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Validity and reliability of the Unified Classification System applied to periprosthetic femur fractures: a comparison with the Vancouver system

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Abstract

Objective: The Unified Classification System (UCS) presents itself as an evolution of the Vancouver Classification (VCS) for the evaluation of periprosthetic fractures of the proximal femur (PPF). The aim of our study was to evaluate the interobserver and intraobserver reliability, with the purpose of highlighting any loss of reproducibility or validity of the new classification system, compared to the previous one, when applied to the proximal femur.

Material and Methods: We tested the interobserver and intraobserver agreement using 40 PPF clinical cases. Each classifying subtype of the UCS and VCS was present in at least two cases. Six experienced hip surgeons (Senior Surgeon, SS) and 5 surgeons in training (Junior Surgeon, JS) classified the clinical cases, twice using the VCS and twice with the UCS. The validity of both classifications was then tested with intraoperative surveys.

Results: The mean κ value for interobserver agreement for the VCS in the JS group was 0.65 (CI 95% = 0.57-0.70) and 0.81 for the SS group (0.74-0.88). The mean κ value for interobserver agreement for the UCS in the JS group was 0.63 (0.57-0.67) and 0.65 for the SS group (0.59-0.73). The mean κ value for intraobserver agreement for the VCS in the JS group was 0.71 (0.66-0.75) and 0.73 for the SS group (0.65-0.80). The mean κ value for intraobserver agreement for the UCS in the JS group was 0.72 (0.67-0.76) and 0.7 for the SS group (0.65-0.75). The validity analysis showed a κ value of 0.56 (0.52-0.61) for the VCS (moderate agreement) and a κ value of 0.64 (0.58-0.7) for the UCS (good agreement).

Conclusion: The UCS completes the Vancouver classification, expanding it. It is reliable, despite the increase in classification categories and number of parameters to evaluate, with a slightly higher validity.

Keywords: Vancouver classification system; periprosthetic fracture; total hip arthroplasty; revision hip arthroplasty; validity; reliability; UCS

Introduction

In Italy, in the last 15 years, we have witnessed a 2.5% annual increase in the number of primary arthroplasties (THA) and a 2.1% annual increase in prosthetic revisions (RTHA) [1]. This is a worldwide trend that affects many industrialised countries [2-3]; in America, they have estimated that the demand for THA will increase by 174% by 2030, with a 137% increase for RTHA [4]. In the United Kingdom, with regard to the same period, they have estimated an increase of 134% for THA and 31% for RTHA [5].

In Italy, periprosthetic fractures (PPF) are among the main causes of RTHA and account for 10.1% of them [1]. In the USA, revisions due to PPFs amount to 6.6%; the incidence of these fractures is expected to increase by 4.6% per decade [6]. Post-operative PFFs occur in a post-operative period equal to 7.4 years for THA and 3.9 years for RTHA [7]. The increase in use of non-cemented prostheses is probably an integral part of this complication's increased frequency: in fact, the risk of developing a PPF with non-cemented prostheses is higher both intra-operatively and post-operatively years later (20-year probability of 7.7% in uncemented prostheses and 2.2% in cemented prostheses) [8]. Another factor that contributes to an increase in the incidence of PPFs is the increased life expectancy of patients who have had primary prosthetic implants in position for the past 20 years and have poor bone quality [9]. In fact, PPFs generally occur as a result of a spontaneous fracture or low-energy trauma [10.11], while rarely due to high-energy trauma. The surgeon must have a clear vision of how to plan the revision surgery, or the osteosynthesis, in order to better manage this serious complication. The most used method for the evaluation of PPFs is the Vancouver Classification System (VCS) that, by dividing the femur into different anatomical zones based on the fracture level [fig. 1], and considering the presence or absence of a mobilisation of the components [fig. 2-3-4-5] and the quality of bone stock, is able to provide a practical and valid system for the management of these injuries [12]. Recently, another classification for PPFs has been put forth: the Unified Classification System (UCS). This system incorporates the VCS, though expanding it by including two further fracture subtypes - when applied to the femur - that are: type D, a fracture that occurs between two prosthetic implants (hip and knee)[fig. 6], and type E, a fracture that occurs in both bones that support a prosthetic implant (acetabulum and femur)[fig. 7] [13]. The F type fracture, or acetabular fracture in case of hemiarthroplasty, can only be used when you take into consideration the UCS applied to the acetabular side. As with the VCS, the B subtypes are subdivided on the basis of implant stability and bone stock quality. An effective classification requires easy understanding, reproducibility, inclusiveness of all possible presentations of the injury and ability to target a well-defined treatment. If we consider the UCS as a logical evolution of the VCS, this increase in information and variables must not undermine its reproducibility and validity. Hence, the purpose of our study was to compare the interobserver and intraobserver agreement for the VCS and UCS, applied to the same cases of femur periprosthetic fracture, with the aim of highlighting any loss of reproducibility or validity.

