Revitan® Straight

Surgical Technique

PFM-Revision of the Second Generation

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Content

Implants – Concept – Instrumentation

Foreword

- This documentation refers to the *Revitan* Straight (PFM-Revision) stem, the primary stability of which is ensured by the press-fit effect alone. It is necessary to distinguish between those stems which have been implanted since 1994, and the other stems, also grouped under the generic name of ***Revitan***, consisting of the curved stems, named *Revitan* Curved, which have a different operative technique as a straight stem.

- All surgeons must make sure that they are thoroughly informed about the used system. It must be remembered that each concept has its own requirements, advantages and disadvantages. Similarly, any implant is a compromise.

P. Le Béguec

As far as the modularity of the stem is not in itself a concept that enables to ensure primary stability, we believe that a straight stem presents significant differences compared to a curved stem. It is important to know those differences in order to avoid serious errors when choosing the strategy and implanting the stem.

Making a choice is a delicate issue, since the designers sometimes tend to minimize the disadvantages and limits of their own implant or method. These drawbacks, on the other hand, will often be the only aspects stressed by those in favour of another concept.

Important:
Components and instruments of the ***Revitan*** Straight system (PFM-Revision of the second generation) cannot be combined with components and instruments of the first-generation PFM Revision System.

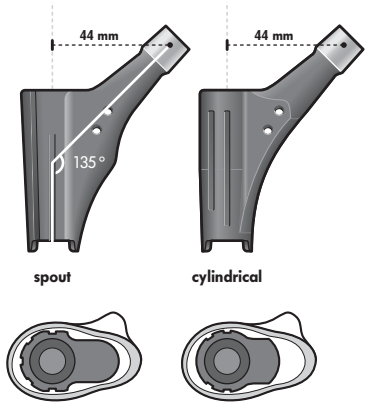
Implants – Concept – Instrumentation

Implants – Concept – Instrumentation
The implants, caracteristical description

The Revitan Straight (PFM-R) consists of a set of femoral stems made of Ti6Al7Nb titanium alloy (Protasul-100). Each femoral stem is made up of 2 parts: one proximal component and one distal component. Mechanical coupling is ensured by a morse taper connection.

Proximal components

There are **2 types** of proximal components: spout or cylindrical. The spout components are wider on the frontal plane whilst the medial profile of the cylindrical components is thicker. Components of 6 different heights are available for each type, in increasing size by steps of 10 mm, from 55 mm to 105 mm. The CCD angle is 135 ° and the offset is 44 mm.
The lateral side with ribs and grooves is hollow, i. e. featuring the female part of the morse taper connection. There are two holes in the medial part that can be used for non-metallic suture to reinsert a flap.

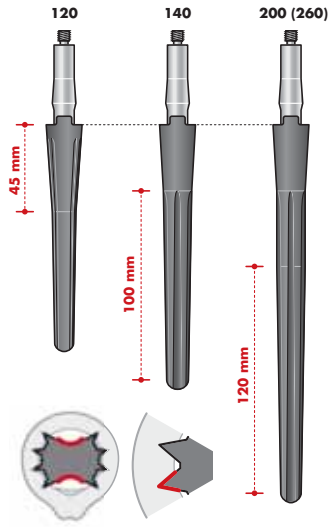


The top of female morse taper is threaded for the impactor and the disassembly instruments for the proximal component.

The offset of 44 mm is a compromise that on one hand ensures a good function of the glutei muscles and on the other hand avoids excessive stress on the coupling area, which is, by definition, weaker.

Distal components

The distal component is available in three different lengths: 140, 200 and 260 mm. The diameter increases by steps of 2 mm from 14 to 24 mm. The whole range includes a total of 16 components.
They are straight stems with 8 longitudinal ribs and, from the size of diameter 18 mm, each stem has a flattened anterior-posterior area, with increasing size as the diameter increases.
The shape of these implants is conical, with a taper of 2 degrees. The height of the conical area is 100 mm for the 140 mm stems, whereas it is 120 mm for the 200 and 260 mm stems.
NB: In addition to this range, a 120 mm stem (diameter 14 mm) is also available. This corresponds to a 140 mm stem that has been shortened by 20 mm. The working area of this implant is the conical proximal area, which is 45 mm high with a taper of 9 ° and lateral ribs.



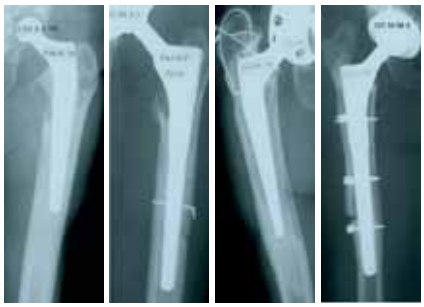
The conical part of the implant is always in a distal position. The greater the slope of the conical part, the shorter the conical part will be and the weaker the distal part of the implant.
The slant of 2 degrees of the conical part means that this part is sufficiently high without excessive weakening of the stem, even for those with the smallest diameters (14 and 16 mm) .

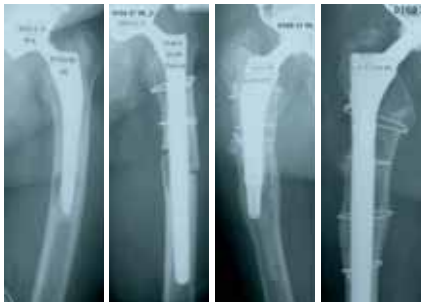
The fins are also conical in shape, which seems to us to be preferable to a vertically grooved design, which would be less effective, or to blade-shaped fins, which would be weaker.

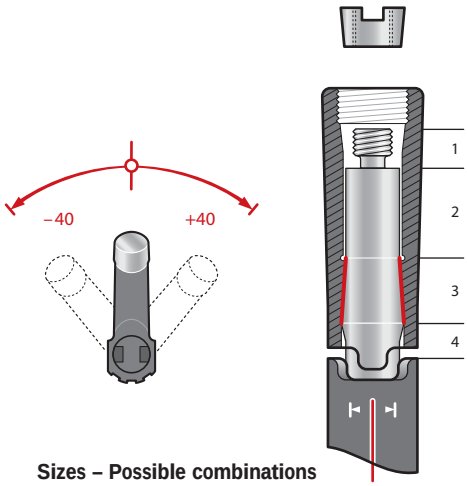
The assembly system

The two parts of the prosthesis are coupled together by means of an original and efficient morse taper system perfected in 1989 and used since then successfully in clinical application. The morse taper has 4 areas:

- Thread for the conical nut.
- Cylindrical area for the centring of the 2 components.
- Conical area for mechanical coupling.
- Area of a narrower cross-section, allowing concentration of stresses at this level.



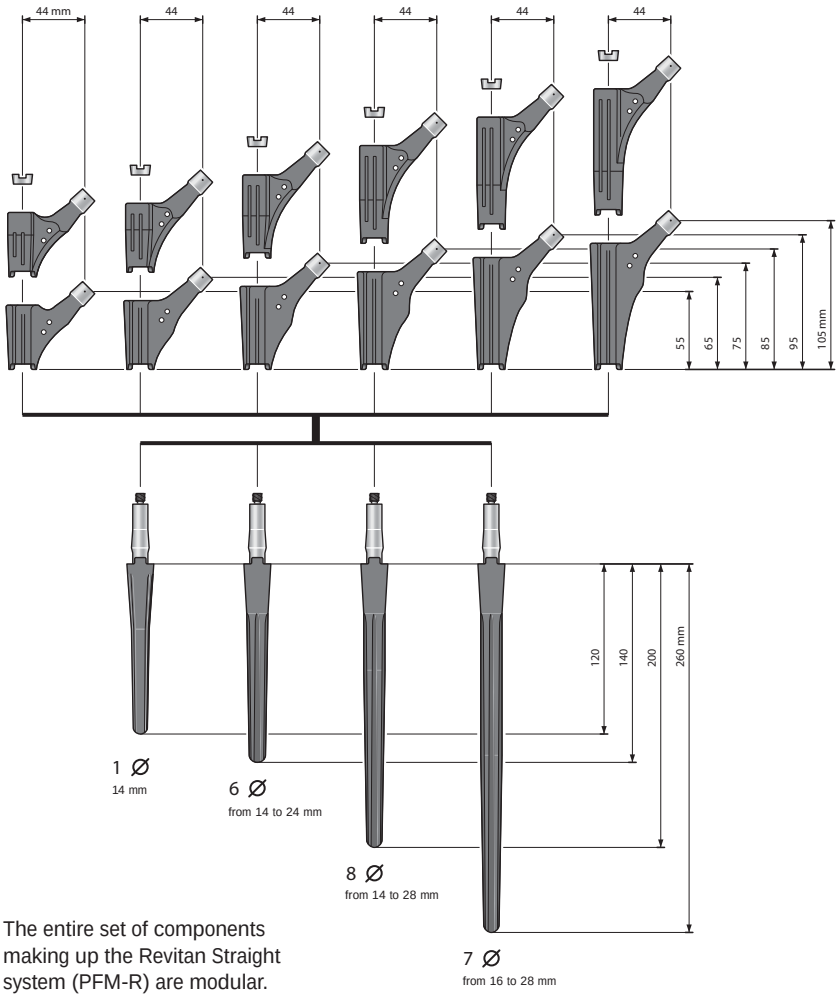




Before the assembly: It is possible to adjust the antetorsion of the proximal component from +40° to −40°.

