



## Principles and methods of fixation of periprosthetic fractures in stem region of hip prosthesis (Vancouver B) – review article

Principi in načini učvrstitve obproteznih zlomov ob deblu kolčne proteze (Vancouver B) – pregledni članek

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### Abstract

An increasing number of implanted hip endoprostheses correlates with the number of complications. Periprosthetic fractures in the femur area after the hip endoprosthesis is a serious complication that can rarely occur during the insertion of the stem and more often a few years after the primary operation. The frequency of these fractures is influenced by several factors that are interdependent. Depending on the position of the fracture and bone quality, these fractures are divided according to the Vancouver classification. The surgery of fractures with stable stem (B1) generally consists of internal fixation while maintaining the stem of primary prosthesis. Opinions on the treatment of fractures in which the stem is not stable but there are no bone defects (B2) are controversial. The classic method is to change the prosthesis with or without additional fixing of the fracture, but lately there are more studies that support osteosynthesis of the fracture with the preservation of the original prosthesis. The basic principle of the osteosynthesis in the region of the prosthesis stem is the anatomic reduction of the fracture by stable fixation. In this way, we re-establish the perfect fit of the prosthesis to the bone. The stem of the prosthesis represents an obstacle to osteosynthesis, rarely also to reduction. In this article we mainly discuss the problems of attaching the plate around the stem of the prosthesis. The simplest way to fix the plate to the bone is by using cerclage, but it offers poor torsional stability and is always required to be additionally fixed with screws. Due to the age-related osteopenia of the bone, which is practically always present, it is ideal to use angle-stable plates with locking bi-cortical screws, but this is only possible when using special plates that allow it. The plate must bridge the maximum length of the bone in order to reduce the stress raiser at the end of the plate. In the article we presented a one-year series of operated B1 and B2 periprosthetic femoral fractures after hip prosthesis performed at the Department of Traumatology of the UMC Ljubljana.

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## Izvleček

Z večanjem števila vstavljenih endoprotez kolka se večja število zapletov. Obprotezni zlom v predelu stegenice po endoprotezi kolka je zaplet, ki redko nastane ob operaciji, pogosteje pa do zloma pride nekaj let po primarni operaciji. Na pogostost tega zapleta vplivajo številni dejavniki, ki so med seboj soodvisni. Glede na mesto zloma in kakovost kosti se ti zlomi delijo po Vancouverski razdelitvi. Zlomi s stabilnim deblom (B1) se praviloma operirajo z notranjo učvrstitvijo ob ohranitvi debela primarne proteze. Mnenja glede zdravljenj zlomov, ob katerih pride do omajanja debela, ni pa prisotnih okvar na kosti (B2), so deljena. Klasična metoda je menjava debela z dodatno učvrstitvijo ali brez nje. V zadnjem času pa se pojavlja vse več študij, ki podpirajo notranjo učvrstitev z ohranitvijo izvorne proteze. Osnovno načelo ob učvrstitvi zloma v predelu debela proteze je anatomsko naravna zloma s stabilno učvrstitvijo. Na ta način ponovno vzpostavimo popolno prileganje proteze kosti. Deblo proteze predstavlja oviro za učvrstitev, le redko tudi za naravno. V članku govorimo predvsem o načinu pritrditve plošče na kost v predelu debela proteze. Najlažja je uporaba t. i. cerklaž, ki pa nudijo slabo torzijsko stabilnost. Zato je potrebno zlom še dodatno učvrstiti z vijaki. Zaradi osteopenije kosti, ki je pri starostnikih praktično vedno prisotna, je idealno uporabiti kotno stabilne plošče in zaklepne vijake, ki so v kosti učvrščeni v obeh kortikalnih (bikortikalni vijaki). Vendar pa je to možno zelo redko oziroma ob uporabi plošč, ki to dopuščajo. S ploščo je vedno treba premostiti čim večjo dolžino kosti, saj na ta način zmanjšamo obremenitev kosti na koncu plošče. Članek prikazuje serijo obprotezni zlomov v predelu debela kolčne proteze brez okvar kosti (B1 in B2), operiranih na Kliničnem oddelku za travmatologijo UKC Ljubljana v obdobju enega leta.

## 1 Introduction

Hip arthroplasty is a successful treatment for degenerative diseases of the hip joint, as well as femoral neck fractures in the elderly. In general, complications following the procedure are rare. A periprosthetic femoral fracture (PFF) is one such complication in which the endoprosthesis stem reduces bone elasticity and thus resistance to fracture by about a third (1,2). This is the most important reason for revision surgery from the fourth postoperative year onwards (3). The average cost of treating these fractures in the UK is £23,000 per patient (4).