Matherials and Methods

We conducted a retrospective data analysis of patients who arrived at our trauma centre with a PPF from 2013 to 2018. Our study included patients who had pre-operative hip digital radiographs in anteroposterior and axial (cross-table lateral) views, lateral femur digital radiograph, Computed Tomography (CT) scan and those who had detailed documentation regarding the characteristics of the fracture and implant stability during surgery. We tested the intraobserver and interobserver agreement using 40 patients with periprosthetic fractures (cases) who were compatible with the inclusion criteria. Each subtype of both classifications was present in at least two cases. The age, sex, time elapsed since THA surgery, radiographic images and CT scans were provided for each case. All the cases were submitted to our observers: 5 orthopaedic surgeons experienced in prosthetic hip surgery (Senior Surgeon, SS) and 6 surgeons in training (Junior Surgeon, JS) classified these fractures on 4 separate occasions. None of the observers had priorly participated in the treatment of the cases. They were given 4 questionnaires with the same cases placed in random order through an IT platform (Google Form, Google Inc.®). The cases in the first two questionnaires were classified with the VCS, while the last two with the UCS. The tests were sent monthly. Each time the questionnaire was sent, the classification in question was summarised in detail. In a second phase of the study, the validity of the two classifications was evaluated by comparing the answers of all the surgeons in the two groups with the intraoperative findings. The data was then analysed on IBM SPSS Statistic 25 using the Cohen κ statistic to determine the agreement between two observers (interobserver reliability) and between the evaluation of a single observer in different points in time T0-T1 (intraobserver reliability) to test the validity for each classification. For more than 2 observers in each group, the reliability mean value was obtained by averaging the results of the Cohen κ analysis for each pair in both groups - SS and JS. The Landis and Koch criteria were used to interpret the Cohen κ values: values ranging from 0.00 to 0.20 indicate a slight agreement; between 0.21 and 0.40 indicate a fair agreement; between 0.40 to 0.60 a moderate agreement; between 0.61 and 0.80 a substantial agreement and above 0.80 indicate an almost perfect agreement [14]. The Cohen κ statistic was also used to evaluate the agreement between each observer (both groups) and the operative findings.

Results

The interobserver agreement was estimated for the VCS and UCS within all the possible pairs of SS and JS [TABLE1]. The mean κ value for the interobserver agreement for the VCS in the JS group was 0.65 (CI 95% 0.57-0.70) and 0.81 for the SS group (CI 95% 0.74-0.88). The results show a good agreement for the first group and an almost perfect agreement for the SS group. The mean value for the interobserver agreement for the UCS in the JS group was 0.63 (CI 95% 0.57-, 067) and 0.65 for the SS group (CI 95% 0.59-0.73); in this case, both results showed a good agreement. The mean κ value of the intraobserver agreement for the VCS in the JS group was 0.71 (CI 95% 0.66-0.75) and 0.73 for the SS group (CI 95% 0.65-0.80). The mean κ value of the intraobserver agreement for the UCS in the JS group was 0.72 (CI 95% 0.67-0.76) and 0.7 in the SS group (CI 95% 0.65-0.75). Both scales show a substantial agreement in both groups, with minimal variations.

Comparing all 40 clinical cases with the intra-operative findings, the Validity analysis showed a value of 0.56 (95% CI 0.52-0.61) for the VCS (moderate agreement) and a κ value of 0.64 (95% CI 0, 58-0.7) for the UCS (substantial agreement). [TABLE 2].

Discussion

Periprosthetic fractures are complications burdened by a high morbidity and mortality rate [15]. Correctly classifying a fracture pattern allows surgeons to plan an effective treatment, thus reducing the high costs inherent in this procedure [16,17].

