

Can the medullary diameter/cortical thickness ratio be a predictor of diaphyseal fracture in elderly patients treated with cephalo-medullary nail for proximal femur fractures? A retrospective cohort study on 488 patients

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Abstract. *Background and aim of the work:* Diaphyseal femoral fracture occurring distal to the CM nail tip is an infrequent complication that presents some similarities with periprosthetic hip fractures. The purpose of this study is to evaluate the correlation between medullary diameter (MD) and cortical width (CW) ratio, a known risk factor for periprosthetic fracture, with the occurrence of diaphyseal fracture distal to the nail tip. *Research Design and Methods:* Study population included patients > 65 years old treated with short CM nail for proximal femur fractures (PFF) at the Cattinara Hospital-ASUGI of Trieste (Italy) Orthopedics and Traumatology Unit between July 2014 and May 2018. Latest follow-up X-rays were evaluated to identify diaphyseal fracture occurrence. We recorded type of trauma, time lapse between CM nailing and diaphyseal fracture and calculate the MD/CW ratio on intra-operative X-rays. Data were analysed to find out a correlation with the occurrence of diaphyseal fractures. *Results:* The study population counted 488 patients. Diaphyseal fracture occurred in 14 cases (2.9%, F:M ratio 6:1, mean age 87 years), at mean 26.07 months after CM nailing. The MD/CW ratio identified a trend of increased risk of diaphyseal fractures as the ratio increases (OR 4.51; CI 0.826-24.642) although the correlation does not reach statistical significance (p 0.082). *Conclusions:* The results of the present study demonstrate a trend towards a higher risk of diaphyseal fracture as the MD/CW ratio increases, although the association did not reach statistical significance due to the small number of events. (www.actabiomedica.it)

Key words: diaphyseal fracture, MD/CW, Cephalo-medullary nails

Introduction

Cephalo-medullary (CM) nails are used worldwide for proximal femur fractures (PFF) fixation. Due to the outstanding number of implants per year, mechanical complications are rising in number. Within these complications fractures around the implant are growing in interest, as they represent a cause of revision surgery that negatively affect outcome and mortality rate. These fractures usually occur at the diaphysis,

within few centimeters from the nail tip, after low energy trauma (Figure 1a-c).

The incidence ranges from 0 to 2.3%, with a mean time from PFF fixation to diaphyseal fracture of 1.5 months (1, 5). The reason might reside in the mechanical stress transmitted through the implant to the nail tip and therefore to the diaphysis (2-4). A similar mechanism has been described for Vancouver type C periprosthetic fractures occurring after hip arthroplasty. In this scenario, the medullary diameter

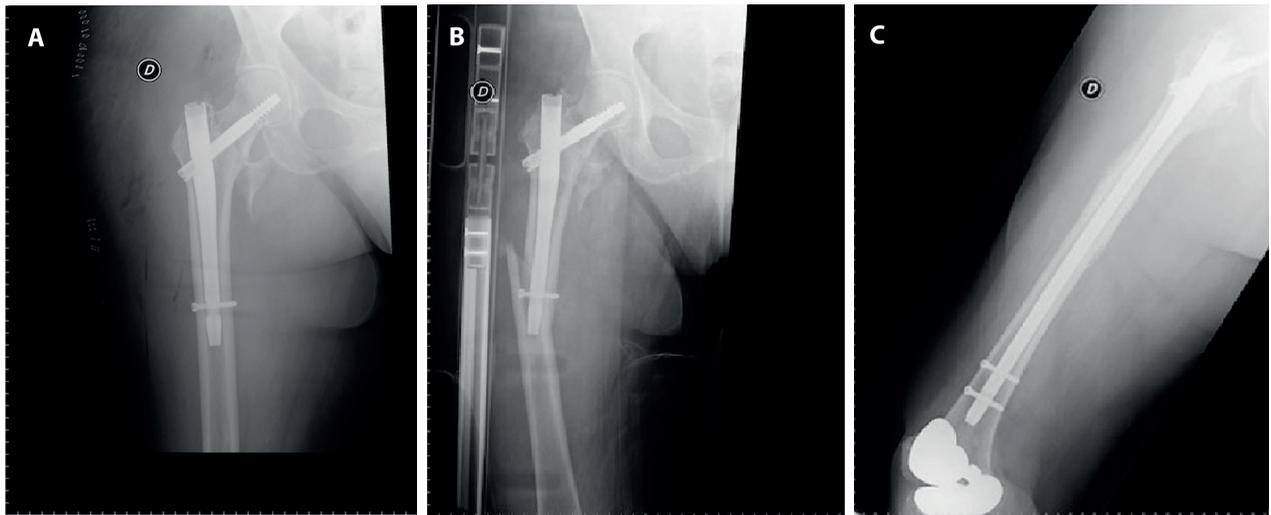


Figure 1. Clinical case of an 82 years old woman treated with CM nailing for a right PFF. a) Post-operative radiographs demonstrating fracture reduction and CM nail fixation. b) One month after CM nailing the patient fell to the ground while walking with crutches, reporting a diaphyseal femur fracture right at the nail tip. c) The patient underwent CM nail removal and fixation of the fracture with a long CM nail two days after trauma. This image shows the healed fracture 11 months after surgery.

to cortical width (MD/CW) ratio (5) has been identified as a risk factor. Therefore, there might also be a relation between MD/CW ratio and diaphyseal fractures around the nail tip.