After the assembly: a gap of about 1 mm between the 2 components enables micromovements without inducing the formation of any metal debris.

Sizes – Possible combinations



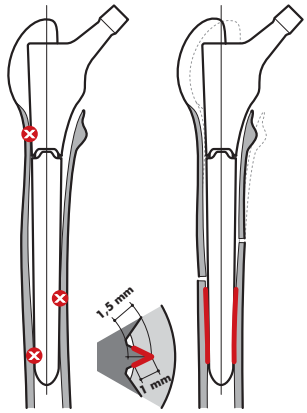
The entire set of components making up the Revitan Straight system (PFM-R) are modular.

Implants – Concept – Instrumentation
The press-fit concept

The press-fit concept is an assembly process consisting of the fitting of 2 separate parts, used frequently in industry (morse taper systems). It is also a good technique to ensure the primary stability of a femoral revision stem in the bone. This was the technique selected by *Wagner* in 1987.
The prerequisites to ensure the press-fit surgically were very well defined by *Morscher*: first of all, achieve a contact surface between the bone and the implant, then ensure that the prosthesis is perfectly wedged into place, and lastly avoid excessive stiffening of the femur.
To achieve these three objectives, a press-fit stem requires very specific geometrical characteristics. It should be stressed here that, while the modular concept does not, as such, ensure the primary stability of an implant, it is a good means for obtaining an effective press-fit.

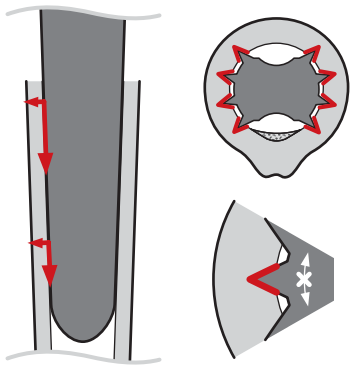
Bone-implant contact surface

A straight stem is the best way to obtain a contact surface between bone and implant.
NB: The longitudinal ribs enlarge the contact surface if their penetration into the cortex is sufficient.
NB: To achieve this aim with a straight stem, it is necessary to **avoid a three-point contact.**
Therefore avoid a varus position of the implant if the femur is straight on the frontal plane. If the femur is curved, a femoral osteotomy will be necessary.
Furthermore a three-point contact on the sagittal plane may result in the choice of an undersized prosthesis, which will threaten the extent of the bone-implant contact on the frontal plane.



Ensuring that the implant is firmly wedged into place

This means ensuring the primary stability of the implant by creating a higher stress (or prestress) at the height of the bone-implant interface than the destabilising forces consisting of axial and rotational stresses.
A conical stem features the best design to ensure a secure wedging: progressive transformation of the vertical shear stress into stabilising horizontal stress, with a more even distribution of the forces and the possibility of re-wedging.
NB: A stem with ribs facilitates wedging (easier impaction) and ensures perfect neutralisation of the rotational stresses which is essential for an uncemented stem.



In order to be wedged into place, a cylindrical stem would have to be slightly oversized with respect to the medullary canal; this entails several drawbacks as difficulties during placement (stress peaks), risk of fracture if the cortical bone is fragile, unensure re-wedging if the initial wedging was not perfectly successful.

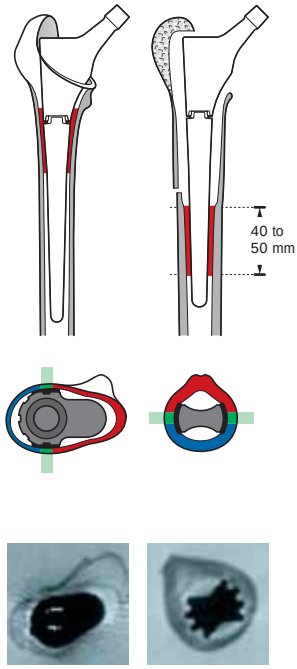
The cross-section of a press-fit stem also has to be carefully considered, since control of rotational stresses depends to a great extent on this cross-section. We believe that a finned stem has a definitive advantage in this respect; whereas a circular cross-sectionned stem with a generally quite smooth surface doesn't provide a high resistance to the rotational stresses.

Avoid excessive stiffening of the femur

In order to lower the risk of stress-shielding. To achieve this, it is necessary to conserve transmission of the stresses (traction and compression), by complying with 3 rules:

- **Try to achieve proximal fixation of the implant** whenever it is possible. If the femur is straight on the frontal plane, fixation in the meta-physeal-diaphyseal region is frequently possible.
- **Limit the height of the bone-implant contact area** when diaphyseal fixation only is possible. The primary stability of a press-fit stem can be achieved over a distance of 4 to 5 cm.
- **Avoid filling the medullary canal too much** and optimise bone-implant contact in the vicinity of the neutral zone of the femur.

NB: The neutral zone is located at the intersection of the traction and com-pression areas. It is on a sagittal plane in the proximal area of the femur and on a frontal plane in the diaphyseal region.



To achieve the aims indicated opposite, a press-fit stem must fulfil some very specific requirements: the metaphyseal part must have a wide profile or a steep conical slant in order to optimise contact between the bone-implant in the sagittal plane. In the diaphyseal region it is necessary to avoid circular contact (in particular on the sagittal plane) so as to ensure bone-implant contact in the frontal plane. Under these conditions, the ribs must be placed on this plane only.

Conclusions

The press-fit concept, which is often mentioned for securing the primary stability of uncemented implants, requires that the above described points are followed consequently in order to achieve the desired results.

When selecting the press-fit concept, it is necessary to choose an implant having well defined features with the only objective to meet the requirements that this method of fixation requires. We believe that a ribbed straight stem with a conical shape is a good choice.

More generally speaking, if a cementless stem is selected for a revision surgery, the design of the implant should always be considered with care. The consequent application of the press-fit concept offers the possibility to choose and use a stem as short as possible and avoiding thereby punctual anchorage over a long distance.

Implants – Concept – Instrumentation
The instrumentation

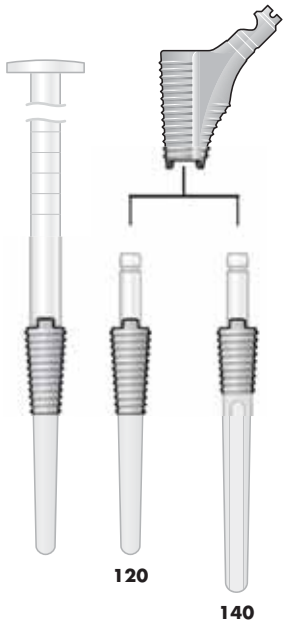
The instrumentation consists of a set of reamers, a system of rasps and modular test prostheses, and proximal trial part enabling the definitive prosthesis to be implanted in 2 stages. Although the rasps and test prostheses are combined in a single instrument, it is suggested to consider it as two distinct instruments, as its function varies depending on the option chosen by the surgeon.

NB: For the reamers refer to the surgical technique: Preparing a bone-implant contact surface.

Modular rasps

The rasp function is only used if the endofemoral approach is selected, with fixation in the metaphyseal-diaphyseal area. In this situation, the rasp also is used as a test prosthesis. The rasp involves the whole range of proximal components (spout and cylindrical).
For the distal components, the rasp is limitated only to the component of length 120 mm and to the 140 mm long components in the diameters 14 to 18 mm.

NB: The use of an implant with a diameter of 20 mm or larger (L.140 mm) means that only diaphyseal fixation can be achieved. In that case the preparation of the femur is done with a reamer, whose diameter is superior to the size of the proximal components, making the rasp ineffective.



A modular rasp enables a two stage preparation of the femur. For this purpose, the surgeon disposes of a rasp adaptor used to drive in the distal rasp and to choose in a second step the size of the proximal rasp (graduated from 55 to 105 mm).
Refer to the surgical technique: Preparing a bone-implant contact surface.

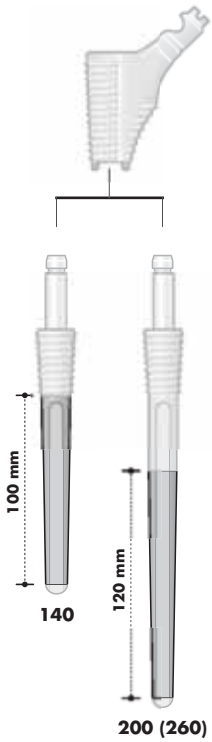
Although the rasp does include the 200 and 260 mm distal components, we believe that it is of lesser use for these implants. Indeed, when proximal fixation is sought, these implants are too long and they should not be used in that case.

NB: The use of a long stem is recommended only when a femoral flap is performed.