PFF can occur during or after surgery. During primary surgery, fractures occur in 1% with cemented fixation and up to 5% with uncemented fixation, while in revision surgery (most often due to endoprosthesis loosening), they are more common, with 4% occurring with cemented fixation and 20% with uncemented fixation (5).

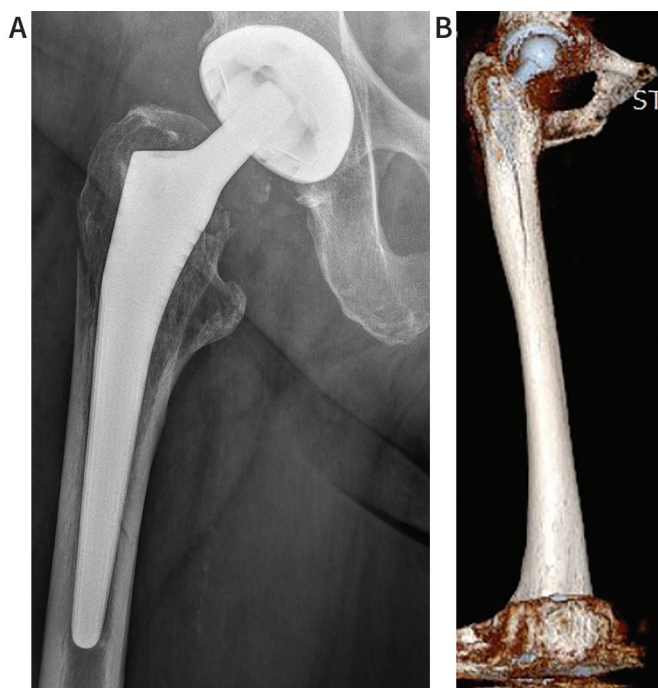
After surgery, PFF most commonly occurs with low energy trauma (falls from a standing height). The incidence of these injuries is around 1% with cemented endoprostheses and between 4%–5% with uncemented endoprostheses (5). The majority occur for the active elderly with osteoporosis. There are several risk factors listed in the literature and most of them are interconnected: age, osteopenia, comorbidities, secondary (already changed) endoprosthesis, and sex. Fractures in femurs with an endoprosthesis occur more frequently in the elderly with osteoporosis. It has been found that with each year of age, the chance of fracture increases by 1% (6). The number of comorbidities increases with age, affecting the probability of a fall. The higher probability of fractures in women is due to more frequent osteoporosis

as well as a higher number of inserted hip endoprostheses, mainly due to degenerative causes. With an ageing population, the need for replacing the endoprosthesis increases due to their limited lifespan as well as loosening of the prosthesis. PFF incidence increases either during endoprosthesis replacement or afterwards (5,7).

In a younger, very active population, the injury is most commonly secondary to high energy trauma, or loosening occurs as a consequence of osteolysis due to microparticles peeling under load, which can occur in intensely active lifestyles. Endoprosthesis stem loosening increases the possibility of PFF (8).

Postoperative PFF occurs more frequently with uncemented endoprosthesis stems than with cemented fixation. The incidence of such injuries begins to rise six months after primary surgery. The reason for this can be found in increased loads on the bone around the stem due to a perfect fit of the endoprosthesis, inserted into bone. In cemented stems, the fracture is most commonly found in the transition of the stem to normal bone, which occurs years after the primary surgery and is most probably the consequence of cement microparticles, formed under load (9).

A femoral fracture is a serious injury and is most commonly treated with surgery. It enables the patient to rehabilitate earlier on, and effectively return to their pre-injury activities. We are trying to achieve the same goal with PFFs. The basic difference between PFF and other femoral fractures is the presence of an endoprosthesis. Additionally, during the primary operation (i.e., insertion of the endoprosthesis), the blood supply within



**Figure 1:** Periprosthetic femoral fracture type B1. (A) an X-ray image of a fracture at the stem of the right hip endoprosthesis. (B) computed tomography scan with tridimensional reconstruction.

In stable stem fractures, displacement is often only minimal. Source: archive of the Clinical Department of Traumatology, University Medical Center Ljubljana.

