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Contribution of the remaining attachment index in the management of Vancouver B1 periprosthetic hip fracture

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ABSTRACT

Introduction: Implant fixation assessment following Vancouver B1 periprosthetic hip fracture is a major decision factor for internal fixation and/or implant revision. The main aim of the present study was to assess the correlation between radiographic Remaining Attachment Index (RAI) and risk of implant loosening at last follow-up following internal fixation of Vancouver B1 periprosthetic hip fracture.

Material and method: A multicentre retrospective study included 50 patients with Vancouver B1 periprosthetic hip fracture with uncemented femoral stem between 2013 and 2019. Preoperative radiographs were analysed independently by 2 senior orthopedic surgeons, distinguishing 2 groups: RAI > 2/3 versus < 2/3. Postoperative and last follow-up radiographs were then screened for signs of complete femoral component loosening.

Results: Median age was 89 years (range: 36–99 years). Two RAI > 2/3 patients showed implant loosening (8%) versus 9 RAI < 2/3 patients (36%), disclosing a significant correlation between early loosening and RAI < 2/3 ($p = 0.005$). Interobserver agreement for both radiographic RAI and radiographic loosening assessment at last follow-up was 98% with kappa correlation coefficient 0.96 [range: 0.88–1].

Conclusion: Remaining Attachment Index < 2/3 in Vancouver B1 periprosthetic hip fracture was a risk factor for early implant loosening after isolated internal fixation. In these often frail elderly patients, first-line implant exchange is to be considered in the light of the risk/benefit ratio. The present results confirm the need for rigorous preoperative radiographic work-up of the remaining attachment area in Vancouver B1 fracture.

Level of evidence: IV.

1. Introduction

Implant fixation assessment in Vancouver B1 periprosthetic hip fracture with uncemented stem is a major decision factor in planning internal fixation and/or implant revision [1,2]. Loss of stem anchorage is difficult to assess on standard X-ray, whereas complete implant loosening in case of migration with or without osteolysis (Vancouver B2 and B3) is easy to diagnose for a trained observer [3]. Conventional CT is systematically artifacted and cannot reliably assess loosening in the remaining attachment area [3]. In internal fixation, moreover, intraoperative assessment of implant loosening is rarely performed as the hip approach is extra-articular [4–6]. The 2005 Symposium of the French Society of

Orthopedic Surgery and Traumatology (SoFCOT) [1] recommended a specific Remaining Attachment Index (RAI) to assess residual fixation, RAI > 2/3 stem-length enabling implant conservation and internal fixation. The present study hypothesis was that RAI > 2/3 allows internal fixation without risk of early secondary loosening. The main aim of the study was to assess the correlation between RAI and risk of radiographic loosening at last follow-up following internal fixation of Vancouver B1 periprosthetic hip fracture.

2. Material and method

2.1. Study population

The present multicentre retrospective study analysed radiographs for 64 patients with Vancouver B periprosthetic hip fracture between January 1, 2013 and December 31, 2019. Inclusion criteria comprised: Vancouver B1 periprosthetic hip fracture on isolated