Modular test prostheses

When fixation of the implant is achieved in the diaphyseal region, the femur is prepared with the reamers. In this case, the rasp is no longer necessary, and only the test prosthesis function is of use.
Primary stability is ensured with the smooth conical area of one of the distal components, 140, 200, or 260 mm (the conical area is demarcated by 2 transversal lines). The proximal components serve to adjust the length of the lower limb.

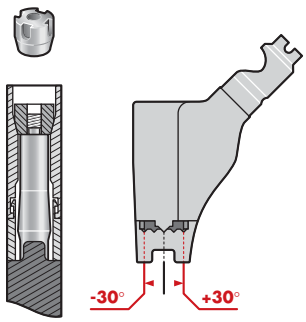
NB: The 140 mm distal components can be used both as rasps and as test prostheses.



When press-fit is selected in order to ensure primary stability, the role of a test prosthesis is essential. Having a modular test prosthesis enables stability to be ensured by the conical area of the implant. Refer to the surgical technique: Ensuring that the implant wedges into place.

Proximal trial part

These instruments enable the definitive stem to be implanted in two stages. There is a proximal trial part corresponding to each definitive proximal component. It is assembled to the distal component by means of a nut screwed to the threaded part of the morse taper without any contact with the morse taper. It is possible to adjust its antetorsion by +/– 30 °.



This instrument set can only be used when a femoral flap has been completed.
In this case, it is essential to ensure that the distal component of the definitive prosthesis wedges perfectly into place.

Summary: The choice of a modular implant implies a modular instrument set, and each definitive implant size must correspond to a test prosthesis.

Pre-Operative Planning

A revision surgery is prepared in three stages: radiological analysis of the femur, determining a surgical strategy, and making a pre-operative template.

Radiological analysis of the femur

In order to carry out a thorough and complete radiological analysis of the femur, it is necessary to dispose of high quality X ray images: an anterior-posterior view of the hip (centred on the loosened prosthesis), an anterior-posterior view of the pelvis, and anterior-posterior and lateral X ray images of the femur extending up to 15 cm below the distal end of the loosened stem are required. These four X-rays are the minimum requirements for defining a surgical strategy with some degree of rigour.

NB: It is necessary to differentiate between X ray images aiming to choose a surgical strategy and those aiming the evaluation of the long term clinical results. This distinction has to be made as far as the important criteria to ensure a safe surgery do not influence the evaluation of the results (deviations of the femur or difficulties in removing the cement).

Determining a surgical strategy

Determining a surgical strategy means selecting an approach to the femur to overcome the eventual obstacles observed during the examination of the X-rays. This choice determines the area where primary stabilisation (the bone-implant contact) will occur.

NB: Each concept has its own imperatives. A good knowledge of the objectives to be achieved in order to ensure primary stability is essential for defining a rational and logical surgical strategy.

Making a pre-operative template

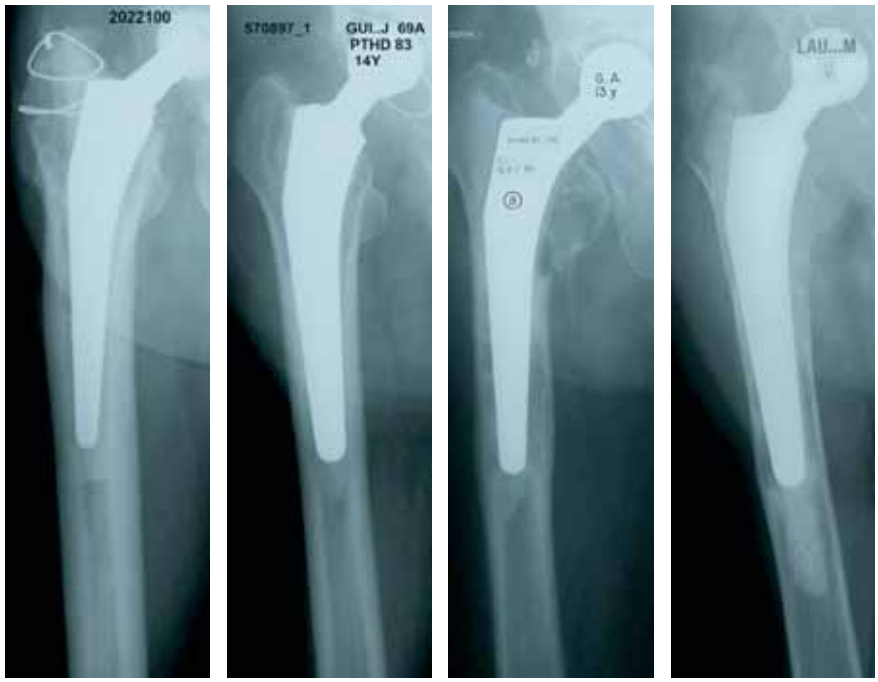
Highlight the main obstacles found while analysing the X-rays of the femur and finally define the strategy. The template also enables to measure the major references that can be used during surgery (length of the flap).

Pre-Operative Planning
Radiological analysis of the femur

The radiological analysis of the femur must be completed with regard to the imperatives imposed by the press-fit concept. Therefore, it must not be limited to an analysis of the defects and of the cement only but extended to the consideration of the degree of osteoporosis and the thorough analysis of the morphotype.

Degree of osteoporosis

Evaluate the thickness of the cortical bone and the geometry of the medullary canal: conical or cylindrical. Carry out this evaluation along an area of the femur without implant on an anterior-posterior X ray, showing the femur over a sufficient length.



1 – Excellent
Thick cortex ++
Narrow med. canal +

2 – Good
Thick cortex +/–
Conical med. canal +

3 – Mediocre
Thin cortex +/–
Cylindrical med. canal +/–

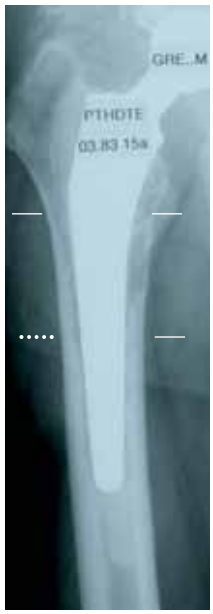
4 – Poor
Thin cortex +
Wide med. canal ++

To differentiate between intermediate stages 2 and 3, give priority to the geometry of the medullary canal. If it is cylindrical, it should be classified as stage 3 even if the bone cortex is not particularly thin.
The term conical medullary canal can refer to a medullary canal that can be prepared into a conical shape while using the conical reamers (thick cortex); similarly, a cylindrical medullary canal can refer to a medullary canal where it is difficult to prepare in a conical shape with the reamers (thin cortex).

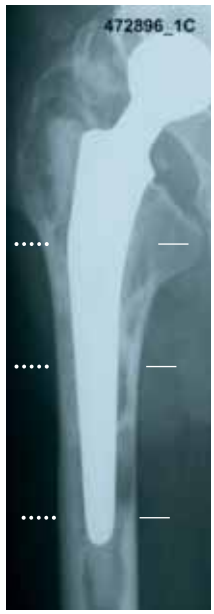
Defects

Evaluate all lesions resulting in a fragile cortical bone in the area of the femur with the implant (granulomas, stress-shielding or osteoporosis, mechanical wear). Evaluate the lesions on the basis of their sizes (**Gruen's** areas).
The following examples refer only to lesions caused by granulomas

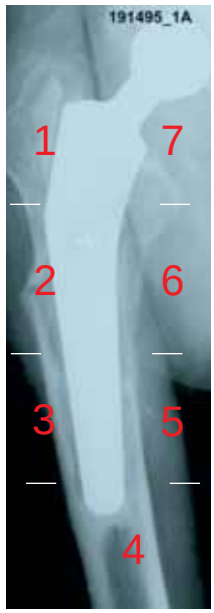
Stage 1
None
Or areas 1 and/or 7



Stage 2
Area(s) 2 and/or 6
No defects in areas 3 and 5



Stage 3
Diaphysis: cortex on one side
Areas 3 or 5 affected



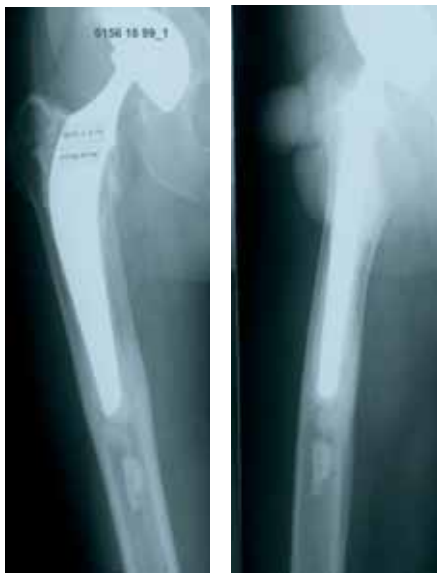
Stage 4
Diaphysis: cortex on both sides
Or fracture around the stem

For stage 2, include lesions affecting one area of the metaphysis (1 or 7) and one area of the diaphysis (prosthesis tilted in a varus angle).
For stage 3, include isolated granulomas in area 4 or, if they are aggressive, at a distance.
For stage 4, include fractures around the stem regardless of the condition of the cortex elsewhere. Defects due to stress-shielding or areas weakened by osteoporosis usually affect the cortical bone on both sides and in most cases are therefore classified as stage 4.