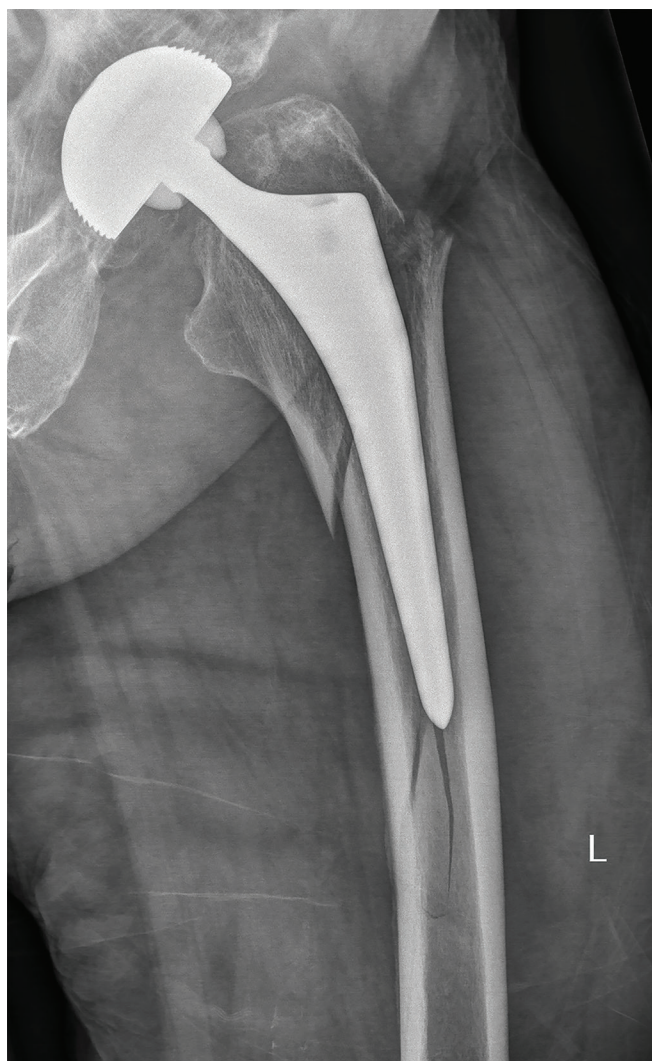
the usually osteopenic bone is always destroyed, and fractures are multifragmentary due to bone fragility (10).

Periprosthetic fractures are divided according to the relationship between the fracture line and the endoprosthesis, via the Vancouver classification (VC); the Unified Classification System for Periprosthetic Fractures (UCPF) has been derived from this, developed by the AO Foundation. According to the VC, fractures around the stem directly supporting the endoprosthesis, or just below it, are classified as type B. A stable stem fracture is classified as B1; if the stem is loose but the bone stock is adequate, the fracture is classified as B2. In case of inadequate bone stock, most commonly secondary to a loose stem, the fracture is classified as B3 (11,12) (Figures 1 and 2).

Type B PFF is treated surgically. The method is decided according to the type of fracture and the general condition and expectations of the (elderly) patient.

Stable stem fractures (B1) are treated with internal fixation (osteosynthesis, OS). Loose stem PFF (B2) and loose stem fractures with bone defects (B3) are treated with endoprosthesis replacement with or without osteosynthesis (11,12).

The presence of the endoprosthesis stem in the femur



**Figure 2:** Periprosthetic femoral fracture type B2. Left femoral fracture with fragment displacement and a loose stem (subsidence, varus position and stem rotation).

Source: archive of the Clinical Department of Traumatology, University Medical Center Ljubljana.

makes fixation a biomechanical and technical challenge. The purpose of this article is to present the principles and methods of PFF internal fixation by preserving the stem and to show a one-year series of stem PFF without bone defects (B1 and B2) operations at the Department of Traumatology, Medical Centre Ljubljana.

## 2 Principles of periprosthetic femoral fracture osteosynthesis

Femoral fractures are treated according to the principles of treatment of the long bones of the lower limbs. The aim is to achieve a functional anatomy of the femur, which means that the bone maintains the appropriate

length, axis and torsion after healing (13).

In simple fractures (two fragments), anatomical reduction is technically possible. However, care should be taken to avoid additionally damaging the fragment's perfusion, already affected by the trauma. Adequate bone perfusion is crucial for healing (14,15). With anatomical reduction, perfect (absolute) and stable fixation (compression between the fragments) should be achieved, which leads to primary fracture healing. Fragment compression can be achieved with the use of lag screws (and, on rarer occasions, with cerclage) and the fracture area should always be relieved (neutralized) with a plate (16).