The purpose of this study is to retrospectively evaluate the correlation between MD/CW ratio and diaphyseal fracture occurring at the nail tip in a cohort of elderly patients treated with CM for PFF.

Patients and methods

Patients > 65 years old treated with short CM nail for PFF at the Cattinara Hospital-ASUGI of Trieste (Italy) Orthopedics and Traumatology Unit between July 2014 and May 2018 were all considered for the study. Exclusion criteria were pathologic fractures, follow-up < 3 months and patients treated with long CM nail. For all included patients, demographic information including age and sex was recorded. Surgical treatment was performed using standard CM nailing technique under fluoroscopic control with the patient lying on a radiolucent traction table. Closed reduction was attempted before surgery in all cases. Osteosynthesis was performed using a single CM nailing system (Gamma 3, Stryker Trauma GmbH, Schoenkirchen,

Germany). For distal locking, a single static screw was inserted using the targeting device in all cases. On the first day post-op, the patient was introduced to rehabilitative program including early weight bearing and hip mobilization. Patients started walking with crutches approximately 48–72 h after surgery except in case of pre-operatively non-ambulatory patients. Radiographic examinations, including standard anteroposterior (AP) and lateral (Lat) views of the hip and AP view of the pelvis, were performed before and after surgery and at follow-up, usually carried out at 6 weeks, 3 months, 6 months, and 1 year after surgery. The MD/CW ratio was calculated on intra-operative X-rays (Figure 2).

For each radiographic measurement, the known diameter of the nail was used to correct for image magnification. Latest follow-up X-rays were evaluated to identify diaphyseal fracture occurrence. In these cases, patient history was examined to retrieve data about type of trauma and time lapse between CM nailing and diaphyseal fracture.

Multivariable logistic regression model was estimated using the IBM Statistical Package for Social Science (SPSS) software version 25. Descriptive statistics are presented as mean \pm standard deviations or counts and percentages, respectively, for continuous

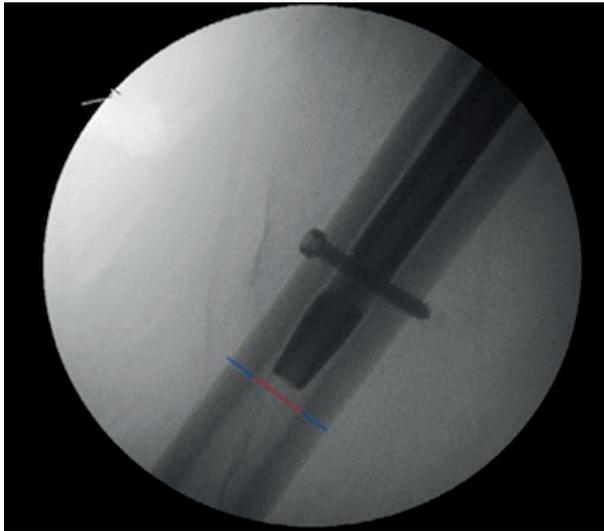


Figure 2. MD/CW measurement. The MD/CW ratio was obtained on the intraoperative x-rays measuring the CW (blue line) and the MD (red line) 2 cm distal to the nail tip in all cases. Magnification was corrected by measuring the known diameter of the nail. In the present case, MD/CW ratio was 1.70.

and nominal variables. Differences between groups are reported with the corresponding ANOVA or Mann-Whitney test or the Chi-square test p values, respectively, for continuous and nominal variables. For each of the variables listed above, univariable odds ratios were estimated (significance p value set at < 0.05) to determine which variables had a strong significant correlation with the onset of diaphyseal fracture. For nominal variables, odds ratio was estimated using as a reference category the most frequent value.

Results

Based on the inclusion/exclusion criteria, the study population counted 488 patients (386 females, 102 males), with an F:M ratio of 3.8:1 and a mean age of 84.76 years (Table 1).

Diaphyseal fracture occurred in 14 patients, of which 12 women (F:M ratio of 6:1), at a mean age of 87.07 years. Patients experienced diaphyseal fracture within 6 months after CM nailing in 42.85% of cases (mean 26.07 months, range 1 - 103 months).

There was no statistically significant correlation between age or sex and diaphyseal fracture.

Table 1. Age and gender distribution

	Whole population	Group with diaphyseal fracture	Group without diaphyseal fracture	p-value
Age	84.79±7.2	87.07±7.2	84.72 ±7.5	0.229
Gender				0.537
Female	386 (79.09%)	12 (85.7%)	374 (78.9%)	
Male	102 (20.91%)	2 (14.3%)	100 (21.1%)	

Table 2. Distribution of radiographic parameters in the study population.