Morphotypes

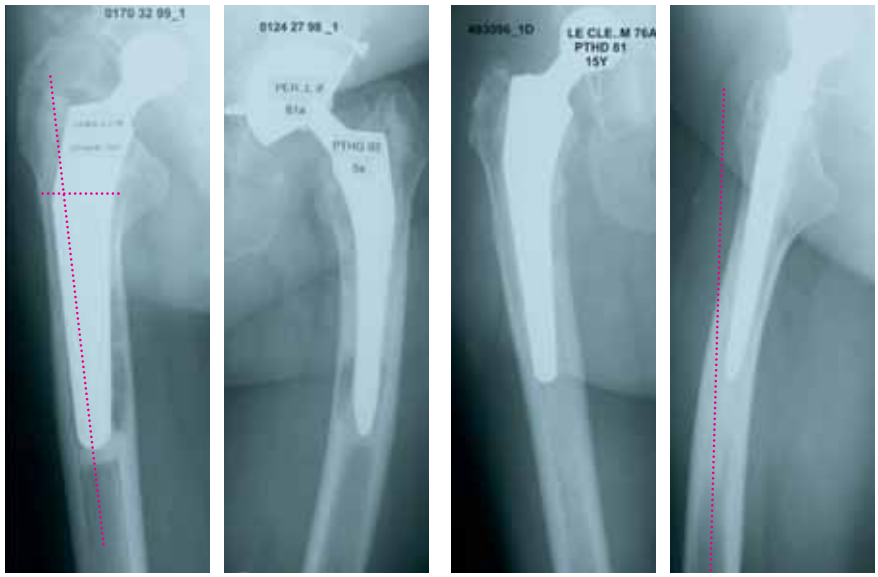
Evaluate the presence or not of a curvature in the frontal plane and the extent of the curvature in the sagittal plane. This verification is very important if a straight stem and the press-fit concept have been selected.
An anterior-posterior X ray and a lateral view X ray will be required, showing the femur up to about 15 cm below the distal end of the loosened implant.
The templates of a long stem must be used.

1 – Femur straight in the frontal plane
Slight curvature in the sagittal plane



2 – Femur curved in the frontal or sagittal plane
Curvature in the frontal plane, regardless of its extent.

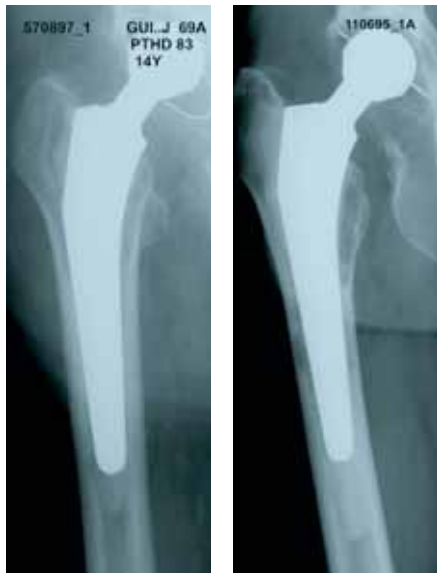
Sagittal: pronounced curvature (overall) and straight in the frontal plane.



Varus deviations in the frontal plane are frequent and it is always wise to consider a curvature of the femur in the frontal plane, even if it is only slight.
In the sagittal plane, the femur is rarely straight and a slight curvature or a double sagittal curvature (diaphyseal curvature with posterior concavity compensated by a proximal curvature with anterior concavity) need not be taken into account since this is usually not an obstacle to place a straight stem.
NB: Overall curvature means a diaphyseal curvature with marked posterior concavity not compensated by a proximal curvature with anterior concavity.

Cement
It is suggested to analyse the cement mantel entirely. The evaluation of the difficulties to remove the cement should not be limited to the presence or not of a distal cement plug, but also to evaluate the thickness of the cement, considering the quality of the cortical bone on both sides.

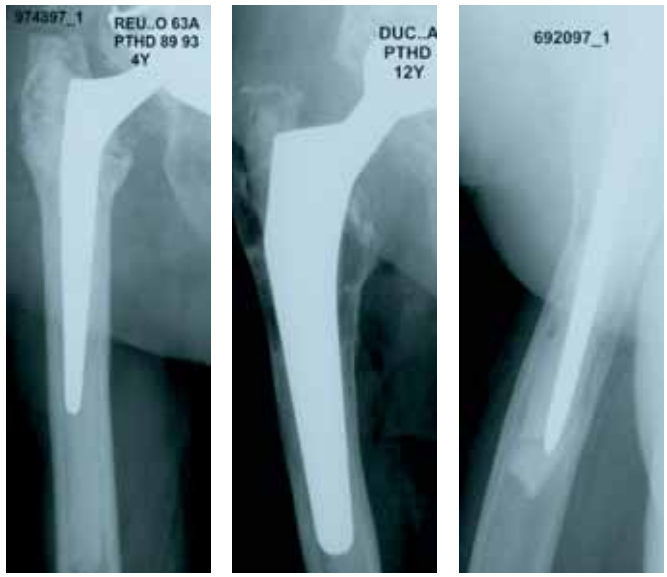
1 – No difficulties
No plug or, if any, < 4 cm and good cortex



A pre-operative X ray planning as described here has the purpose of defining a surgical strategy aimed at avoiding any worsening of the bone lesions and at enabling to get to the objectives imposed by the press-fit concept as:

- To achieve bone-implant contact as a surface, which means that it is necessary to evaluate the extent of the defects and the presence of any curvature of the femur to avoid a three-point contact of the implant.
- To ensure that the prosthesis is wedged perfectly into place, which depends mostly on the surgical technique but implies also a good evaluation of the geometry of the medullary canal.
- To avoid stiffening the femur. This objective depends on the design of the implant but also on the possibility to achieve proximal or short diaphyseal fixation, which depends on the morphotype, on the extent of the defects, on the quality of the cortical bone, and on the appearance of the medullary canal.

2 – Presence of difficulties
Plug > 4 cm even if the cortical bone is good
or thick cement or plug < 4 cm with fragile cortex +



If the cement is thick and well adhering to fragile cortical bone on both sides, the risk of a via falsa is significant. The same applies if the distal end of the stem is off-axis frontally or sagittally.

Pre-Operative Planning
Determining a surgical strategy

Determining a surgical strategy consists in an initial choice of an approach to the femur to overcome the various obstacles identified during the radiological analysis, without ignoring the objectives imposed by the press-fit concept. The area of the femur where primary stability of the implant will be achieved depends on this choice.

Femoral approach(es)

It is possible to opt either for the endofemoral approach or a femoral flap. This choice will depend on the quality of the cortical bone and, above all, on the presence or not of a curvature of the femur, knowing that varus deviations are frequent in the case of implant loosening.

NB: The difficulties to remove the cement influence that choice only when discussing which of the two approaches to the femur should be chosen.
Reminder: For the cortical bone, take granulomas into account but also the presence or not of stress-shielding or osteoporosis.

Fixation area(s) (bone-implant contact)

- If an endofemoral route has been chosen, fixation in the metaphyseal-diaphyseal area or in the proximal diaphyseal area will be targeted.
- If a femoral flap is carried out, fixation can only be diaphyseal, in the isthmus of the femur. Fixation may be a short or long diaphyseal fixation (bone-implant contact over a height of 4 to 5 cm or 5 to 8 cm respectively).

NB: The choice of the height of the bone-implant contact will depend on the geometry of the medullary canal; that is most frequently on the degree of osteoporosis (conical or cylindrical medullary canal). Short fixation should be selected whenever this is possible.

The various options

The combination of the four parameters used for the radiological analysis, together with their binary classification (curvature of the femur and difficulty of removing the cement) or their classification in four stages (bone defect and degree of osteoporosis) results in the identification of **6 main strategic options**:

Option 1 (endofemoral approach and proximal fixation) and **options 3 and 5** (femoral flap and diaphyseal fixation) are the fundamental options.

Options 2 and 4 are intermediate options, in which the choice between the endofemoral approach and a flap is open to discussion.

Option 6 is a special option and is only indicated for a small amount of patients. However, it is worthwhile to highlight it separately, as far as in this case the choice of a press-fit stem may be contraindicated.