In multifragmentary fractures, anatomical reduction is practically impossible without additional impairment to bone perfusion. Thus, the goal is to achieve functional reduction. With non-anatomical reduction, absolute stability is impossible to achieve, so partially (relatively) stable reduction is always performed. Such fractures heal with a callus. Relative stability can be achieved with intramedullary fixation or a bridging plate. When trying to achieve relative stability, there is a danger that the fracture will not heal without enough stability, due to excessive fragment displacement under load; on the other hand, a too-stable osteosynthesis in non-anatomical reduction can also lead to nonunion and a repeat fracture (13,17,18).

PFF that occur well below the stem (type C in the AC) can be treated using both principles. With good bone quality (younger patients) and simple fractures, anatomical reduction and stable fixation is chosen. With osteopenic patients or multifragmentary fractures, reduction is functional and fixation relatively stable. Anatomical reduction of multifragmentary fractures is technically impossible to achieve due to the large number and small size of fragments; additionally, in osteopenic bone, adequate fragment compression to ensure absolute stability is impossible to achieve. Due to the presence of the stem in the proximal femur, an intramedullary nail cannot be used with PFF, so the fracture is always bridged with a plate (19).

In stem PFF (type B), the fracture is located in an area of bone that provides support to the endoprosthesis. In uncemented endoprostheses, the base is completely adjusted to the stem, while in cemented endoprostheses, the bone is in close contact with cement. While maintaining the primary stem, a perfect fit of the bone to the endoprosthesis or the periprosthetic cement mantle needs to be maintained or restored to ensure stem stability. It is therefore imperative to achieve anatomical reduction of bone fragments; with anatomical reduction, the goal is also to achieve absolute fracture stability. The

stem completely occupies the medullary canal for most of its length, so compression between the fragments cannot be achieved with gap screws; instead, cerclage is commonly used for this purpose. Stability is further protected with a plate (11,12).

### 3 Osteosynthesis in type B periprosthetic femoral fractures

With PFF fixation, only extramedullary implants are used. The construct, made of an extramedullary implant (plate, allograft), is fixed to the bone with cerclage or screws (standard or locking), to ensure fracture stability. Bone screws can be bicortical or monocortical.

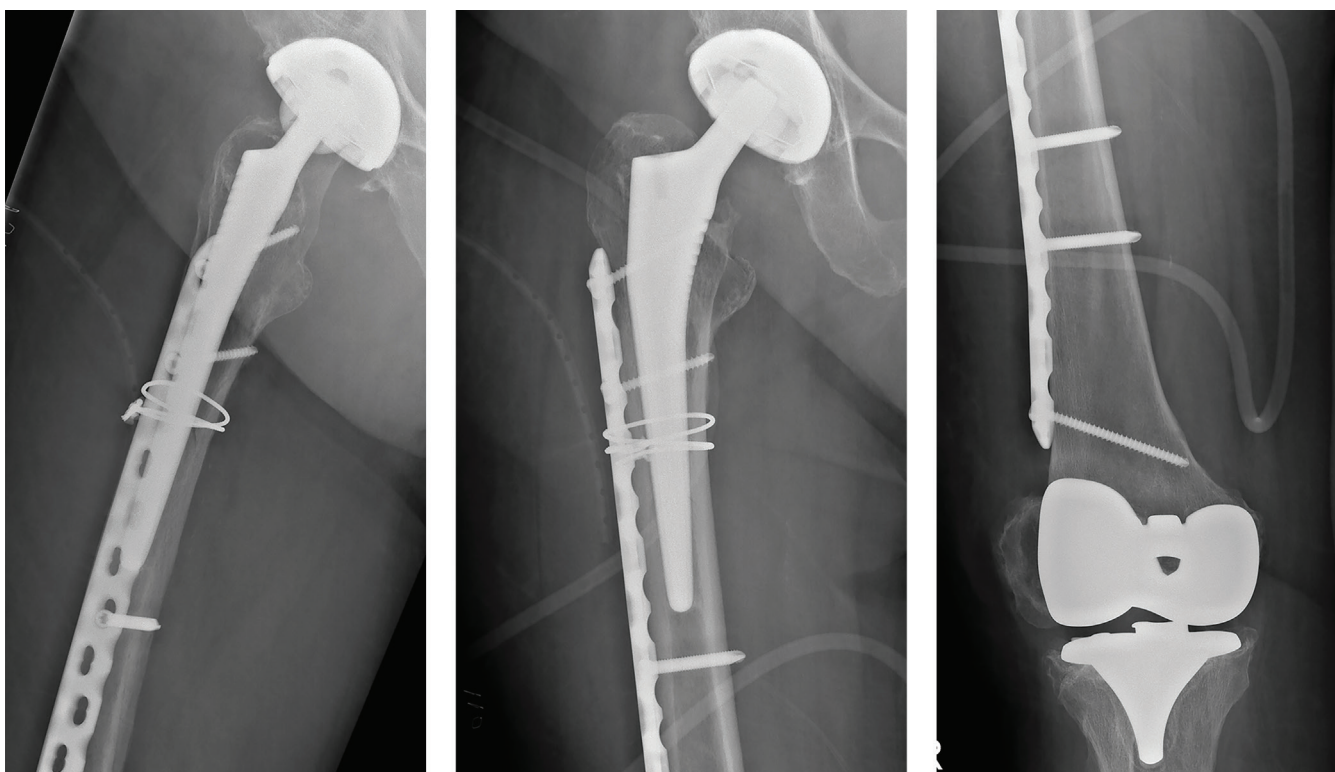
Some biomechanical studies have shown that the strength of the periprosthetic fracture union is the same when using an allograft, plate or revision arthroplasty (24,25). On the other hand, some studies have shown the plate to be more stable than one or even two allografts (25). The combination of a plate and allograft offers the strongest support (21,27-29); however, the force that causes a fracture under such constructs is significantly greater than can be expected under normal physiological loads.