	Mean	Min	Max
MD	13.6 mm	9.68 mm	24.15 mm
CW	7.11 mm	1.18 mm	12.32 mm
MD/CW	2.04 mm	1.01 mm	5.54 mm

Mean MD was 13.6 mm (range 9.68- 24.15) while mean CW measured 7.11 mm (range 1.18 - 12.32). The mean MD/CW ratio was 2.04 (range 1.01- 5.54) (Table 2).

In the diaphyseal fracture group, mean MD was 14.11 mm (range 11.26 - 17,10) while mean CW measured 7.5 mm (range 5.12 - 9.46). The mean MD/CW ratio in this group was 2.34 (range 1.51- 4.78) (Table 3).

Considering diaphyseal fracture distal to the CM nail as the dependent variable, the MD/CW ratio identifies a trend of increased risk of fractures as the ratio increases (OR 4.51; CI 0.826-24.642) although the correlation does not reach statistical significance (p 0.082) (Table 4).

Discussion

Diaphyseal post-operative fracture represents an infrequent but severe complication occurring after PFF CM nailing, resulting in a significant increase of morbidity, mortality and economic and social costs. The incidence of this complication in the literature is reported to range from 0 to 2.3% (1,5). However, compared with other extensively studied complications

Table 3. Distribution of radiographic parameters in the group with diaphyseal fracture.

	Mean	Min	Max
Medullary diameter	14.11 mm	11.26 mm	17.10 mm
Cortical width	7.5 mm	5.12 mm	9.46 mm
MD/CW	2.34 mm	1.51mm	4.78

Table 4. Analysis results.

Diaphyseal fracture	P-value	Odds ratio	95% Confidence Interval
MD/CW	0.082	4.51	0.826-24.642

with multiple parameters recognized as risk factors, it is unclear which factors influence the occurrence of diaphyseal fracture distal to the CM nail. In the literature, both patient related factors (comorbidities, risk of falls) and implant-related factors (nail design, mechanical stress transfer to the nail tip, nail tip micromovements, distal locking technique) have been considered (5-8). However, there is a controversy on evidence that short CM nails are associated with a higher risk of refracture than long CM nails (4, 5). On the other hand, studies that have analysed risk factors for periprosthetic femoral fracture on hip prostheses have identified the MD/CW ratio as a possible predictor of periprosthetic fracture (5). It has been shown that an increase of the medullary canal diameter and thinner cortices, with a consequent increase in the MD/CW ratio, are predictive of periprosthetic fracture. Considering the mechanical similarities of the prosthetic stem-to-nail ratio to the diaphyseal femur, MD/CW values in patients treated with short CM nail were correlated in the present study with the occurrence of diaphyseal fractures distal to the nail. To the best of our knowledge, there are no other studies in the literature that have analysed this correlation. Interestingly, data from the present study show an increasing trend in the risk of diaphyseal fracture distal to the nail as the MD/CW ratio increases (OR 4.51; CI 0.826-24.642). However, this association did not prove to be statistically significant (p 0.082). It is the authors opinion that further studies with a larger number of cases examined could overcome the limits of the present study and confirm the value of this finding. It would be extremely useful for clinical

practice to define a MD/CW cut-off ratio to identify high risk patients that might deserve a long CM nail for PFF fixation, thus reducing the incidence of later diaphyseal fractures. The limitations of this study are the retrospective design and the small number of events. In contrast, the strengths are the number of patients involved, the careful radiographic evaluations and the thorough statistical analysis of retrieved data.

Conclusion

The results of the present study demonstrate a trend towards a higher risk of diaphyseal fracture distal to the nail as the MD/CW ratio increases, although the association did not reach statistical significance due to the small number of events. Further studies are needed to confirm these results and to define a MD/CW cut-off ratio identifying high risk patients that might deserve a long CM nail for PFF fixation, thus reducing the incidence of later diaphyseal fractures.

Conflict of Interest Statement: Each author declares that he or she has no commercial associations that might pose a conflict of interest in connection with the submitted article.

Author Contributions Statement: G.C.: Conceptualization, methodology, software, validation, review and editing. P.N.: Formal analysis, investigation, data curation, original draft preparation. A.D.L.: Formal analysis, investigation, data curation, review. C.R.: Conceptualization, methodology, review. L.M.: Conceptualization, methodology, software, validation, review.

Funding: None.

Ethics Approval and Consent to Participate: Authors state that the protocol for the research project has been approved by a suitably constituted Ethics Committee of the institution within which the work was undertaken and that it conforms to the provisions of the Declaration of Helsinki (authorization CEUR-2020-Os-245 dated 29/10/2020). All investigations on human subjects must include a statement that the subject gave informed consent and patient anonymity should be preserved.

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Received: 28 October 2022

Accepted: 16 March 2023

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