Radiological analysis				Synthesis
Morpho-type	**Degree of osteoporosis**	**Defects**	**Cement**	**Strategy options**
Frontal plane (1) femur straight (1) Sagittal plane: femur straight or slightly curved	Stages (1) – Excellent (2) – Good (3) – Mediocre	Stage 1	No Yes	**Option 1.** Propitious situation: femur straight in the frontal plane and slightly curved in the sagittal plane. Absence of any bone defects or localized onto zones 1 and/or 7 (no defects onto zones 2 and/or 6). The only obstacle could be the possible difficulties in removing the cement: plug or thick layers adhering to fragile cortex (osteoporosis stage 3).
		Stage 2	No Yes	**Option 2. Intermediate** option characterized by a femur straight in the frontal plane with defects onto zones 2 and/or 6, often combined with defects onto zones 1 and/or 7, but no lesion onto zones 3 or 5. In that case, evaluate on one hand the difficulties in removing cement and on the other hand the extent of the defects onto zones 2 and/or 6.
		Stage 3	No Yes	**Option 3.** This situation is characterized by **defects + leading to a weakening of one or both cortexes** with in any case lesions of the cortex onto zone 3 and/or 5. It is often a granuloma but also can be a stress-shielding or something similar (cemented prosthesis and osteoporotic femur) or seldom a mechanical wear (abrasion of the cortex due to an abnormal mobility of the couple prosthesis/cement).
		Stage 4	No Yes	
Frontal or sagittal plane (2) femur curved (2) Overall curvature (pronounced diaphyseal curvature)	Stages (1) – Excellent (2) – Good (3) – Mediocre	Stage 1	No Yes	**Option 4. Intermediate option** which apply only to slight curvatures in the frontal plane. In that case, evaluate the difficulties in removing the cement: plug or thick layers adhering to fragile cortex (osteoporosis stage 3). **If the curvature in the frontal plane is pronounced, carry out a femoral flap** in any situation.
		Stage 2	No Yes	**Option 5.** This situation is characterized by a **curvature of the femur in both planes, frontal and sagittal, always combined with an other obstacle** which is in the best case defects stage 2 only but it can be also an osteoporosis stage 3 and/or difficulties in removing the cement. **NB:** A curvature in the frontal plane has always to be considered, whatever its extent is. In the sagittal plane, only pronounced curvatures has to be considered (overall curvature) with a femur straight in the frontal plane.
		Stage 3	No Yes	
		Stage 4	No Yes	
Femur straight or curved	Stade 4 Bad	Stages 1 to 4	Yes or No	**Option 6.** Particular situation characterized by an **advanced osteoporosis** (stage 4) with very thin cortex and large cylindrical medullary canal. In that case, the placement of a press-fit stem should be discussed thoroughly as risks associated with stress-shielding are high if a long, large diameter implant is placed.

Strategy: Femoral access route, fixation type(s) and implants

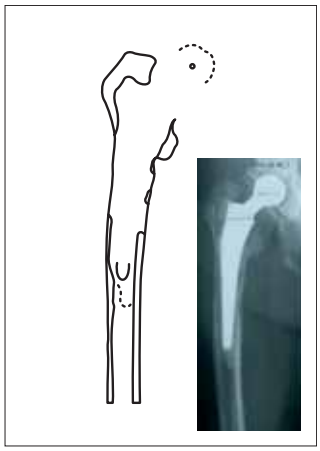
Femoral access route	Fixations type(s) and implants
Endofemoral approach with, if necessary, a **window** to remove the distal cement. (Widely open the greater trochanter laterally and posteriorily). If the greater trochanter is fragile due to granulomas, it is recommended to carry out a **trochanterotomy** preserving the insertions of the M. vastus lateralis (digastric trochanterotomy).	**Proximal fixation:** Bone/Implant contact in the **metaphyseal-diaphyseal** zone, over a height of 2 to 3 cm. Avoid a too tight diaphyseal fixation, particularly in presence of osteoporosis and add if necessary bone in the medullary canal. In the proximal fixation is not guaranteed, aim to get also a short diaphyseal fixation (more or less global fixation). **Implants: Short** distal component L. 120 or 140 mm and spout proximal component. It is not recommended to place a 200 mm long distal component in that case.
2 Possible choices according to the presence or not of difficulties in removing the cement. **– Endofemoral approach:** the fixation mode depends on the extent of the defects if no difficulties in removing the cement are present: **proximal fixation** if the defects are of a lesser importance onto zones 2 and/or 6 (give advantage to that option in case of osteoporosis +/–) or **diaphyseal fixation** if major defects onto zone 2 and/or 6 (possible option if no osteoporosis). Refer to option 1. **– Femoral flap:** with difficulties in removing the cement select always a diaphyseal fixation according to the modalities varying as a function of the stage of osteoporosis. Refer to option 3.	
Femoral flap, in any case to avoid an aggravation of the bone lesions and to remove the cement. It is a semi-circular lateral flap and generally it is not necessary to combine it with a osteotomy of the medial cortex as the femur is straight in the frontal plane and slightly curved in the sagittal plane.	A femoral flap is necessarily associated with a **diaphyseal fixation.** **– Short fixation,** with a bone/implant contact of 4 to 5 cm if the cortex is good and the medullary canal more or less conical. In that case, use a 140 mm distal component generally combined with a cylindrical proximal component, particularly if the height is > 7.5 cm or the femur is narrow. **– Long fixation**, with a bone/implant contact of 5 to 8 cm if the medullary canal is cylindrical or according to the morphotype (tall patient). In that case use a 200 mm distal component generally combined with a cylindrical proximal component (it is very seldom to use a 260 mm distal component).
2 Possible choices according to the presence or not of difficulties in removing the cement. **– Endofemoral approach:** if no difficulties in removing the cement aim to a **proximal fixation.** Refer to option 1. **– Femoral flap:** if difficulties in removing the cement select always a **diaphyseal fixation.** Refer to option 5. **NB:** Presence of a cement plug and if a proximal fixation is considered (osteoporose): an endofemoral approach with a femoral window can be chosen. In that case, a trochanterotomy can also be an alternative to the femoral flap.	
Femoral flap in any case, as at least 2 obstacles are combined for the placement of a straight press-fit stem and one has to consider a curvature in the frontal plane, even the slightest one. Carrying out a flap avoids a varized placement with a three-point contact in the frontal plane (which is always an issue with straight stems) and eases removing the cement if the cortex is fragile + + due to granulomas or osteoporosis. In that situation combine the lateral flap with an ostotomy of the medial cortex, either to improve the bone/implant contact (if strong varization), or to avoid a three-point contact in the sagittal plane (if pronounced curvature in the sagittal plane), particularly with long stems. **NB:** in the case of a curvature in the sagittal plane (pronounced sagittal curvature) carry out first the lateral flap and if necessary proceed with the osteotomy of the medial cortex keeping in mind that this osteotomy is not always necessary using a short stem.	A femoral flap is necessarily associated with a **diaphyseal fixation.** **– Short fixation,** with a bone/implant contact of 4 to 5 cm if the cortex is good and the medullary canal more or less conical. In that case, use a 140 mm distal component generally combined with a cylindrical proximal component, particularly if the height is > 7.5 cm or the femur is narrow. **– Long fixation**, with a bone/implant contact of 5 to 8 cm if the medullary canal is cylindrical or according to the morphotype (tall patient). In that case use a 200 mm distal component generally combined with a cylindrical proximal component (it is very seldom to use a 260 mm distal component).
The **exeter** or **double mantel**, described by **M. Kerboul, MD**, are both possible options. In certain cases, one may place a press-fit stem but aim in any case to a proximal fixation and avoid diaphyseal fixation. The femoral access route has to be an endofemoral approach or a trochanterotomy and add bone in the medullary canal.	

Pre-Operative Planning
Making a pre-operative template

When a flap is indicated, the template may be prepared in the following 5 successive steps:

1. Tracing the contours of the femur

Trace the contours of the femur, highlighting the zones of defects, the distal end of the loosened implant and the cement plug, if any.
Mark the centre of rotation of the loosened prosthesis.

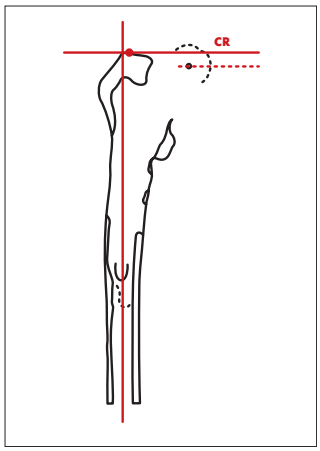


The template should be made on an anterior-posterior X ray showing the femur over a sufficient length to avoid any off-axis errors (about 15 to 20 cm below the distal tip of the loosened implant).

Reminder: If the femur is straight in the frontal plane, a curvature in the sagittal plane has to be considered only if it is pronounced.

2. Trace the axes of the femur

Medullary axis: carefully centre the template of a long stem (200 or 260 mm long distal component) in the diaphyseal region, trace the centro-medullary axis and estimate its position at the level of the proximal femur, at the height of the lesser trochanter and in relation to the tip of the greater trochanter.
Axis of the centre of rotation: trace a line perpendicular to the centro-medullary axis at the height of the summit of the greater trochanter. In principle, the centre of articular rotation of the revision implant should lie on that axis.



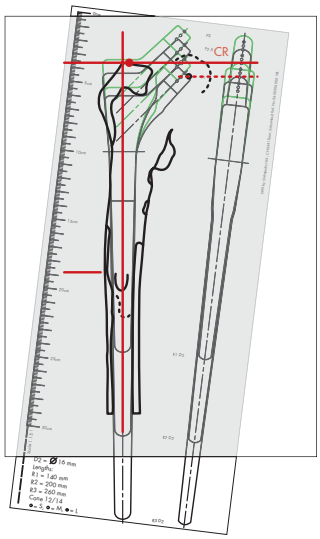
This is an important step of the preparation of the template, since it enables to evaluate the extent of a curvature, if any. The curvature is often more appearant on the templates as on x-rays.

