adults. The reporting of this study conforms to the Reporting of studies

Conducted using Observational Routinely-collected health Data (RECORD) Statement [13].

Setting

The study was conducted in Denmark, where all persons with permanent citizenship are registered in a national register and are provided with a unique identification number [14]. This allows for exact individual-level record linkage between registers [15]. The identification number follows the person until death or emigration, and the Civil Registration System continuously updates this information with accurate censoring upon event. The Danish healthcare system is tax-supported and includes free access to general practitioners, hospitals, outpatient specialty clinics, and services for all persons granted a residence permit [16]. Emergency diagnosis with radiographic imaging is possible only in Danish public hospitals, and the healthcare services are registered for reimbursements. Therefore, all patients with an HSF are registered in the Danish National Patient Registry (DNPR).

Data source

The DNPR is a population-based administrative register used for continuous monitoring of hospitals and healthcare services in Denmark [17]. It records data per visit, and patients may have several records linked by their unique identification number. In 1978, the register achieved national coverage in collecting information on inpatient admissions to somatic departments. Diagnoses have been registered using the International Classification of Diseases Version 10 (ICD-10) with national extensions since 1994, and surgeries have been coded using the Nordic Medico-Statistical Committee Classification of Surgical Procedures since 1996 [17,18]. The completeness of patient registration in the DNPR is 98.8%, as departments are required by law to report administrative data including diagnosis and procedure codes [17,19]. The authors were able to access individual-level data from 1996 to 2018 from the DNPR and population estimations were accessible from Statistics Denmark [20].

Participants

The study population included all adult patients 18 years or older who were registered at Danish emergency departments with an HSF (ICD-10: S42.3) in the DNPR from 1996 through 2018. The accuracy of the HSF diagnosis code in the DNPR has been validated with a positive predictive value (PPV) of 89% [21]. All new HSF diagnoses that were reported from an emergency department within 90 days after the primary HSF diagnosis were removed from the dataset to minimize errors in coding due to possible reencounters. After this period, the same patient could re-enter the dataset with a new HSF diagnosis. Diagnoses reported from outpatient clinics were not included in the dataset.

Variables

Surgical procedure codes indicated whether patients were primarily treated non-surgically or surgically. Surgical procedures were defined as those with relevant surgical procedure codes (Table A, see Supplementary data) within 21 days from the first registered contact. If no relevant procedure codes were reported within the first 21 days, the treatment was defined as non-surgical. Similarly, all patients with a relevant surgical procedure code within the first 21 days were coded as primary surgical treatment. Surgical procedure codes were further divided into 3 categories: plate osteosynthesis (KNBJ61), nail osteosynthesis (KNBJ51), and "other procedures" (external fixation [KNBJ21], K-wire fixation [KNBJ41], screw fixation [KNBJ71], and combined fixation [KNBJ81]).

199 cases of HSF with a registered shoulder arthroplasty procedure code were omitted prior to the analysis due to the likelihood of misclassification issues of proximal humeral fractures. An HSF that requires arthroplasty must involve the proximal end to an extent that the fracture entity is consistent with a proximal humeral fracture.

Statistics

Descriptive statistics were used to report on age, sex, number of HSF, and primary treatment approach. Crude, age-adjusted, and age-specific incidence rates for age strata of 5 years were estimated using the number of new HSF cases per 100,000 persons for each calendar year. The mid-year populations for adults ($\geq$ 18 years) for each calendar year were estimated using data from Statistics Denmark [20]. To reflect the increased risk of fractures with age and to account for the ageing population, direct standardization and age stratification were used to estimate the age-adjusted rate. European population data was used to represent the standard population [22]. Temporal changes were visually summarized using line charts with 95% confidence intervals (CI) to account for the uncertainty associated with the point estimates. Crude incidence rates were used to calculate CIs for incidence rates, stratified by both sex and age strata of 20 years. Population proportions were used to calculate CIs for treatment approach and procedure estimates. A clinically relevant trend was defined as a change of more than 10% in the study period.