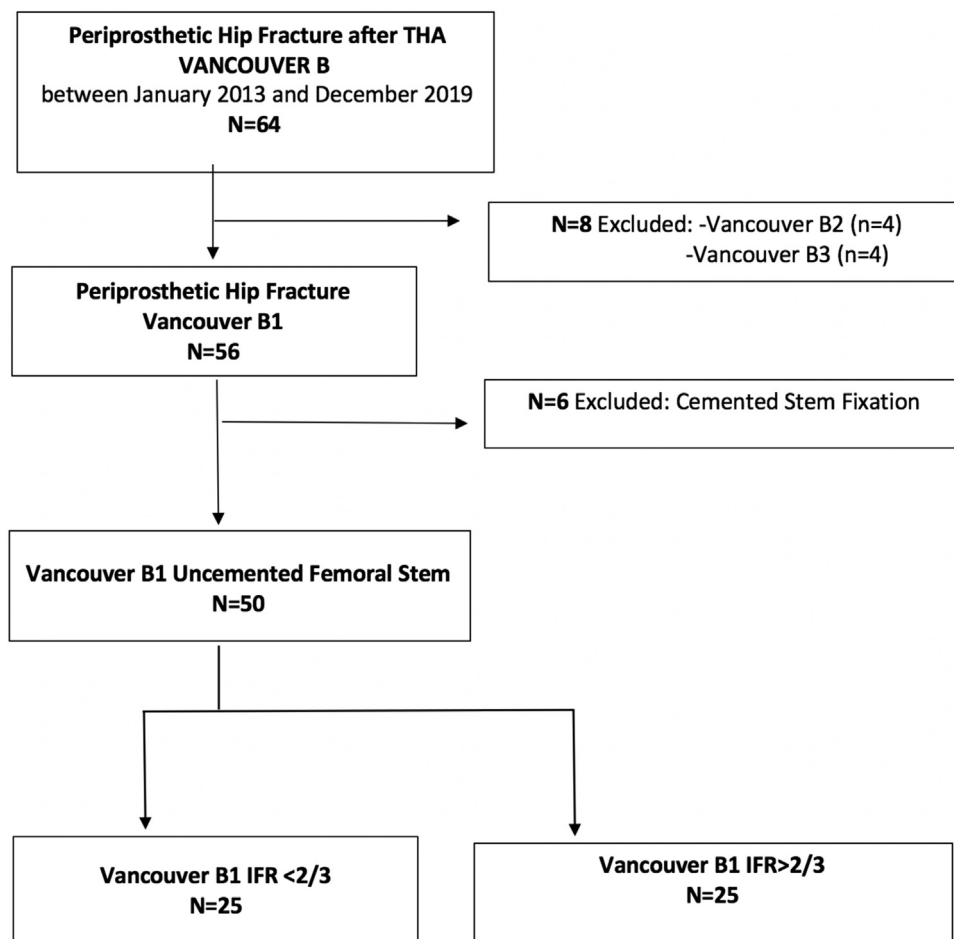


Fig. 1. PRISMA flowchart.

internal fixation with uncemented femoral stem. This included 50 patients. Exclusion criteria comprised: Vancouver B2 fracture with complete radiographic loosening ($n=4$), Vancouver B3 fracture with periprosthetic osteolysis ($n=4$) and Vancouver B1 fracture with cemented stem ($n=6$), all of which indicated prosthetic reconstruction according to the most recent SoFCOT guidelines (Fig. 1) [1]. Preoperative CT was performed ($n=21$) to screen for loosening radiolucency in the remaining attachment area (leading to reclassification as Vancouver B2) or osteolysis overlooked on initial radiography (reclassification as Vancouver B3). RAI was measured only in radiographs showing Vancouver B1 periprosthetic hip fracture with uncemented stem.

2.2. Assessment criteria

Radiographic analysis was performed independently by 2 senior surgeons. Preoperative radiographs were analysed for all patients with periprosthetic hip fracture, and 2 groups were constituted: B1 fracture RAI $> 2/3$ versus RAI $< 2/3$. Postoperative and last-follow-up radiographs were then analysed for signs of complete femoral component loosening (radiolucency > 1 mm at the stem and/or femoral implant migration). RAI was measured as described in the SoFCOT symposium [1] as A/B ratio on AP view where A is the minimal remaining anchorage height and B is the total initial height (Fig. 2).

2.3. Statistical analysis

Analyses used JMP® software 11.0.0 (SAS Institute Inc.). The numerical variables showed non-normal distribution and

intergroup comparison used non-parametric Wilcoxon test for continuous variables [age, body-mass index (BMI), follow-up duration] and Fisher exact test for qualitative variables (gender, ASA score, walking autonomy). Multivariate nominal logistic analysis on gender, age, BMI and RAI $> 2/3$ identified loosening risk factors, eliminating confounding factors. The significance threshold was set at $p < 0.05$.

Interobserver agreement on RAI values and on loosening was assessed on kappa correlation coefficient and expressed as percentage.

3. Results

The 50 patients with Vancouver B1 periprosthetic hip fracture with uncemented stem and isolated internal fixation comprised 25 women and 25 men (sex ratio: 1); median age at fracture was 89 years (range: 36–99 years). Median BMI was 22 (range: 16–34). ASA score was ≥ 2 in 94% of cases ($n=47$). Forty-two per cent ($n=21$) had Parkinson syndrome and 80% ($n=40$) had cardiovascular history. Only 26% ($n=13$) were initially able to walk without mechanical or human assistance.

After X-ray and CT analysis, 25 patients were identified as having RAI $> 2/3$ (50%) and 25 with RAI $< 2/3$ (50%). Interobserver agreement was 98% with kappa correlation coefficient 0.96 [0.88–1]. The only significant intergroup difference was for BMI, which was greater in RAI $> 2/3$ ($p=0.017$). Table 1 presents patient data.