Although the Vancouver classification is currently the most widely used system, the UCS is struggling to have the same successful diffusion. The VCS shows an almost perfect agreement among the SS, while the UCS does not reach this degree of interobserver agreement in either group. This figure could be either justified by the fact that surgeons with an extensive experience have a greater familiarity with this classification system, or by the imperfect study of the newly learned UCS, even if the methodology of the surveys was designed to minimized this eventuality. In fact, all the surgeons examined use the VCS routinely in their clinical practice. To the best of our knowledge, 3 other studies performed a validation study of the VCS. The first validation study, performed by the group from which this classification originated, showed an interobserver κ value of 0.61 [18]. A European study performed by Ryan et al., with 18 participants, 6 consultants, 6 surgeons in training and 6 medical students, showed an interobserver κ value of 0.72, 0.68 and 0.61, respectively. [19]. In 2012, Naqvi et al. revalidated the classification with an interobserver reproducibility with a κ value of 0.69 for the consultants and 0.61 for the surgeons in training [20]. No nearly perfect agreement was achieved in any interobserver reliability testing, except for with our study.

However, the validity does not reach a nearly perfect agreement in any of the studies conducted. In previous studies, the validity reached a substantial agreement, in ours it reaches a moderate agreement. The ability to establish implant stability in the fractures of subgroup B through radiographic projections alone is disputed. The Swedish register analysis shows that one of the causes of the high failure rate of periprosthetic fractures was precisely identified in a failure to diagnose implant instability [21]. Corten et al., in their series of fracture cases pre-operatively classified as B1, encountered an unstable intra-operative stem in 20% of cases [22]. More recently, Lee et al. evaluated the VCS reliability and validity exclusively on type B fractures in cementless prostheses [23]. The κ value of the interobserver reproducibility was 0.45, with a 79% agreement in the validity analysis, pointing out the inadequacy of an evaluation based solely on radiographic images alone as the cause for this low agreement. In our clinical practice, CT scans carried out during the pre-operative study aid in the planning, however this does not exempt us from an intra-operative assessment of the implant's stability.

As for the UCS, two studies analyse the reproducibility applied to the proximal femur. Vioreanu et al., from the group that developed the classification, performed a reliability assessment with a panel of 11 international experts and 17 surgeons in training with a reproducibility of 0.8 and 0.69 respectively [24]. Subsequently, while performing an external validation, Huang et al. reported an interobserver reliability of 0.84 for the 3 consultants and 0.76 for the 3 trainees [25]. The validity, tested only in this study, is 0.69 with a substantial agreement. The validity of 0.64 in our findings is in line with these results, which is higher than the agreement obtained with the VCS. We must highlight that in this study validity was tested in all VCS and UCS types of fractures, although the others study assesses only type B fracture. That decision was made in order to compare classifications together: considering this purpose, comparing the validity in type B fractures of both classifications would not have added information, because the subtypes do not change between the two systems. Therefore, a comparison of our validity results with previous studies is not applicable.

However, the new classification model fails to resolve the main VCS controversy, linked to the difficulty of evaluating the stem's stability in type B fractures. Other limitation is the absence of some specific fracture pattern usually presents in PPF. Despite this, the purpose of the introduction of the UCS seems to be achieved, increasing the classification detail without reducing the reproducibility and the validity of the previous classification. The main advantage of the newly system is the ability to provide further information directly related to the surgical treatment, giving a full view of the entire segment and its articular relationship.

To overcome the remaining limits Huang et al. modified the UCS for PPF of the femur, introducing new categories for pseudo trochantieric fractures that involves some diaphyseal cortical portion and new categories for fractures around a broken stem [26]. The modified classification has also been tested by the same group over more than four hundred cases, revealing an high intra- and interobserver reliability, between substantial and almost-perfect agreement [27]. Validity was tested also on type B showing 89.85% of agreement. Those modifications of the Unified Classification could be useful in increasing both validity and reliability of the system, but studies are needed to perform further validation of this system.

UCS can also be applied to other body areas. The same Group that proposed it performed an assessment of the reliability applied to periprosthetic knee fractures [28]. The agreement was substantial in interobserver reliability, with κ value results of 0.74 for the panel of experts and 0.76 for the trainees; nearly perfect agreement in intraobserver reproducibility. Further validations for the remaining body segments will allow us to attest to its universality.

Conclusions

The UCS classification appears to be equally reliable with respect to the Vancouver classification, despite the fact that it introduces further evaluation parameters by opening the view to the entire bone segment and to its articular relationships with the acetabular prosthetic component. The UCS is an easy to use and easy to learn tool. Further studies will be needed to allow us to evaluate reproducibility in the remaining body segments.