Ethics, funding, and disclosures

Results

All adults diagnosed with HSF between 1996 and 2018 were included for analysis apart from cases with registered shoulder arthroplasty. 23,718 were included for analysis (Figure 1).
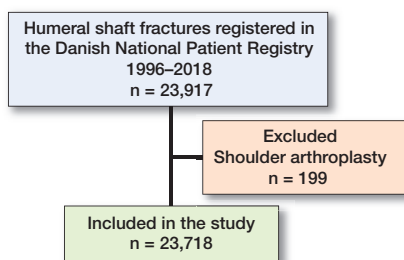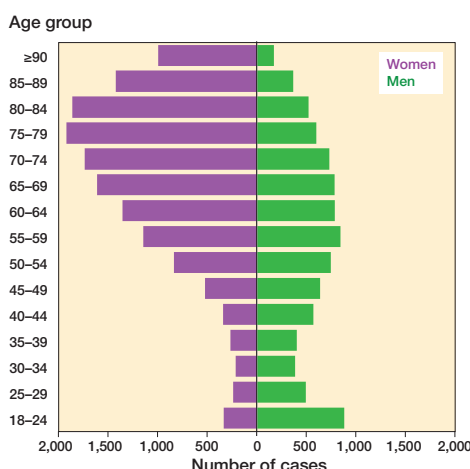
Figure 1. Flowchart of patients.

Age group

Figure 2. Humeral shaft fracture distribution by age group and sex.

Figure 3. National incidence rates with 95% CIs for humeral shaft fractures by age group and sex from 1996 to 2018.

Epidemiology

Females accounted for 62% of the patients (Table 1). The age distribution for females was unimodal, with the highest number of HSFs in the 75–79-year age group (Figure 2). The age distribution for males was bimodal, with the highest number of HSFs in the 18–24-year and 55–59-year age groups. The second peak started to increase around the age of 50 years. The population over 50 years of age accounted for 78% of all HSF cases.

Between 1996 and 2018, the absolute increase in HSF was 21%. Female HSFs increased by 28% and male HSFs increased by 7%. The absolute increase stratified by age group was 1% in the 18–64-year age group, and 39% in the ≥ 65-year age group. The mean incidence rate was 25 fractures (range 21–28) per 100,000 persons per year (Table B, see Supplementary data). The trend was stable for crude and age-standardized incidence rates. The trend remained stable following stratification by sex and age strata of 20 years; however, in men 80 years and older, the trend declined (Figure 3).

The overall and sex-stratified age-specific incidence rates increased gradually with age. The overall rate increased from 11 to 141 fractures per 100,000 persons
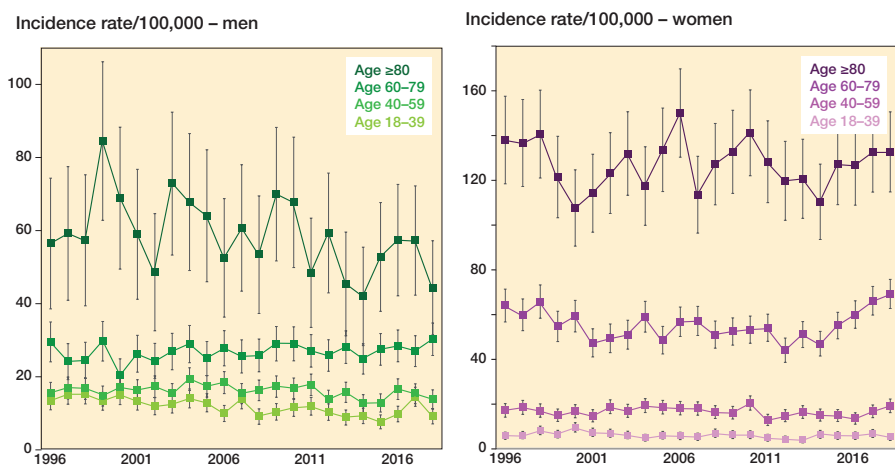
Table 1. Humeral shaft fracture demographics from 1996 to 2018 in Denmark

