Evaluation Study

ASSESSMENT OF SURGICAL DECISION-MAKING FOR FRACTURES AROUND TROCHANTERIC NAILS: VERGILIUS CLASSIFICATION SYSTEM VALIDATION

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ABSTRACT

The increasing incidence of fragility fractures, particularly those affecting the proximal femur, has led to a rise in patients with fixation implants and peri-implant fractures. These secondary fractures, occurring around implanted devices such as intramedullary nails, present significant challenges in diagnosis and treatment. A novel classification system, the Vergilius Classification, was developed to provide a structured approach to peri-nail fractures, incorporating fracture location, morphology, fragment count, and healing status of previous fractures. This study aimed to evaluate the agreement among medical professionals in applying this new classification system. A total of 35 medical professionals, including physiatrists, trauma surgeons, and radiologists, participated in the study. They were asked to classify 15 anonymized clinical cases according to the Vergilius system, and their responses were analyzed for accuracy, agreement, and face validity. The results showed a high level of agreement (80%) across most categories, with the location of the fracture, fracture morphology, and number of fracture fragments (2, 3, >3) demonstrating the strongest consensus. However, agreement regarding the healing status of previous fractures was lower. Participants rated the classification as clear, easy to use, and potentially beneficial in clinical practice. This study confirms that the Vergilius Classification System is reliable and applicable for peri-nail fractures. Future real-world cohort studies are needed to further assess its clinical impact.

KEYWORDS: *peri-implant, peri-nail, fragility, classification, extracapsular, hip fracture*

INTRODUCTION

With the constant increase in life expectancy and fragility fracture rates, a growing incidence of patients with fixation implants and peri-implant fractures is to be expected (1, 2). A possible definition of this type of injury is a secondary fracture occurring in patients who have been treated with a fixation device (such as an extramedullary plate and screws or an intramedullary nail) and that is still present in the bone. The most common fragility fracture is the proximal femoral fracture (PFF), commonly distinguished in intracapsular and extracapsular (3). These latter are generally treated using intramedullary nails. A constant increase in the incidence of peri-nail fractures is observed (2, 4-7).

Norris et al. analyzed over 13,000 patients in a systematic review, discovering that the incidence of secondary fractures around the nail was 1.7% (4). Very few guidelines exist for treating peri-nail fractures (6, 8, 9). Recently, we developed a new classification system; considering the increasing incidence of peri-nail fractures, there arises a need for an adequate description of these cases that might aid in diagnosis and treatment decision-making (2). After a consensus meeting, we developed a hierarchal classification system based on the fracture location, morphology, the number of fracture fragments, and the healing state of the previous fracture (Fig. 1, 2).

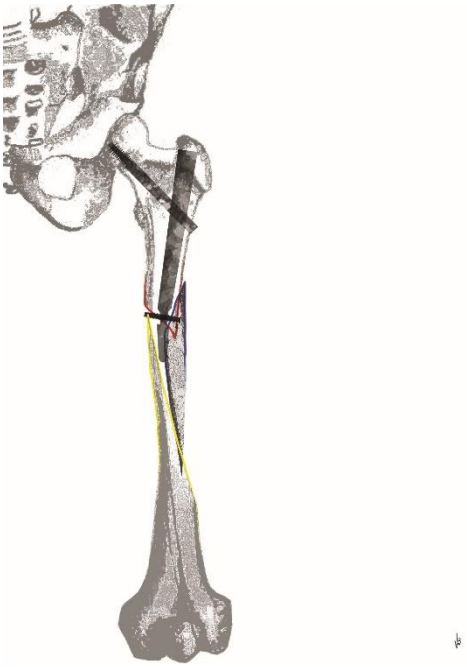

Fig. 1. *A drawing showing a BS3 peri-nail fracture.*

Fig. 2. *An X-ray showing a BO3 fracture. Note the small fragment around the distal screw apex.*

The objective of this study was to evaluate the concordance among a group of physicians in defining a fracture according to our new classification proposal.