The stability of PFF fixation does not only depend on the type of implant, but also on the osteosynthesis method at the stem area. It is characteristic of all endoprostheses that the contact between the stem or cement surrounding the endoprosthesis and the bone must be perfect. The stem of the prosthesis represents an obstacle to osteosynthesis, due to a lack of space in the bone and the possibility of damage to the cement stabilizing the cemented endoprosthesis stem, while the screws increase the load on the bone, which can cause a fracture. The plate can be attached to the bone with standard screws, screws that offer angular stability, or cerclage.

The technically simplest method of attachment is with cerclage. The basic biomechanical disadvantage of this method is its poor torsional stability. The biological disadvantage of the method is perfusion impairment. In recent years, cables have been used for cerclage, being mechanically more stable and less prone to impairing the periosteal perfusion than wires (30,31).

Comparisons of bicortical and monocortical screws and cerclage for osteosynthesis at the stem have shown that bicortical screws offer the greatest stability (32-34).

Fixation with locking bicortical screws at the stem offers the greatest stability, but it is often not technically feasible due to the presence of the implant in the bone. Newer locking plates for PFF treatment allow the locking screws to be placed at different angles. Additionally,



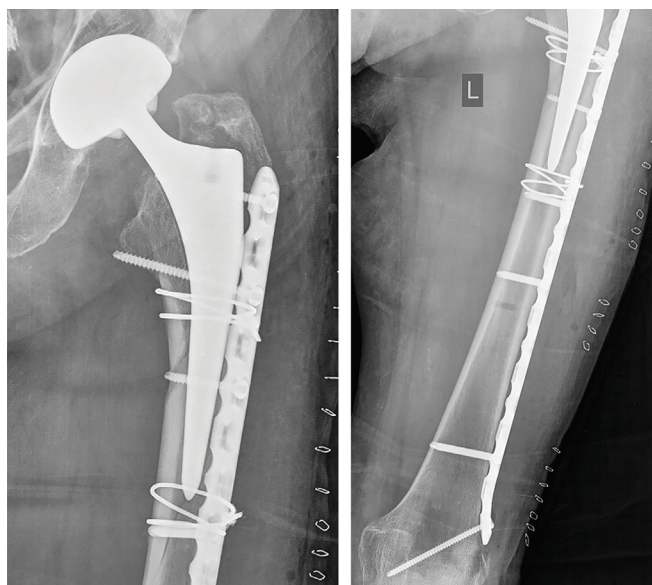
**Figure 3:** Type B1 fracture osteosynthesis: anatomical reduction was achieved; the plate was attached to the bone at the stem with cerclage and two standard bicortical screws. Under the endoprosthesis, the plate was attached to the bone with three locking bicortical screws; the final screw was standard.

Source: archive of the Clinical Department of Traumatology, University Medical Center Ljubljana.

plates that attach to the base plate are also used and allow the locking screws to avoid the stem when being placed. With good bone stock, osteosynthesis with standard screws is also possible (35). In case such plates are not available, biomechanical studies have shown that a construct with monocortical locking screws with or without cerclage is also acceptable (36,37). Other studies have shown even better results with the use of monocortical locking screws without cerclage (33).