|	Total	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
n	23,718	1,018	1,018	1,061	966	994	918	952	976	1,058	1,001	1,061	1,020	986	1,051	1,113	1,026	935	1,002	941	1,034	1,123	1,237	1,227
Sex																								
Female	14,807	644	637	679	575	616	542	594	598	629	613	680	632	627	641	696	620	566	624	600	675	702	791	826
Male	8,911	374	381	382	391	378	376	358	378	429	388	381	388	359	410	417	406	369	378	341	359	421	446	401
Age																								
18–24	1,216	51	65	72	63	61	58	50	57	51	66	48	54	48	43	48	55	52	26	45	38	54	70	41
25–29	733	36	36	59	28	42	41	30	34	36	26	17	36	27	29	43	21	21	26	28	27	27	44	19
30–34	600	38	32	25	28	49	31	31	28	28	24	28	27	20	22	24	25	16	20	19	20	16	23	26
35–39	668	35	43	37	43	47	36	38	26	31	27	23	25	23	29	17	24	19	23	26	17	23	30	26
40–44	911	40	40	46	29	43	35	52	44	48	44	39	48	41	46	43	38	29	35	25	42	33	33	38
45–49	1,160	49	52	57	48	47	41	52	37	71	57	60	53	48	59	51	50	38	40	58	42	52	50	48
50–54	1,581	69	81	77	56	70	70	65	63	60	62	70	71	74	72	83	56	65	73	61	50	76	73	84
55–59	1,988	72	79	63	82	88	83	99	97	111	107	106	79	83	75	104	88	84	97	67	78	71	91	84
60–64	2,141	100	56	69	72	59	59	61	75	97	79	99	121	119	115	118	105	90	88	97	104	112	119	127
65–69	2,395	94	87	87	81	79	74	71	79	88	81	103	100	110	106	139	122	137	110	115	151	138	138
70–74	2,467	98	98	105	102	78	81	87	80	98	86	109	89	73	97	108	111	92	114	113	137	150	170	191
75–79	2,518	108	120	129	106	131	103	103	112	118	98	98	103	91	107	107	86	81	106	91	125	111	134	150
80–84	2,383	103	109	114	94	96	97	101	108	100	111	102	104	104	125	115	102	93	81	87	97	114	111	115
85–89	1,790	95	70	76	95	56	71	72	82	71	79	87	69	72	73	95	72	77	79	63	89	87	83	77
≥ 90	1,167	30	50	45	39	48	38	40	54	50	54	72	41	53	53	52	54	56	57	51	53	46	68	63
median	66	66	66	66	67	63	65	64	66	64	65	67	64	65	66	65	66	67	67	66	69	68	68	69
min	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
max	106	97	102	101	100	100	98	98	100	103	100	104	99	104	97	99	102	100	101	102	100	101	101	106
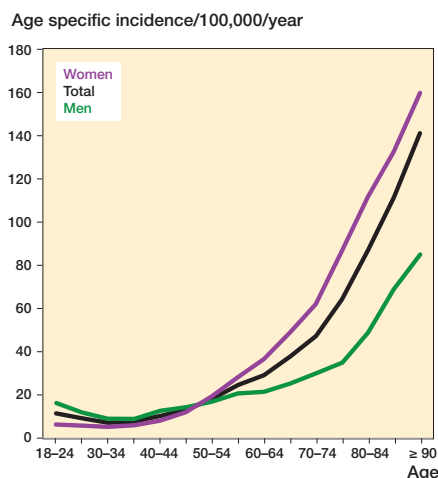
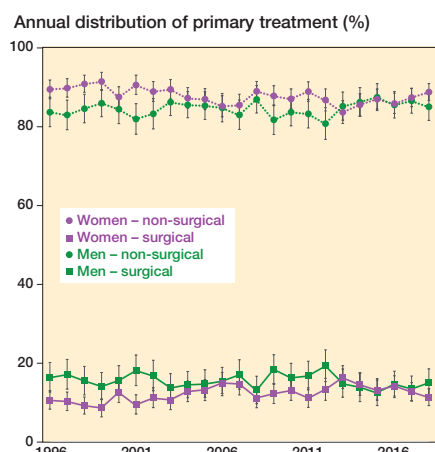Figure 4. Age-specific incidence rates for humeral shaft fractures from 1996 to 2018.