MATERIALS AND METHODS

A total of 35 medical professionals were involved in this study: 10 physiatrists, 17 trauma surgeons, and 8 radiologists. Each participant was shown a brief presentation of the proposed classification system, with slides available throughout the study.

The primary aim of this evaluation was not to establish the ease of memorizing the classification but rather to determine the level of agreement among participants in defining individual cases. A further stratification was performed to evaluate the level of agreement for each specific category of participants. After presenting the Virgilio classification, each participant was invited to complete a form that included three different sections of questions.

Section 1: participant information

In the first section, questions regarding the participating physician were asked, including:

- the type of specialization obtained;
- the number of years in practice;
- the type of institution where they practice (Level I, II, III);

Section 2: clinical case evaluation

In the second section, 15 clinical cases of patients, strictly anonymized, were presented and previously selected by the authors of the study. Participants were to assess four essential parameters that define the Vergilius classification system:

- location of the fracture line: (A) fracture around the nail; (B) fracture around the distal screw; (C) fracture distal from the tip of the nail;
- morphology of the fracture: (S) spiral fracture; (O) oblique fracture; (T) transverse;
- number of fracture fragments: (2) two fracture fragments; (3) three fracture fragments; (3+) more than three fracture fragments;
- any prior consolidation of the fracture.

Section 3: classification feedback

In the third and final section, participants were invited to express their satisfaction with the classification using a score based on their responses to the following questions:

- did you find the classification clear?
- did you understand how to apply the classification?
- do you think this classification could be useful in clinical practice?
- does the classification adequately measure the properties of the fracture?

Parameters for evaluation:

1. accuracy: the authors of the classification stratify the cases and assess the percentage of correct classifications;
2. agreement percentage: this involves considering the percentage of participants who respond consistently to the clinical cases evaluated;
3. face validity: Two distinct Likert scales were used to evaluate clarity and understanding, requiring a score between 0 and 5. Face Validity was calculated as the average value of these indices.

Acceptable results defined at the start of the study:

- accuracy >80% for each individual case;
- agreement >80% for each individual case.

RESULTS

Of the 35 medical professionals initially involved in the study, 22 completed the evaluation protocol (65%). Of these, 12 were trauma surgeons (54.5%), 4 were radiologists (18.2%), and 6 were physiatrists (27.3%). 76% of the investigators reported to work in a high-volume hospital for trauma care. As a cumulative result, a good agreement between the observers was observed in 12/15 cases (80%). Regarding the subitems of the classification: the ABC (localization of the fracture line) reached the agreement in 10/15 cases; the SOT (fracture morphology) reached the agreement in 11/15 cases. The number of fracture fragments reached the agreement in 13/15 cases. Finally, the healing status of the previous fracture reached the agreement in 8/15 cases. Regarding face validity, 81% of the professionals found our classification clear, and 86.4% found it easy to use. According to 77.3% of professionals, the classification appropriately describes the characteristics of peri-nail fractures and would aid their daily practice.

DISCUSSION

The increase in life expectancy has led to a continuous growth of fragility fractures, especially those affecting the proximal femur (1, 10). These fractures are generally distinguished in intracapsular and extracapsular, presenting different clinics, patients' characteristics, treatment options, and outcomes (3). Extracapsular fractures are generally treated with intramedullary nailing (11). This technique presents some complications, including screw cut out, cut through, and nail failure (12). Among these, the secondary fractures arising along an implanted trochanteric nail are of growing interest (2). However, the exact incidence is unclear, considering these fractures are generally included among the peri-implant fractures (occurring around an implanted fixation device). The incidence in various studies ranged from 0% to 2.3% (11-14). Particularly, Parker et al., in a systematic review, found an incidence of 2.0% (39/1933) (12). Overall, the reported modern rates of peri-nail fractures have been 0% - 3.3% for short nails and 0% - 1.5% for long nails (11, 14). The reported incidence is of note, especially considering the high number of trochanteric nails implanted and comparing the incidence of periprosthetic fractures. These latter affect 1% of cases of primary total hip arthroplasty (THA) and 4% of revisions (15). Lindahl et al., through analysis of the Swedish hip prosthesis registry from 1979 to 2000, reported an annual incidence of 0.07% for the first 18 years, increasing to 0.1% by the end of the study period (16). The cumulative incidence was 0.4% for primary implants and 2.1% for revisions (16). Periprosthetic fractures accounted for 6% of the causes for revision (16).