Postoperative loosening was screened for on at least 2 X-rays at last follow-up [mean: 3 months (range: 1–48 months)]. Interobserver agreement again was 98% with kappa correlation coefficient

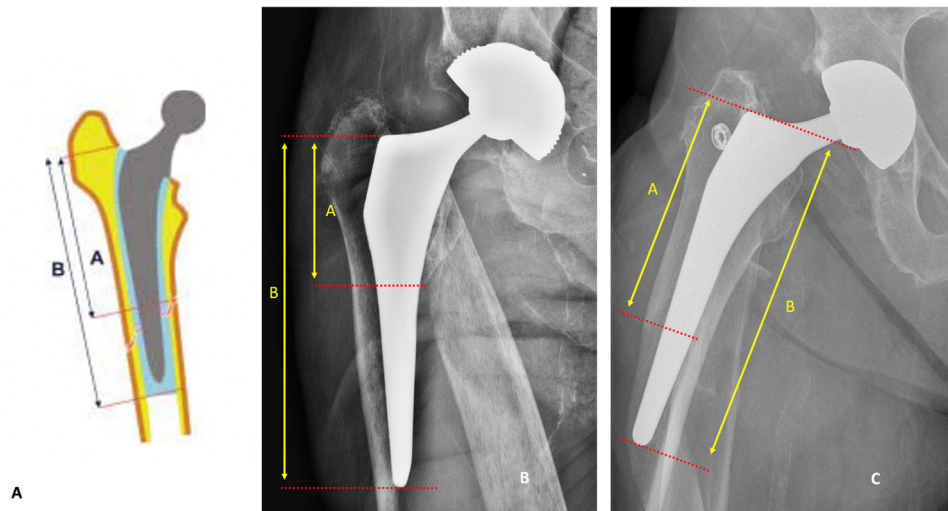


Fig. 2. Remaining Attachment Index (RAI) is measured as described in the SoFCOT symposium [1] as A/B ratio on AP view where A is the minimal remaining anchorage height and B is the total initial height (A). X-rays of Vancouver B1 periprosthetic fracture with a RAI less than 2/3 (B) and greater than 2/3 (C).

Table 1

Patient characteristics and distribution between groups (RAI > 2/3, RAI < 2/3). Non-parametric Wilcoxon test for continuous variables and Fisher test for qualitative variables.

	RAI < 2/3 (n = 25)	RAI > 2/3 (n = 25)	p
Median age [range]	89 [66–99]	87 [36–99]	0.19
Gender – Male	5	11	0.13
Female	20	14	
Median BMI [range]	20 [16–31]	23 [16–34]	0.017
ASA 1	0	3	0.11
2	13	12	
3	12	9	
4	0	1	
Cardiovascular history (%) (HBP/Cardiopathy)	20 (80%)	19 (76%)	1
History of Parkinson's Syndrome (%)	10 (40%)	10 (40%)	1
Autonomy – unassisted walking	4	9	0.25
Assisted walking	19	14	
No walking	2	2	
Median follow-up [range]	3 months [1–48]	3 months [1–8]	0.25

RAI: remaining attachment index; BMI: body-mass index; HBP: high blood pressure.

0.96 [0.88–1]. In RAI > 2/3, 2 patients showed implant loosening (8%) versus 9 in RAI < 2/3 (36%), showing a significant correlation between early loosening and RAI < 2/3 ($p = 0.005$).

At last follow-up, none of the patients with implant loosening after internal fixation of Vancouver B1 fracture required implant exchange (Fig. 3).

4. Discussion

Two of the present patients with internal fixation of Vancouver B1 periprosthetic fracture with RAI > 2/3 developed implant loosening (8%) versus 9 with RAI < 2/3 (36%), showing a significant correlation between early loosening and RAI < 2/3 ($p = 0.005$). In the literature, internal fixation is the first-line gold standard in Vancouver B1 fracture [7,8], despite loosening rates of 19–29% [9–11].

In the 2005 SoFCOT symposium [1], internal fixation of Vancouver B1 fracture was assessed comparing RAI > 2/3 versus RAI < 2/3 in a series of 811 patients. In case of RAI > 2/3, fixation was intact at last follow-up in 73% of cases, versus only 31% in case of RAI < 2/3. Prosthetic reconstruction was therefore suggested in case of RAI < 2/3. However, there was no significant correlation between RAI and subsequent implant revision (13% in RAI > 2/3 and 19% in RAI < 2/3). In the present series, none of the patients with implant loosening underwent implant revision. Population characteristics were comparable to those found in the literature, except for mean age at fracture, which ranges between 59 and 76 years depending on

the report [12,13], compared to a median 89 years in the present series. This may account for the frequent abstention from secondary reconstruction, due to the major risk of secondary complications in case of radiographic loosening [10].