Figure 5. Annual distribution with CI for primary treatment of humeral shaft fractures by sex from 1996 to 2018.
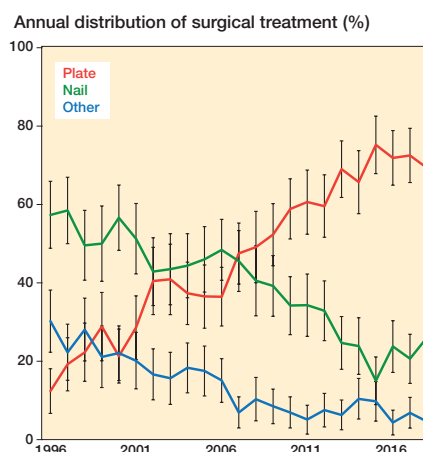
Figure 6. Annual distribution with CI of surgical treatment implants for humeral shaft fractures from 1996 to 2018.
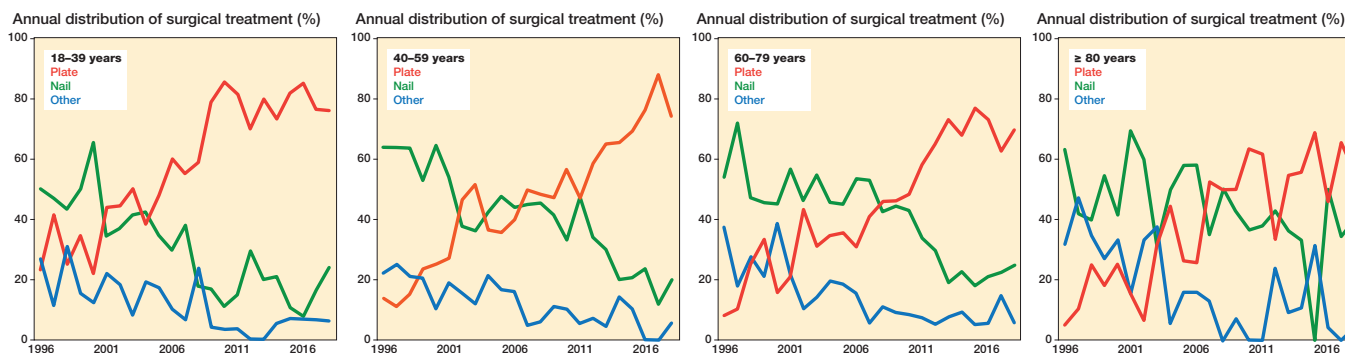
Figure 7. Annual distribution of surgical treatment implants in 4 age groups of humeral shaft fractures.

per year (Figure 4). Incidence rates by sex were almost equal from 18 to 50 years of age, with higher incidence rates for males. The incidence rates for sexes crossed at 50–54 years of age. Mean differences for male incidence rates were 5 points higher than females until 50 years; this difference changed to 37 points, favoring females from 50 years and older (Table B, see Supplementary data).

Treatment

The proportion of cases with primary non-surgical treatment was 87% (range 84–89%, n = 20,534) (Table C, see Supplementary data). HSF was predominately treated non-surgically between 1996 and 2018, without any considerable changes in the distribution between surgical and non-surgical treatment (Figure 5).

The predominant choice of implants (Figure 6) also changed throughout the study period when stratified by age (Figure 7). In 1996, intramedullary nails were the preferred choice of treatment implant and were used in 57% of surgically treated HSFs, equaling 7% of the total number of HSFs in 1996. Over the period 2007 to 2018, plate osteosynthesis became the preferred method. By 2018, plate osteosynthesis was used in 69%
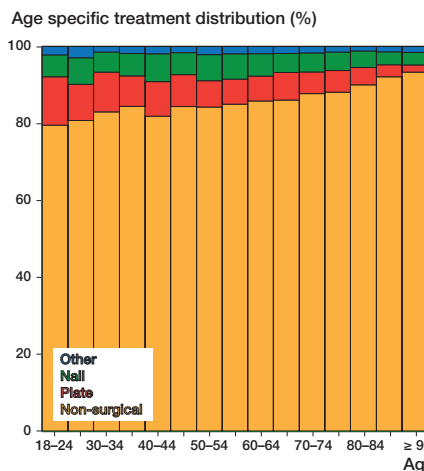
Figure 8. Age-specific treatment distribution for humeral shaft fractures from 1996 to 2018.

of surgical cases. The use of other techniques decreased from 30% to 5% and included external fixation, screw fixation, K-wire fixation, and combined fixation.

Surgical treatment was more frequently used in younger patients (Figure 8).

Discussion

We aim to report HSF incidences and distribution of primary treatments in Denmark from 1996 to 2018. We showed a stable incidence rate of 25 fractures/100,000 persons per year with an overall increase of HSF that was 20% driven by the age group 65 years and older. Regarding surgery, we showed stable trends in choice of treatment with a strong preference for non-surgical treatment; however, plate osteosynthesis surpassed intramedullary nailing as the preferred surgical method.

Epidemiology

The absolute increase in the elderly population (≥ 65 years) by 40% indicates that population ageing and the underlying increase in the prevalence of osteoporosis may be a risk for HSF.

The incidence rate gradually increased with age; for women, the rate increased exponentially from the sixth decade. Most HSFs occurred in women (62%), and 78% of all HSFs were sustained over the age of 50 years. This supports the statement that most HSFs should be considered osteoporosis-related fractures. Previous epidemiological studies have reported comparable fracture incidences and distribution of HSF by age and sex [5,8-12]. The incidence has been reported as between 7 and 20 fractures/100,000 persons per year. Mahabier et al. [5] also included pediatric humeral shaft fractures, which explains the lower reported incidence. The other studies report slightly higher incidences ranging from 12 to 20 fractures/100,000 persons per year [8-12]. Comparable to the Danish setting, the 2 Swedish studies based on 401 and 262 HSFs estimated an overall incidence rate of approximately 14 fractures/100,000 per year for 1998–1999 and 2011–2013, respectively [10,11]. Furthermore, similar to our findings, the incidence rate reported in these studies increased with age and showed the same steep increase from the sixth decade.