Choosing the correct surgical strategy is essential to minimize the risk of new complications and to ensure the maximum chance of healing of peri-nail fractures; therefore, we developed an original hierarchal classification system based on a previous consensus meeting (2). The 'Vergilius Classification System' is based on the evaluation of those factors considered most important for the peri-nail fractures treatment according to the panel of experts:

- location of the fracture line: (A) fracture around the nail; (B) fracture around the distal screw; (C) fracture distal from the tip of the nail;
- morphology of the fracture: (S) spiral fracture; (O) oblique fracture; (T) transverse;
- number of fracture fragments: (2) two fracture fragments; (3) three fracture fragments; (3+) more than three fracture fragments;
- healing status of the previous extracapsular fracture: (n) fracture not healed.

Therefore, our classification system presents 54 potential categories in which the peri-nail fracture could be classified, and a single fracture could be described using 3 to 4 alphanumerical codes. According to Bernstein et al., a classification system should be reliable, simple, and the basis for treatment decision-making (17). After conceiving the Vergilius Classification System, we decided to evaluate its reliability and usefulness, as reported by those physicians who generally treat patients with peri-nail fractures. According to the present study, our classification system should be considered reliable, especially for the parameters of fracture localization (ABC), morphology (SOT), and fracture fragments (2, 3, +3). The evaluation of the healing state (n) of the previous fracture did not reach an agreement in most cases, raising some questions about its applicability. However, we considered that the quality of the imaging for some of the analysed x-rays was poor. In fact, the radiologists reach the highest percentage of agreement in the evaluation of this item. Although the usefulness of the 'Vergilius Classification System' needs cohort-based real-life studies, we consider of note that most of the evaluators found it clear, easy to use, and potentially useful in their daily practice thanking a clear description of the fracture.

CONCLUSIONS

Peri-nail fractures represent an emerging and dreadful complication of extracapsular fracture treatment. An appropriate classification of peri-nail fractures is mandatory for their adequate treatment. We developed a classification system based on the evaluation of fracture line localization, fracture morphology, number of fracture fragments, and healing state of the previous fracture. Our classification categorizes the peri-nail fractures in 54 different types. According to the present study the Vergilius Classification System was proved to be reliable and to have a potential impact in daily practice of the physicians involved in peri-nail fractures treatment.