The radiological Vancouver classification is reliable and reproducible [2,14]. This was confirmed in the present study, with 98% interobserver agreement and a kappa coefficient of 0.96 [0.88–1] for both fracture classification and RAI measurement. Although RAI is easy to measure and reproducible, fixation is assessed only on AP view, despite most B1 periprosthetic fractures being spiroid, leading to risk of under- or over-estimation of anchorage. It should nevertheless be stressed that preoperative CT analysis of remaining attachment area, ruling out loosening there, did not diverge from the radiographic analysis in all the present B1 fractures. This confirms the findings of Rupp et al. [3], that standard CT does not improve assessment of loss of stem attachment, further indicating the relative non-contributiveness of CT in Vancouver B1 fracture if initial X-ray is of good quality and interpreted by an experienced observer.

In terms of treatment, indications in type A or C fracture are straightforward: internal fixation except in case of demonstrable pre-existing loosening [7,8]. In type B, the choice between internal fixation and implant exchange is more problematic [11]. In B3 or B2 fracture, where fixation is obviously defective and/or accompanied by osteolysis, exchange is logical, as advocated by Berry [15], Ko [16] and Springer [17]. Most series focused on internal fixation

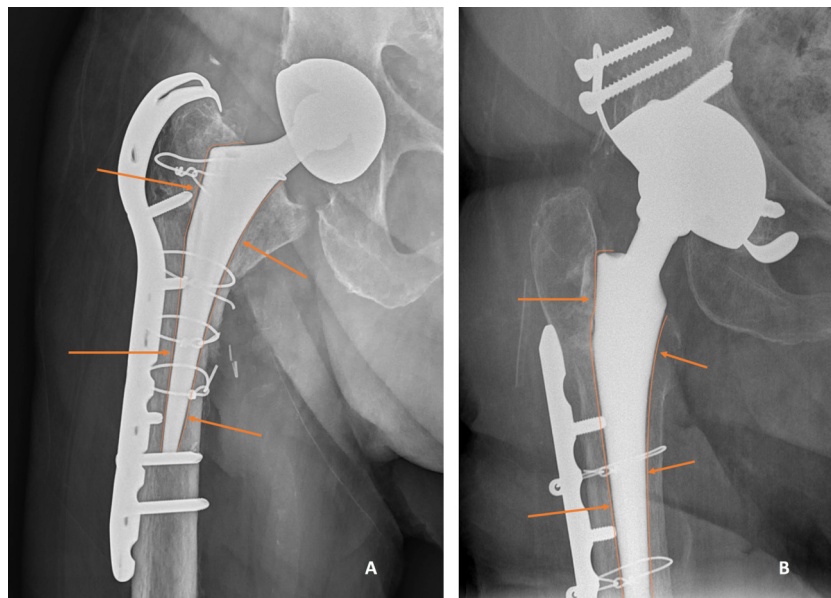


Fig. 3. X-rays control showing two cases of early implant loosening after isolated internal fixation for Vancouver B1 periprosthetic fracture with a RAI less than 2/3.

for B1 fracture [4–6,18], but analysing the remaining attachment area is essential to guide indications and avoid long-term loosening and surgical revision. Exchange, on the other hand, is not without risk, notably of increased implant instability, with rates approaching 10%, and of intraoperative fracture, associated with 3.3–11.6% 1-year mortality [10,19,20]. At the same time, unlike exchange, internal fixation does not allow early weight bearing, which can be of poor prognosis in elderly patients [21].

Among B1 periprosthetic fractures, we excluded cemented femoral stems; B1 fracture around a cemented stem breaks the cement mantle or detaches the cement from the bone, inevitably entailing loosening [1,22]. Karam et al. [23] recently reported equivalent results in fractures around cemented or uncemented implants, and argued that surgical treatment should be the same for both.

The present series had short follow-up, but focused exclusively on last-follow-up X-ray, without attempting to assess morbidity and mortality, as was done in other studies [24]. Longer prospective radiological and clinical follow-up is needed to assess progression in internal fixation with implant loosening, as suggested by Bates et al. [25]. A prospective comparative study of internal fixation versus prosthetic reconstruction in Vancouver B1 fracture with RAI <2/3 would doubtless finally confirm the 2005 SoFCOT recommendations [1].

5. Conclusion

Remaining Attachment Index <2/3 in Vancouver B1 periprosthetic hip fracture is a risk factor for early implant loosening after isolated internal fixation. In these often frail and elderly patients, first-line implant exchange should be considered in the light of the individual risk/benefit ratio. The present findings confirm the recommendations of the 2005 SoFCOT Symposium and the necessity of rigorous preoperative radiographic assessment of the remaining attachment area in Vancouver B1 fracture.

Disclosure of interest

The authors declare that they have no competing interest.

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Author contributions

Dr Odri contributed to statistics; Dr Pesenti and Dr Ollivier, to revision; Dr Andriamanaivo and Dr Rongieras, to article writing; Dr Mattesi and Dr Renault, to radiographic analysis; and Dr Severyns, to project management.

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