With screw fixation near cemented endoprostheses, contact between screws and cement is often unavoidable. It is presumed that the screws in contact with cement cause a crack which can cause endoprosthesis loosening, but evidence to support this theory is weak. However, it has been proven that screws that only partially enter into the cement cause a crack significantly less often than if they are completely anchored in the cement, or even touch the stem (38). It has also been proven that with the use of plates that enable the screws to avoid the cement, damage to the cement is therefore avoided, thus ensuring the stem remains stable (39).

The presence of an implant in bone reduces the force, necessary to cause a fracture, by approximately a third (1). With PFF fixation, it should be noted that by implanting a new endoprosthesis, the most vulnerable



**Figure 4:** Osteosynthesis of a type B2 fracture without stem replacement: anatomical reduction was achieved. At the stem, the plate was attached with two cerclages, one bicortical and one monocortical standard screw, and under the endoprosthesis, the plate was attached to the bone with three bicortical locking screws; the final screw was a standard monocortical screw.

Source: archive of the Clinical Department of Traumatology, University Medical Center Ljubljana.

spot for a periprosthetic fracture is moved distally on the femur. The probability of a distal endoprosthesis fracture is around 8%, so the maximum length of bone must always be bridged (20-22). Due to increased loads at the end of the plate, the choice of fixation method is of utmost importance. The bicortical locking screw increases load the most, followed by the monocortical locking screw. The load is least increased with standard screws or cerclage. The load difference between bicortical locking screws and standard screws or cerclage is 40% (22,23). Bridging the entire bone and with implant overlap (endoprosthesis and extramedullary implant), the force that would cause a fracture returns to normal (1).

The standard position of extramedullary implants is on the lateral side of the femur. According to Wolff's diagram, the normal distribution of forces on the femur is such that there are compression forces on the medial side and tension forces on the lateral side (40). With lateral fixation, problems arise when the bone on the medial side is shattered and approximation between the main fragments cannot be achieved with fracture reduction. In such cases, tension forces on the laterally lying implant increase significantly, and the screws may be pulled out, or the plate may break, leading to osteosynthesis disintegration. Such a fracture requires more than just lateral fixation. The two-plane fixation options in the proximal femur are in the 900-900 configuration, when one implant is attached to the lateral side and the other to the anterior side of the femur, or 1800-1800, when one implant is attached to the lateral side and the other to the medial side of the bone. In the first case, both implants can be plates attached to the bone with screws or a plate on the lateral side and an allograft on the anterior side, the latter attached with cerclage. In the second case, the plate is attached to the lateral side and the allograft, attached with cerclage, to the medial side (21,25,27,28,41-43). In both cases, attaching multiple implants in different configurations leads to significantly more soft tissue injury, which further impairs bone perfusion.

Therefore, modern literature suggests an anatomical fracture reduction at the stem. Fixation should be stable with the use of cerclage, which are relieved by a long plate covering the entire length of the bone. In the stem area, the plate should ideally be attached to the bone with bicortical locking screws. The end of the plate should be attached less rigidly to the bone in the area without an implant, either with monocortical standard screws or cerclage (Figures 3 and 4).

#### 4 An overview of management of trauma patients with periprosthetic femoral fracture type B at the Department of Traumatology, Medical Centre Ljubljana

In the last 5 years, the number of proximal femoral fractures treated at the Department of Traumatology at the Medical Centre Ljubljana has risen by approximately 15%. Periprosthetic femoral fractures are included among them, and their number has risen by more than 50% in the same period. The majority of our patients with PFF had primary hip arthroplasty performed due to arthrosis.

Using a retrograde analysis of patients with periprosthetic proximal femoral fractures who had surgery from 1. 1. 2019 to 31. 12. 2019, we checked how management recommendations were followed and what the radiographic (X-ray) results were.

Using our department's list of operations, we obtained data on trauma patients who had surgery for PFF over a one-year period. With the help of X-ray images, fractures were classified, data obtained on the method and type of fixation, and X-ray images were analyzed at the end of treatment. Due to a relatively small sample size, the data has not been statistically processed.

In 2019, we performed 931 operations for proximal femoral fractures at the Department of Traumatology. We inserted 299 partial or total hip endoprostheses due to fractures. In this period, we operated on 35 patients with periprosthetic femoral fractures; 17 of them had type B fractures. Ten patients were female. The age ranged from 56 to 90 years (median 78 years). In this year, we also operated on one patient with a repeat PFF.

Seven patients (41%) had type B1 fractures and in 10 cases (59%), the fracture caused stem instability (type B2). In all our patients, the bone stock was assessed as adequate, meaning there were no type B3 fractures in our series.