Reminder: varus deviations of the femur are frequent in cases of implant loosening.

It is now possible to determine any length discrepancy to be corrected. However, it is only an indicative value, as far as during revision surgery, respecting the conventional references to determine the length of the lower limb (degree of subsidence of the prosthesis) is not an absolute rule.

3. Determine the length of the flap

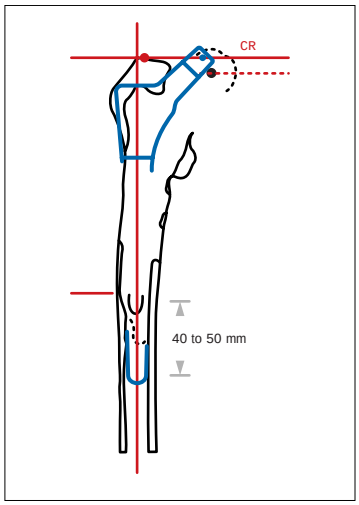
Position a template on the centro-medullary axis, so that the summit of the greater trochanter coincides with the centre of rotation of the revision stem (choose a medium-sized proximal component).
Determine the length of the flap, which has to overcome the obstacles (femoral curvature) and respect the isthmus of the femur at the same time.
Trace the distal end of the flap.



The average length of the flap is 15 cm +/– 2 cm and it should always respect the isthmus of the femur.
Avoid making the flap too long with the only aim to remove an extensive cement plug.
It is possible to make a shorter flap (10 to 12 cm) in the case of dysplastic femur or short patients.

4. Choose the implant length.

This involves determining the height of the bone-implant contact area.
Whenever possible, a short distal component (140 mm) should be selected, preferably with a bone-implant contact over a length of 40 to 50 mm.
Trace the contours of the proximal component (in particular the shoulder of the implant, and the centre of rotation) as well as the distal end of the possible distal component.

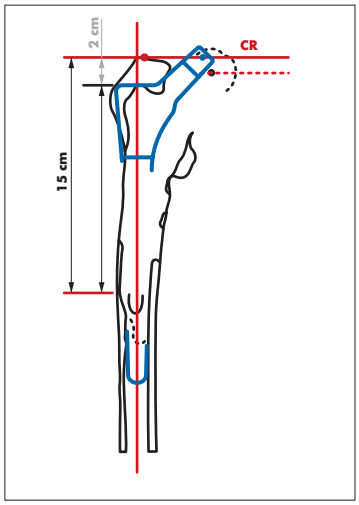


Generally, it is possible to determine the length of the distal component. However, the other references provided by the template (height of the proximal component and diameter of the distal component) are indicative only and very often, the choices made intra-operatively differs from the selected component during the pre-operative planning.

5. Verify the length of the flap and the depth of penetration of the implant.

Determining the length of the flap requires to measure the distance between the summit of the greater trochanter and the distal end of the flap.
The depth of penetration of the stem is calculated, starting from the distal end of the flap, considering the shoulder of the implant in situ as reference.
As far as the distance between the centre of rotation and the shoulder of the implant in situ is about 20 mm and the length of the flap is known, it is possible to determine whether the implant is in the correct position or not. The distance between the shoulder of the revision stem and the distal end of the flap must be equal to the length of the flap – 20 mm.

NB: The distance between the centre of rotation and the shoulder of the implant is only 10 mm in the proximal component of height 55 mm.



This is a particularly important reference point to consider, as far as during surgery, with the reclined flap, the summit of the greater trochanter can no longer be used as reference to evaluate the depth of penetration of the implant. Only the distal end of the flap can serve as reference to evaluate the position of the revision stem.

The depth of penetration calculated on the basis of the template is indicative only and the final choice is always made during surgery, after completing several trial reductions.

NB: When there is significant shortening, it is often preferable to avoid restoring exact leg length of the two lower limbs.

Conclusions

Making a template is simple if the necessary documentation is available, in particular an X ray on the frontal plane with sufficient length of the femur. Very often it enables identification of a slight frontal curvature that might otherwise easily remain unnoticed until the centro-medullary axis has been traced. Lastly, the length of the flap is the only dimension that the surgeon must always keep in mind during surgery and the final size of the implant is always determined intra-operatively.

Surgical Technique

General considerations.

- **Prudence and perseverance are essential while gaining experience.** Any surgeon using a new implant will inevitably require a learning phase, regardless of the prosthesis that is selected.
- **Any concept implies its own specific surgical technique.** The surgeon must familiarise himself with the imperatives of a concept before putting it into practice.
- **Any technical error often results in immediate failure.** When the use of a cementless implant has been decided, the surgical technique has to be followed rigorously.
- **The 2 main aims to be achieved are sparing the existing bone stock and ensuring perfect primary stability of the implant.**
  Sparing the existing bone stock depends, first and foremost, on the choice of the approach to the femur, and we feel that it is never good to change strategy during the course of the surgery.
  To ensure primary stability through the press-fit concept, it is always advisable to comply with the principles defined by **Morscher,** that is, to obtain bone-implant contact as a surface and to ensure that the prosthesis is wedged firmly into place without making the femur too stiff.

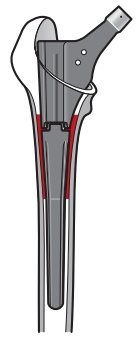
The surgical technique will vary depending on the selected approach to the femur: a femoral flap (option 1) or the endofemoral approach (option 2). Before, describing these two techniques, however, a few general comments should be made. These considerations are: **rational use of the various implants and practical application of the press-fit concept, or how to prepare a bone-implant contact surface, and ensure that the prosthesis is wedged properly into place.**
NB: The two surgical techniques are presented in such a way that they can be used separately, which explains certain repetitions.

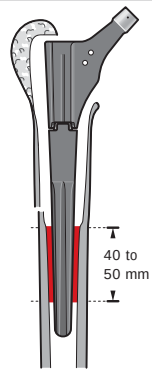
Surgical technique

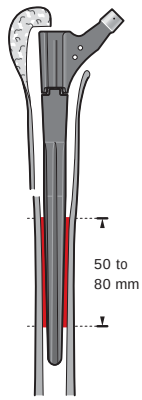
Surgical Technique
Rational use of the implants

As a general rule, avoid combining high proximal components (95 or 105 mm) with short distal components (length 120 or 140 mm). When a high proximal component is required, it is preferable to choose a "cylindrical" component. The 260 mm distal component is very rarely used.

Length of the distal component	Height of proximal component Total length	
120 mm	55 ▸ 175 mm 65 ▸ 185 mm 75 ▸ 195 mm 85 ▸ 205 mm	**Endofemoral approach and fixation in the metaphyseal-diaphyseal region** In this case, the "working" part of the distal component is the proximal conical area (height 45 mm). Choose a proximal component, which will usually be of the "spout" type, although it is also possible to use a "cylindrical" component.
	95 ▸ 215 mm 105 ▸ 225 mm	It is frequently preferable to choose a 140 mm distal component with a shorter proximal component.
140 mm	55 ▸ 195 mm 65 ▸ 205 mm 75 ▸ 215 mm 85 ▸ 225 mm 95 ▸ 235 mm	**Short diaphyseal fixation by the endofemoral approach or after a femoral flap** In this case, the "working" part of the distal component is the distal conical area (height 100 mm). Choose a "spout" or "cylindrical" proximal component. This implant can also be used for a proximal fixation through an endofemoral approach, in particular when a femoral window must be bridged.
	105 ▸ 245 mm	Avoid, if possible, and prefer a 200 mm distal component
200 mm	55 ▸ 255 mm 65 ▸ 265 mm 75 ▸ 275 mm 85 ▸ 285 mm 95 ▸ 295 mm 105 ▸ 305 mm	**Long diaphyseal fixation with femoral flap** In this case, the "working" part of the distal component is the conical area (120 mm high), remembering that the 200 mm components always have an intermediate cylindrical area that is not adapted for wedging. If a high component is necessary, chose a proximal component of the "cylindrical" type.
		Reminder: The 260 mm distal components are used very rarely, and mostly for treating complications with multiple bone lesions. In these cases, they are used as a medullary nail.







Surgical Technique
Preparing a bone-implant contact surface

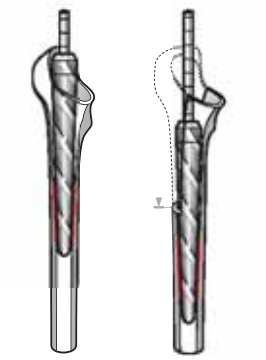
To obtain a bone-implant contact as a surface is the major objective to achieve when the choice of a press-fit concept was made to ensure the primary stability of an uncemented implant. This preparation performed with reamers or rasps depends on the area of the femur where the primary stability will take place.