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Table 1: Interobserver and Intraobserver agreement of VCS and UCS. JS= Junior Surgeon; SS= Senior Surgeon

	Interobserver *mean (95% CI)*	**Intraobserver** *Mean (95% CI)*
JS – Vancouver Classification System	0.64 (0.57-0.70)	0.71 (0.66-0.75)
SS – Vancouver Classification System	0.81 (0.74-0.88)	0.73 (0.65-0.80)
JS – Unified Classification System	0.62 (0.57-0.67)	0.72 (0.67-0.76)
SS – Unified Classification System	0.66 (0.59-0.73)	0.7 (0.65-0.75)

Table 2: Validity and Confidence Interval

	Validity (mean)	**95% Confidence Interval**
Vancouver Classification System	0.56	0.52-0.61
Unified Classification System	0.64	0,58-0,7

Figure 1: Agt type periprosthetic femur fracture according to VCS and UCS

Figure 2: B1 type periprosthetic femur fracture according to VCS and UCS

Figure 3: B2 type periprosthetic femur fracture according to VCS and UCS

Figure 4: B3 type periprosthetic femur fracture according to VCS and UCS

Figure 5: C type periprosthetic femur fracture according to VCS and UCS

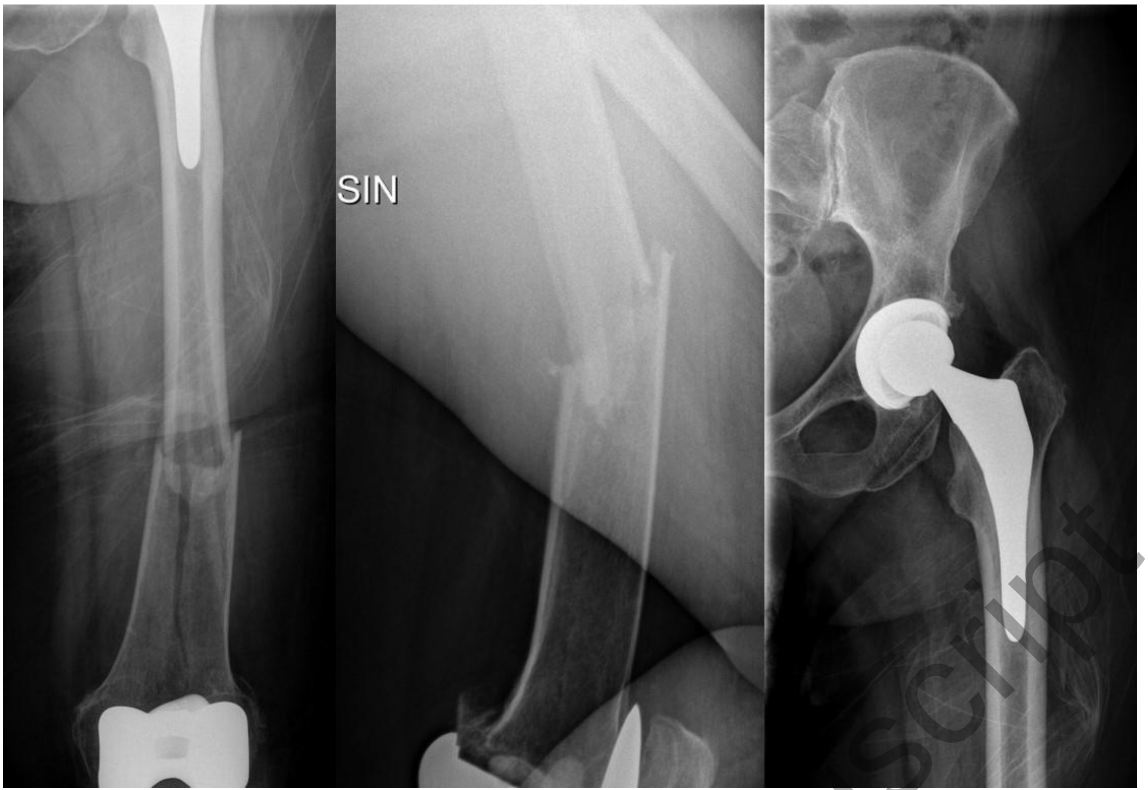

Figure 6: C type periprosthetic femur fracture according to VCS; D type fracture according to UCS

Figure 7: B1 type periprosthetic femur fracture according to VCS; E type fracture according to UCS