Ten patients were treated with fixation (7 B1 and 3 B2); the median age with type B1 was 78 years, and 81 years in type B2. Two patients with type B2 fractures who had osteosynthesis had an uncemented stem and one had a cemented stem, while five patients (71%) with type B1 fractures had an uncemented stem. In all patients, the LCP (locking compression plate) was used as an implant, offering the choice of using both locking and standard screws. With type B1 fractures, we performed an anatomical fracture reduction in 6 cases (86%) and always with type B2 fractures. In all patients with type B2 fractures, the fracture healed without a

**Table 1:** Comparison of periprosthetic femoral fracture of type B1 and B2 treatment.

		B 1	B 2
Number		7	3
Age (median)		78 (56–90)	81 (80–85)
Type of endoprosthesis	uncemented	5 (71%)	2 (66,7%)
	cemented	2 (29%)	1 (33.3%)
Reduction	anatomical	6 (86%)	3 (100%)
	functional	1 (14%)	0
Healing	primary	5 (71%)	3 (100%)
	secondary	2 (29%)	0
Screws	standard	2 (29%)	0
	locking	4 (57%)	2 (67%)
	combination	1 (14%)	1 (33%)
	bicortical	3 (42%)	2 (67%)
	monocortical	2 (29%)	0
	combination	2 (29%)	1 (33%)
Cerclage		6 (86%)	3 (100%)
Final screw	bicortical	7 (100%)	2 (67%)
	monocortical	0	1 (33%)
	locking	5 (71%)	1 (33%)
	standard	2 (29%)	2 (67%)
Healing duration (average)		4.6 months	5 months
Endoprosthesis subsidence		0	2
Mechanical problems		0	1 (varus)

visible callus, signifying primary healing and absolute fixation stability. In type B1, there were 5 such patients (71%).

At the stem in type B1 fractures, we used only standard screws in 2 cases (29%), only locking screws in 4 cases (57%) and a combination in 1 (14%). In 3 patients (42%), all the screws were bicortical, in 2 (29%) only monocortical, and in 2 (29%) a combination of mono- and bicortical. In type B2, we used a combination of screws at the stem in 1 patient (33%) and in 2 (67%), we used only locking screws; however, in 2 (67%) they were bicortical and in 1 (33%) a combination of mono- and bicortical. Cerclage around the stem was used in type B1 in 6 cases (86%) and always in type B2. The final screw on the lower end of the fixation was always bicortical in type B1, 2 of these (29%) were standard,

and 5 (71%) a locking screw was used; in type B2, the final screw was locking in 1 case (33%), and standard in 2 (67%); in 2 cases, it was bicortical (67%) and in 1 (33%) it was monocortical.

Endoprosthesis subsidence or other mechanical complications did not occur in type B1 fractures. On average, these fractures healed in 4.6 months. In type B2 fractures, endoprosthesis subsidence occurred twice by 0.5 cm, and in one case, varus deformation of 10 degrees at the fracture site occurred. The median duration of fracture healing was 5 (Table 1).

In 7 cases (70%), type B2 fractures were treated with stem replacement and in all cases, additional fixation was performed. The median age of these patients was 75 years. In all cases, cerclage was used, and in one case, an additional plate and screws (Table 2).

**Table 2:** Comparison of periprosthetic femoral fracture of type B2 treatment between the group with osteosynthesis and the group with endoprosthesis replacement.

		B 2	
		osteosynthesis	endoprosthesis replacement
Number		3	7
Age (median)		81 (80–85)	75 (64–85)
Type of endoprosthesis	uncemented	3 (100%)	5 (71%)
	cemented	0	2 (29%)
Cerclage		3 (100%)	7 (100%)
Healing duration (average)		5 months	3.7 months
Endoprosthesis subsidence		2	0
Mechanical problems		1 (varus)	0

### 5 Comparison of our results with results from the literature

Compared to 2005, the number of primary hip arthroplasties is projected to increase by 174% by 2030; the number of periprosthetic fractures will increase by a similar proportion (44). As patients with these fractures are mostly elderly with comorbidities, it will put a strain on the healthcare system. A similar growing trend is also noticeable in patients treated at the Department of Traumatology at the Medical Centre Ljubljana. In the last five years, the number of periprosthetic fractures has increased by about half. In our series, all but one of the patients are over the age of 65, which is consistent with observations of other studies that show that a periprosthetic fracture is an injury of the elderly (45). In the literature, maintaining the stem is always recommended if it is stable, even after a fracture. It has been debated for several years whether stem replacement is truly always necessary in cases where stem instability occurs after a femoral fracture. By definition, the authors of classical studies have always advised replacement due to fracture of the shaken prosthesis (46–48). Newer studies show that stem replacement is not always necessary and that good results can be achieved with fracture fixation. Besides pre-injury activity and patient expectations after surgery, bone stock and the type of fracture should be taken into account as they should allow anatomical reduction and stable fixation. It is important that the endoprosthesis for this treatment method was stable prior to injury; if it was loosened beforehand, the stem must always be replaced

during PFF surgery. In cemented stems, osteosynthesis without stem replacement should only be considered if the cement mantle remained intact after the fracture in the area of contact between the cement and bone (4,49–51).