Preparation of the femur with the reamers

If diaphyseal fixation is required, the femur is prepared with the reamers, which have the role of giving the medullary canal a conical shape. To obtain bone-implant contact as a surface with the reamers, three rules have to be complied with:

Stay close to the fixation area

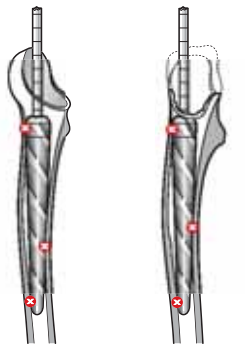
If the press-fit area can be in the proximal diaphyseal area, preparation through the endofemoral approach is possible.
If the press-fit area has to be in the isthmus of the femur, it is often preferable to carry out a femoral flap.



It is difficult to prepare a contact surface remaining at a certain distance from this area. Attempting to ream a femur in the isthmus through the endofemoral approach is often risky!

Ream a straight segment of the femur

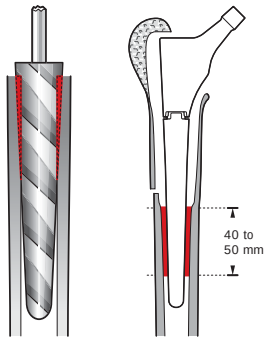
The role of the reamers is to give the medullary canal a conical shape, and they are only effective if there is a certainty of working on a straight segment of the femur.



The reamers are not able to make a femur straight if it is curved!

Ream a short segment of the femur

It is easier to make a segment of the femur “conical” if the height of this area is not too large.
Warning! The references provided by the reamer (diameter and length) are only indicative for the choice of the definitive implant, which must always be done with a test prosthesis.



It would be an illusion to believe that a medullary canal can be made conical over a height of 8 to 10 cm!

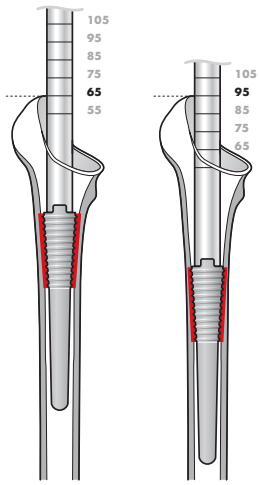
Surgical Technique
Preparing the femur with the rasps

It is only possible to prepare a bone-implant contact surface with the rasps if an endofemoral approach is chosen and the primary stability area is situated in the metaphyseal-diaphyseal area of the femur (in revision procedures it is rarely possible to achieve fixation in the metaphyseal area).

In this case, **take advantage of the modularity of the rasp** to perform a two stage preparation of the medullary canal.

Preparation of the metaphyseal-diaphyseal area (bone-implant contact area)
In a first stage, “find” the area of primary stability using the distal part of the rasp. Impact it with the means of the cylindrical graduated impactor, which will also allow then to determine the height of the proximal component used in the second stage.

Reminder: It is suggested to use the distal rasp of length 120 mm but it is also possible to use the rasp of length 140 mm. The distal components of length 200 mm should not be employed in such a case.



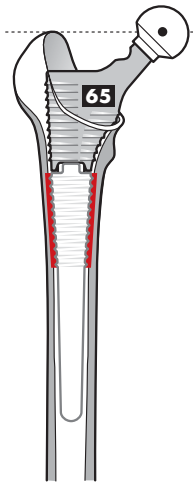
In revision procedures, the position of the area of primary stability is always difficult to determine beforehand. A modular rasp enables a selective preparation of the bone-implant contact surface.

Preparation of the metaphyseal area (selection of the implant)

- Assemble the two components of the rasp: the distal part used in the first stage with the proximal part which sizes has been determined in the previous stage.

  NB: For this operative step, the spout proximal rasp should be the first choice but the cylindrical proximal part may also be used.

- Impact the assembled rasp and when its depth of penetration corresponds to the one achieved in the first stage, a perfect bone-implant contact in the metaphyseal-diaphyseal area is guaranteed.



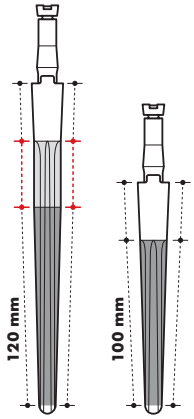
An assembled rasp can remain stucked in the higher metaphyseal area. In this case, there is no longer a surface contact but only local point contacts, which are often insufficient to guarantee the primary stability.

Surgical Technique
Ensuring that the implant wedges into place

This is a delicate phase of the surgery. In addition to the necessity of an exact perception of the area where the implant will be wedged into place, it is necessary to comply with three rules in order to ensure good fixation:

Use the conical part of the implant

For stems of the same length the conical area is situated distally with a constant height.
The height of the conical area is 120 mm for a 200 mm distal component and about 100 mm for a 140 mm distal component.



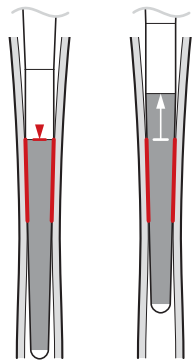
This feature, which is common to all conical stems, means that a long stem has always a cylindrical area that is not suitable for the wedging of the stem. Contrarily, short stems (diameter 14 to 18 mm) are conical over the whole length which is a good reason to prefer this type of implant each time it is possible.
Reminder: For the stem of length 120 mm, only the proximal conical area of a height of about 45 mm, will serve to wedge the implant into place.

Keep some conical anchorage area in reserve

Keeping some reserve of the conical anchorage area means ensuring that the implant is wedged into place (bone-implant contact) with the distal part of the conical area of the implant.

Why should some conical anchorage area be kept in reserve?

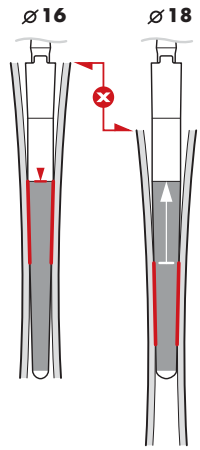
If the implant is wedged into place using the proximal part of the conical area, there will be a risk of instability following the least secondary subsidence of the implant.
NB: When a stem of length 200 or 260 mm is chosen, the fixation area relocates at the cylindrical area, which is not suited for a re-wedging of the implant.
On the contrary, if there is some reserve of the conical anchorage area, re-wedging is possible, and the quality of the wedging will be even better.



The notion of a reserve of the conical anchorage area must be considered when the preparation of the femur is done with the reamers (diaphyseal fixation).
It is difficult to know if there is a reserve of the conical anchorage area or not, if there is no precise knowledge of the area of the femur where the wedging takes place.
This is a good reason for the realisation of a femoral flap as soon as the fixation is intended to be in the isthmus of the femur.

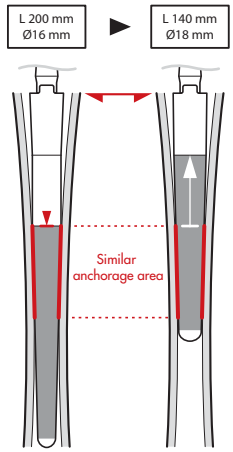
How can some conical anchorage area be kept in reserve, if this has not been achieved?

- To keep some reserve of the conical anchorage area, it is necessary to increase the diameter of the implant without increasing the diameter of the medullary canal.



If a monobloc stem has been selected, the consequence of this choice can be, however, a lengthening of the leg and this might cause a difference in length between the 2 lower limbs.
A modular system offers a real advantage to overcome that drawback.

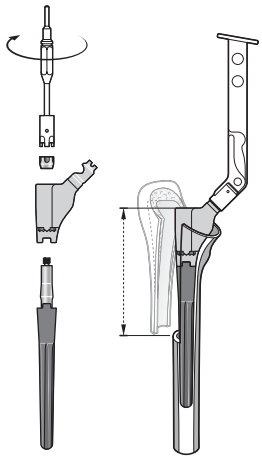
- With a modular system it is easy to increase the diameter of an implant (keeping some reserve of the conical area) without inducing a difference in length of the 2 lower limbs.
  The surgeon has two options:
  If a short stem is selected (length 140 mm), increase its diameter and adjust the length of the lower limb using one of the proximal components with different height.
  If a longer stem is selected (length 200 mm), replace it in most cases with a stem of a larger diameter (+ 2 mm) and shorter in length (length 140 mm).
  NB: These 2 implants have then **a similar anchorage area**, which lies distally for the short stem, thus providing some reserve of the conical anchorage area and as far as the distal component is shorter, the equal length of both lower limbs is conserved or easily adjusted with one of the proximal components.



The size of the definitive implant must not be determined with the reamers but with the test prostheses. Furthermore, to choose a stem providing some reserve of the conical anchorage area without risking a leg length inequality, the test prosthesis must also be modular.
A modular system makes the choice of a shorter stem easier, which is always preferable.

Completing an implant placement in two stages

The test prosthesis and the definitive implant do not always wedge into place at the same height!
Implanting the prosthesis in two stages using a proximal trial part makes possible to choose then the height of the proximal component after having placed the definitive distal component.



Placing an uncemented stem with sharp longitudinal ribs jeopardises the stable wedging if one tempts to equalize the length of the 2 lower limbs!