This study reported higher overall incidence compared with other countries, which could be due to a higher rate of identified HSF. To mitigate inaccuracies caused by readmissions, a 90-day "quarantine period" was established [23].

Treatment

We found that non-surgical treatment was the preferred choice for HSF management in 87% of cases, with surgical treatment gradually decreasing with advancing age. In cases aged 18–24 years, 20% had surgical treatment, whereas this proportion gradually decreased to 7% in cases aged 90 years or older in agreement with Swedish data but higher than Finnish data with 53% of cases non-surgically treated [7]. In 2 register-based studies from the USA and the Netherlands, the predominant choice of management was surgical treatment with rates of 68% and 67%, respectively [4,5]. However, a similar decrease in surgical utilization with increasing age was reported.

The variation in treatment management between countries is likely due to the lack of large randomized trials with sufficient external validation and low risk of bias.

While the overall treatment management remained stable throughout the study period, there was a notable shift in method preference in our study. Intramedullary nailing was gradually replaced by plate osteosynthesis as the primary choice across all age groups, with the use of plates surging from 12% to 69% between 1996 and 2018. This trend corresponded with findings from studies conducted in the USA and Finland [4,24]. This may be caused by the increased risk of shoulder complaints with an antegrade humeral nail, but no clinically relevant risk differences have been demonstrated between the implants [25]. Furthermore, this shift in implant preference may be closely linked to technological advancements with the introduction of locking plates in the early 2000s, corresponding to a period of increased plate usage as seen in other studies [26,27], underlining the role of innovation in driving this shift in implant preference.

In Denmark, non-surgical treatment for HSF is favored, with a higher proportion compared with other Western countries. The preference for non-surgical treatment may be explained by the high treatment threshold: 7 patients need surgery to avoid 1 nonunion [2]. Yet, the serious risks of surgery, such as infection, nerve injury, and re-intervention, must be considered. However, in other Western countries patients do not have similar rights to full pay during sick leave, which may change patients' preference towards surgery, as it typically yields faster recovery.

Strengths and limitations

The DNPR has national coverage, and hospitals are required by law to continuously report administrative data to the authorities. This ensures high completeness of the DNPR regarding HSF. We cannot dismiss that some patients are treated in the private sector; however, it became a requirement in 2003 that all private healthcare was reported to the DNPR, and private emergency departments do not exist [17]. Therefore, the missed data would only include patients who did not receive emergency treatment for an HSF, which we believe is few.

A further limitation is the lack of data accuracy for procedure codes in the DNPR for HSF. However, the registration of orthopedic procedures is generally high in Denmark [28], and the classification of surgical procedures has not changed since 1996. Therefore, we assume that the coding practice was stable throughout the study period. Fractures are not registered in the DNPR using a fracture classification system, and erroneous coding cannot be detected through the register.

A strength of this study is that the HSF diagnosis in the DNPR has been validated and has a high PPV (89%). However, there may have been an overestimation of the incidence as the accuracy is not optimal [21]. Furthermore, the validity

study showed that a majority of the misclassified cases consisted of proximal humeral fractures. In Denmark, non-surgical treatment is the common approach for proximal humeral fractures [26]. Consequently, this misclassification would be primarily attributed to 1 treatment, leading to an overestimation of non-surgical treatment.

The definition of primary treatment for HSF within a 21-day timeframe is representative of the Danish healthcare context [26,27]. In Denmark, surgical treatment of a humeral shaft fracture is rarely performed on the same day but most likely the extended 21-day window ensures all procedures are included and accurate documentation of the actual prevalence of such interventions without including secondary procedures. Currently, the DNPR cannot be used to report on secondary procedures following HSF. Comprehensive validation procedures for nonunion diagnosis and reoperation procedure codes are necessary to ensure accurate reporting of nonunion and reoperation rates.

Conclusion

In Denmark, most HSFs occur after the age of 50 years and the incidence increases with age. Between 1996 and 2018, the overall incidence remained stable. Non-surgical treatment was the preferred choice for all ages, although surgery was more common in younger patients. Over time, plate osteosynthesis replaced intramedullary nailing as the preferred method for all ages.

Supplementary data

Tables A–C are available as supplementary data on the article page, doi: 10.2340/17453674.2023.21125

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