In our series, patients with a stable stem (B1) were younger than those with an unstable stem after fracture (B2); from this, we can indirectly infer the bone stock, as stronger bone provides better support to the stem. In type B2 fractures, the patients in which we decided on fracture fixation without stem replacement were older than patients in which we replaced the stem (81 vs. 75 years). This shows that we also decided on the method of treatment on the basis of expected activity. Most fractures occurred at the uncemented part of the stem, which is consistent with studies that showed that the probability of a periprosthetic fracture in the elderly is reduced if a cemented stem is used (5). In 90% of our patients, the anatomical reduction of the fracture ensured the re-fitting of the stem or cement mantle to the femur, and in this way established the support of the endoprosthesis, which is also advised in the literature (4,49–51). The fracture healed without radiographic signs of a callus in 80%, indicating the absolute fixation stability that is desirable in these fractures (11,12). As the use of gap screws is impossible due to the presence of the stem, we tried to achieve absolute stability in 90% of the fractures with the use of cerclage.

In most cases (except one), this ensured sufficient stability for primary healing. However, due to the poorer resistance of this type of fixation to torsional forces, we also always used a plate and screws to protect and



increase fixation stability. In most cases (80%), the plate was attached with bicortical screws. If locking screws could not be used due to the stem, standard ones were used. Modern literature also advocates such a principle (32-34).

Biomechanical studies warn of the possibility of a fracture at the implant if the plate is too short (ends in the diaphysis) or is attached to the bone too rigidly at the distal part or at the transition to unstrengthened bone (20-22,28).

In our series, all plates reach to at least the beginning of the distal femoral metaphysis. In 60%, the final screw was a locking screw, and in all cases but one, bicortical. Despite quite rigid fixation at the distal femur, no fractures occurred at the implant under the plate. The reason for this can probably be found in the plate length, which did not end in the diaphysis, but rather in the significantly wider metaphysis.

All periprosthetic fractures at the stem have healed; in type B1 fractures, healing was, on average, half a month faster than in type B2 fractures. In patients with type B2 fractures who were treated with stem replacement, the fracture healed 1.3 months faster than in those whose stem was not replaced.

In type B1 fractures, all fractures healed without subsidence or deformations, confirming the stability of the stem before and after injury. With a loose stem (type B2), fixation achieved union, but in two cases of uncemented fixation, subsidence of the original stem by 0.5 cm occurred, and with a cemented endoprosthesis, varus position of 10 degrees occurred. Such deformations cause mild shortening of the lower limb, which is disruptive in functionally demanding patients and should therefore be avoided.

## 6 Conclusion

With the increase in arthroplasties due to degenerative hip joint disease and femoral neck fractures, the rise in the number of PFF is expected. Our goal should always be anatomical reduction with stable fixation in the case of these injuries and a stable stem. In fractures causing endoprosthesis instability, bone stock, type of fracture, endoprosthesis stability before the fracture and the expected patient functionality should all be taken into account. If it is possible to ensure a stable stem after anatomical reduction and stable fixation with adequate bone stock, fixation of type B2 fractures in the less active elderly can be a successful method of treatment. When deciding on such a method, we must always consider the biomechanical properties of fixation at the stem. Anatomical reduction and stable fixation must be ensured. Most commonly, cerclage is used, but always with the addition of a plate that extends over most of the bone and ends in the metaphyseal part of the distal femur, where it should not be attached too rigidly. At the stem, the plate should always be attached to the bone with screws, which can be monocortical, but are ideally bicortical. In case of endoprosthesis loosening prior to injury, or if the type B2 fracture occurs in a younger and very active patient, the stem should be replaced, for only in this way can we ensure healing in the proper position.

Treatment of periprosthetic fractures is difficult. Treatment should be adjusted to the type of fracture and patient characteristics, therefore, knowledge of osteosynthesis techniques as well as revision arthroplasty is essential.

## Conflict of interest

None declared.

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