How should periprosthetic fractures at the tip of cemented or uncemented femoral stem be treated?

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Response/Recommendation:

The literature supports the notion that transverse or short-oblique B1-periprosthetic femoral fractures at the level or just below the tip of the stem (either cementless or cemented) have poorer results when treated only with a single lateral plate osteosynthesis. We therefore recommend that either augmentation with an additional orthogonal plate/cortical strut allograft, or revision with a longer stem (preferably with a cementless, tapered fluted stem, with endosteal reaming during femoral preparation) bypassing the fracture level should be the gold standards for treatment.

Level of Evidence: Moderate

Rationale

Periprosthetic femoral fractures (PFFs), which can occur either intra- or postoperatively, are usually classified according to the Vancouver system.[1] The reported incidence of postoperative PFF after primary total hip arthroplasty (THA) ranges between 0.4%-1.2%, depending on several factors such as patient age, sex, previous stress shielding, previous implant stability, and type of fixation.[2] While fractures with a loose stem, or Vancouver B2 and B3 fractures, are mostly treated with revision with a longer femoral component bypassing the fracture level, most fractures with a well fixed stem, or Vancouver A, B1 and C, are treated with [3] open or minimally-invasive reduction and internal fixation.[4]

Although the Vancouver classification system simplifies a challenging case by organizing it into distinct categories, it largely depends on a reliable assessment of implant stability. However, in up to 20% of unstable uncemented stems, pre-operative imaging is insufficient to make the distinction between stable and unstable.[1] Furthermore, the binary approach of revising loose stems and fixing well-fixed stems has been called into question. [5] There are several circumstances in which the current classification systems may not offer enough information to help select a proper treatment option. More consideration should be given to the frailty and ambulatory capacity of the patient and the risk of failure and reoperations when selecting the most appropriate treatment. For example, fixation of anatomically-fixable B2 fractures around polished tapered stems is a viable option, especially in frail patients, avoiding extensive revision surgery.[6][7]

Another issue that has been barely considered in both classification systems is fracture pattern and location with respect to the previous stem. These factors are considered in the Cooke and Newman classification. When the fracture lies at the tip of the stem, with the stem being fixed (Cooke-type 3 [8]), there is an increased stress and concentration of forces in a zone of limited cortical bone contact. Therefore, the best treatment option for such fractures has historically remained controversial.[9] While revision arthroplasty to a long-stem prosthesis has been recommended, this may not be suitable in very low-demand patients with ‘difficult-to-extract’ components because it is a time-consuming, complex, and expensive treatment option.[9] In such cases, fixation with single or double-plating may be recommended. However, no algorithm yet exists to select the most appropriate treatment in these scenarios. Therefore, we aimed to perform a systematic review of the literature about the outcomes of treatment of Vancouver B1-PFF at the tip of a previously fixed stem.

Following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, we conducted a systematic search of the online bibliographic databases MEDLINE and PubMed from inception through March 2024 to identify studies on Vancouver-type B1 periprosthetic fractures about the tip of the stem. Exclusion criteria consisted of biomechanical or cadaveric studies, editorials, commentaries, case reports, reviews, technique articles without patient data and articles not written in English language. Two of the authors independently screened the title and abstract of an initial number of 1177 articles in order to apply the selection criteria. Disagreements were solved by consensus after reading the full-text. We finally reviewed the full-text of 58 articles included in this review.

Although biomechanical reports were not finally included in the literature search, the study by Moazen *et al* should be noted. The authors analyzed the effect of fracture stability using progressive loading, finding that mechanical stress on a lateral femoral plate was substantially higher in unstable fracture configurations (e.g. those with a fracture gap ≥10 mm, usually seen in transverse patterns), suggesting that in such cases a revision with longer stem bypassing the fracture gap would be a valid option.[10] In a retrospective cohort study of 41 B1-PFFs, it was shown that in the non-healing group (n=12), a factor significantly associated with this outcome was a transverse-type fracture pattern at the tip of the stem (p=0.04).[11] Additionally, in two different articles, Tsiridis *et al* reported two fixation failures at the level of the tip of the stem out of three B1-fractures treated with a Dall-Miles plate,[12] and three additional non-healings (i.e., failures) out of seven B1-fractures treated with a dynamic-compression-plate, including one fracture of the plate.[13] Similarly, Buttaro *et al* described a series of B1-PFFs of which six of 14 fractures treated with a lateral locking-compression-plate due to an index fracture at the level of the tip of a cemented stem suffered (either transverse or short-oblique fracture) a new fracture of the plate at the same level.[14] The authors of the same paper strongly encouraged additional use of strut graft besides the plate to provide additional biological and mechanical stability, since all failures except one occurred in constructs in which a cortical strut allograft had not been utilized. Also, the authors suggested stem revision with a longer one bypassing the fracture (and reaming at the fracture level) even in patients with well-fixed stems who present with this fracture pattern.[14]