REFERENCES

1. Tarantino U, Iolascon G, Cianferotti L, et al. Clinical guidelines for the prevention and treatment of osteoporosis: summary statements and recommendations from the Italian Society for Orthopaedics and Traumatology. *Journal of Orthopaedics and Traumatology*. 2017;18(S1):3-36. doi:https://doi.org/10.1007/s10195-017-0474-7
2. Toro G, Moretti A, Ambrosio D, et al. Fractures around Trochanteric Nails: The "Vergilius Classification System." Korovessis P, ed. *Advances in Orthopedics*. 2021;2021:1-9. doi:https://doi.org/10.1155/2021/7532583
3. Toro G, Lepore F, Cicala SD, et al. ABO system is not associated with proximal femoral fracture pattern in Southern Italy. *HIP International*. 2018;28(2_suppl):84-88. doi:https://doi.org/10.1177/1120700018813219
4. Norris R, Bhattacharjee D, Parker MJ. Occurrence of secondary fracture around intramedullary nails used for trochanteric hip fractures: A systematic review of 13,568 patients. *Injury*. 2012;43(6):706-711. doi:https://doi.org/10.1016/j.injury.2011.10.027
5. Müller F, Galler M, Zellner M, Bäuml C, Marzouk A, Füchtmeier B. Peri-implant femoral fractures: The risk is more than three times higher within PFN compared with DHS. *Injury*. 2016;47(10):2189-2194. doi:https://doi.org/10.1016/j.injury.2016.04.042
6. Chan LWM, Gardner AW, Wong MK, Chua K, Kwek EBK. Non-prosthetic peri-implant fractures: classification, management and outcomes. *Archives of Orthopaedic and Trauma Surgery*. 2018;138(6):791-802. doi:https://doi.org/10.1007/s00402-018-2905-1
7. Baig M, Mac Dhaibheid C, Shannon FJ. Hip Fracture in a Patient with Primary Hyperparathyroidism: Medical and Surgical Lessons. *Cureus*. 2018;10(1). doi:https://doi.org/10.7759/cureus.2104
8. Skála-Rosenbaum J, Džupa V, Bartoška R, Douša P, Waldauf P, Krbec M. Distal locking in short hip nails: Cause or prevention of peri-implant fractures? *Injury*. 2016;47(4):887-892. doi:https://doi.org/10.1016/j.injury.2016.02.009
9. Videla-Cés M, Sales-Pérez JM, Sánchez-Navés R, Romero-Pijoan E, Videla S. Proposal for the classification of peri-implant femoral fractures: Retrospective cohort study. *Injury*. 2019;50(3):758-763. doi:https://doi.org/10.1016/j.injury.2018.10.042
10. Hall AJ, Clement ND, Ojeda-Thies C, et al. IMPACT-Global Hip Fracture Audit: Nosocomial infection, risk prediction and prognostication, minimum reporting standards and global collaborative audit. *The Surgeon*. Published online March 2022. doi:https://doi.org/10.1016/j.surge.2022.02.009
11. Kleweno C, Morgan J, Redshaw J, et al. Short Versus Long Cephalomedullary Nails for the Treatment of Intertrochanteric Hip Fractures in Patients Older than 65 Years. *Journal of Orthopaedic Trauma*. 2014;28(7):391-397. doi:https://doi.org/10.1097/bot.0000000000000036
12. Parker MA, Handoll H. Gamma and other cephalocondylic intramedullary nails versus extramedullary implants for extracapsular hip fractures in adults. *Cochrane Database Syst Rev*. Published online October 19, 2005. doi:https://doi.org/10.1002/14651858.cd000093.pub3
13. Robinson CM, Adams CI, Craig M, Doward W, Clarke MCC, Auld J. Implant-Related Fractures of the Femur Following Hip Fracture Surgery. *The Journal of Bone & Joint Surgery*. 2002;84(7):1116-1122. doi:https://doi.org/10.2106/00004623-200207000-00004
14. Shannon SF, Yuan BJ, Cross WW, et al. Short Versus Long Cephalomedullary Nails for Pertrochanteric Hip Fractures: A Randomized Prospective Study. *Journal of Orthopaedic Trauma*. 2019;33(10):480-486. doi:https://doi.org/10.1097/bot.0000000000001553
15. Sidler-Maier CC, Waddell JP. Incidence and predisposing factors of periprosthetic proximal femoral fractures: a literature review. *International Orthopaedics*. 2015;39(9):1673-1682. doi:https://doi.org/10.1007/s00264-015-2721-y
16. Lindahl H, Malchau H, Herberts P, Garellick G. Periprosthetic Femoral Fractures. *The Journal of Arthroplasty*. 2005;20(7):857-865. doi:https://doi.org/10.1016/j.arth.2005.02.001
17. Bernstein JA, Monaghan BA, Silber JS, Delong WG. Taxonomy and treatment - a classification of fracture classifications. *J Bone Joint Surg Br*. 1997;79-B(5):706-707. doi:https://doi.org/10.1302/0301-620x.79b5.0790706