In line with these findings, Min *et al* described a failure rate of 43% (3/7) when using single locking-compression-plate osteosynthesis in 7 cases with a transverse PFF below (i.e., at the tip) a well-fixed stem.[15] Furthermore, Chakrabarti *et al* used ORIF with lateral cable plates without bone grafts in a series of 15 transverse B1-fractures around cemented stems, of which 4 cases developed nonunion and plate failure within 7-12 months, whereas in the group with long-oblique B1-fractures (including 8 cemented and 16 cementless stems), no nonunion was detected.[16] When treating in transverse B1 fractures, the authors recommended either use of additional cortical strut grafts or revision of the prosthesis.[16] In a retrospective cohort study of 129 consecutive unilateral Vancouver-B-fractures around cemented Exeter stems which included 31 B1-fractures, Powell-Bowns *et al* found that transverse patterns were associated with increased relative risk of reoperation (OR 4.22; 95%CI: 1.63-10.9, p=0.008).[17] On the other hand, some have reported good healing outcomes in such fractures. In a study where a lateral locking-compression-plate plus an anterior cortical strut allograft was used for 17 patients with a B1-PFF around an uncemented stem, all fractures (7 transverse) healed in 12-30 weeks.[18] Another study reported on successful treatment of 22 B1-fractures with both transverse (n=17) or short-oblique (n=5) patterns using a locking plate (Intrauma, Rivoli, TO, Italy) without bone grafting, where the presence of cement was not found to affect the healing rate, with nonunion occurring in only 1 patient with a short-oblique fracture line and uncemented stem.[19]

Very few studies compared different methods for treatment of this specific subgroup of B1 fractures, and most were biomechanical reports.[20,21] After analyzing 321 PFFs including 90 B1-fractures of which 9 were treated with revision surgery, 5 with revision + ORIF and 74 with ORIF-only (2 cases with other treatments), Lindahl *et al* reported that 3/9 of the former group required an additional surgery, while 1/5 of the revision + ORIF group and 22/74 of the ORIF-only group did so.[22] Although the authors did not specifically sub-analyze fracture patterns and level, they alleged that many of the ORIF-only cases that failed may be related to fractures being treated with a single plate only without use of either an additional strut graft or a supplementary orthogonal plate.[23,24] In a recent study, Gausden *et al* reported on a high nonunion rate in transverse or short-segment B1 fractures; nonetheless, the nonunion rate of fractures treated with dual-plating was 20% (95%CI: 5%-59%) as compared to 36% (95%CI: 15%-70%) of those treated with a single lateral plate (p=0.16).[25] In another study reviewing 202 PFFs, Pavlou *et al* concluded that transverse B1-fractures at the tip of the stem treated with stem revision compared to those treated with ORIF with a plate showed a nonsignificant trend towards improved overall union rate (OR=2, p=0.6, 95%CI:0.14-28.4) and significantly shorter times to union (p=0.038, mean 12±6.573 months versus 4.48±0.757 for stem revision).[26] The authors thus suggested that stem revision for transverse B1 fractures was a viable treatment option to achieve axial stability and healing, as this configuration is difficult to control with single plating. However, the treatment of B1-fractures with a revision cemented stem (n=17) showed higher 2-year reoperation rate (29.4% vs. 5%, p=0.002) and local complications (47.1% vs. 8.6%, p<0.001) than ORIF (n=116).[27]

It must be noted, of course, that the best treatment strategy should be adjusted for patient age and comorbidities. In many cases, damage control with a plate may be the standard of care in patients with a high risk of perioperative mortality, with or without the addition of further systemic anabolic treatment (e.g., teriparatide).[28] Also, conservative management may also be considered for some undisplaced B1-fractures in selected cases.[29]

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