Summary:
Ensuring good wedging means ensuring the primary stability of the implant.
An effective press-fit does not depend on the height of the bone-implant contact surface but on how well the implant is wedged into place.
This is a difficult stage of the surgery if no modular system is available when choosing the implant and during the placement of the definitive implant.

Surgical Technique
Option 1: Femoral flap

During revision surgery, carrying out a femorotomy with a femoral flap, is a good way to avoid incidents during the surgery and to ensure a perfect primary stability, which, in this case, is always in the diaphyseal region.

Main objectives

Both of the two articular approaches, anterolateral or posterolateral may be completed. However it is suggested to prefer the posterolateral access route if a lateral flap is planned.

In all cases, carry out a pedunculated femoral flap with the M. vastus lateralis, combined if necessary with an osteotomy of the medial cortex during the course or at the end of the surgery.

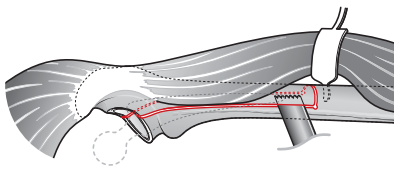
When selecting the prosthesis: take full advantage of the modularity of the test prosthesis and, whenever it is possible, place a short stem with a bone-implant contact over a height of 4 to 5 cm.

The definitive implant is placed in two stages. Assembly of the proximal component is carried out in situ, after having placed the definitive distal component.

Resecting the femoral flap

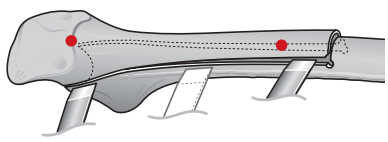
Cut a pedunculated femoral flap of an average length of 15 ±2 cm.
To preserve the isthmus of the femur where primary stability should be achieved, avoid to cut a too narrow flap in the diaphyseal area or a too long flap with the only objective to remove a cement plug. The femoral flap can be carried out in two different ways:

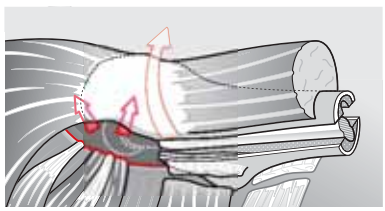
After having luxated the prosthesis and removed the implant. Carry out osteotomies of the cortical bone using the oscillating saw, from the lateral cortex towards the medial cortex, through the medullary canal, after having cut the distal end of the flap.



This is an attractive technique; however, it is preferable to avoid it if the hip has become very stiff and the cortical bone is fragile (risk of a fracture during luxation).

Prostheses not luxated and implant in place. The posterior and distal cuts of the osteoromy will be carried out with the oscillating saw and the anterior part with a bone chisel, guided underneath the M. vastus lateralis.
Before making any attempt to lift the flap, it is necessary to free it from its attachment points: cement in the distal and proximal areas (greater trochanter), incomplete osteotomies (anterior or angled distal cut), adhesions at the level of the articular cavity (inner surface of the M. glutei).



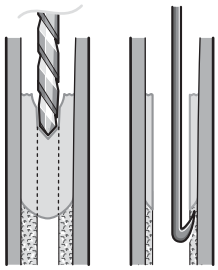


An incomplete anterior osteotomy is often the source of difficulties when lifting the flap.
In this case, and after freeing the articular cavity, it is possible to lever and tilt the flap to proceed with the anterior cut, which is usually placed at the right «place» if the anterior osteotomy has been properly initiated at both ends.

Removing a cement plug

In a first step, drill a hole in the plug with the 6 mm drill bit, after making sure that the latter is correctly centred.

In a second step, after having verified that there is no via falsa, enlarge the opening to about 11 mm, so as to pass a wide cement extraction curette through it.



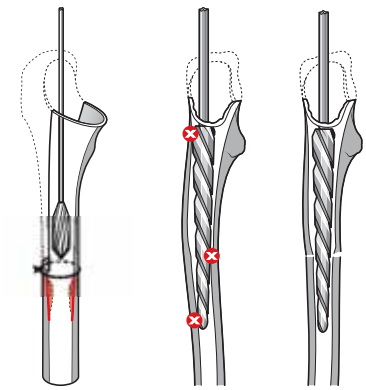
Before removing the cement, ensure a perfect exteriorisation of the proximal femur, freeing it from its fibrous and capsular attachments.

Remove the cement plug after removing all the proximal and intermediate lying cement.

Calibrate the femur and verify the lateral axis

In a first step, use the cylindrical reamers to eliminate any narrowing at the end of the prosthesis and calibrate the medullary canal.

Then, verify whether the sagittal curvature (anterior cortical bone) is an obstacle preventing progress of the reamer along the axis of the diaphysis. To do this, use a long conical reamer with a diameter smaller than the inside diameter of the medullary canal.



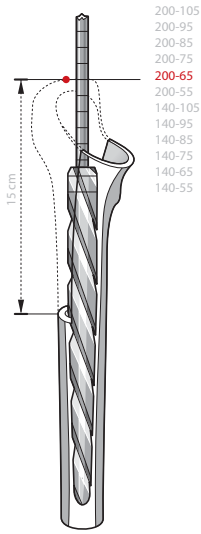
There is no necessity in attempting to increase the diameter of the medullary canal unless it is narrow (reaming to 12 or 13 mm is the minimum required).

If the anterior cortical bone is an obstacle, it is preferable at this stage of the surgery to carry out an osteotomy of the medial cortical bone, particularly if it is fragile.

Reaming the femur (making the medullary canal conical)

Increase the diameter of the reamers progressively and evaluate the depth of penetration by aligning the mark on the handle with the line passing from the summit of the greater trochanter to the centre of rotation of the implant.

Example opposite: for a 15 cm long flap, the summit of the greater trochanter will correspond to the mark **2/65**. This reference corresponds to an implant of the same diameter as the reamer in place and 265 mm long, i. e. a 200 mm long distal component (the digit 2) coupled with a 65 mm high proximal component.



To calculate the depth of penetration with the help of a sterile ruler, the summit of the greater trochanter is positioned at a distance corresponding to the length of the flap from the distal end of the flap.

Avoid being in a situation where a 260 mm distal component is necessary (tip of the greater trochanter in sector 3). In this case, increase the diameter of the reamers to end up within the sector 2, corresponding to a 200 mm distal component.
Remember that the references provided by the reamers are simply indicative for the determination of the definitive implant.

Selecting the distal component

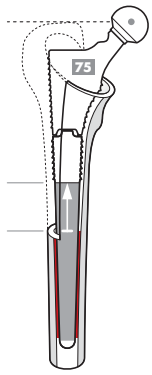
Warning! In practice, the distal component (which ensures primary stability) and the height of the proximal component (which restores the length of the lower limb) are selected simultaneously, during the course of the surgery. However, in order to clarify the explanations, these two stages of the surgery will be described separately below.

Assemble the two parts of the test prosthesis corresponding to the references provided by the reamer and impact them gently into place by applying light hammer blows. After impacting them, evaluate and compare the position of the conical area of the implant with the anchoring area (bone-implant contact area). The surgeon may be confronted to the following two situations:

There is some reserve of the conical anchorage area

In this case, primary stability is ensured with the distal part of the conical area of the implant. The proximal line limiting the working conical area of the stem in place is situated clearly (4 to 5 cm) above the distal end of the flap.

Reminder: When primary stability is achieved in the isthmus of the femur, cutting a flap makes this verification easier.

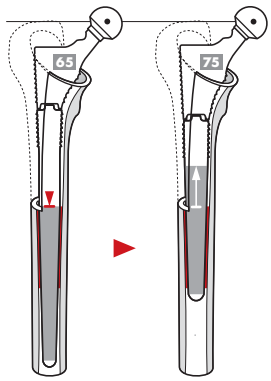


If the endofemoral access route has been selected, it is very difficult, if not impossible, to evaluate and compare the position of the conical area of the implant with the anchoring area in the femur, if the latter is in the isthmus.

The necessity to evaluate properly the position of the conical area of the implant is a good reason for not making a flap too short!

There is no reserve of the conical anchorage area

In this case, primary stability is ensured by the proximal part of the conical area. The proximal line limiting the working conical area of the stem is situated at the height of or below the distal end of the flap.
If the distal component is 200 mm long, it will be necessary to replace it with a 140 mm distal component with a larger diameter of +2 mm, without additional reaming.
If the distal component is 140 mm long, all that has to be done is to increase the diameter of the implant.



Reminder: To restore some reserve of the conical anchorage area, it is necessary to increase the diameter of the implant without increasing the diameter of the medullary canal.
Replacing a 200 mm stem (with no reserve of conical anchorage area) with a shorter, larger diameter stem, is a situation that the surgeon will be confronted to occasionally (these two implants have a similar anchoring area).

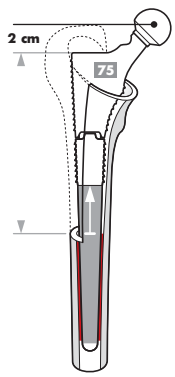
Selecting the proximal component

At this stage of the surgery it is necessary to determine the height of the proximal component, avoiding the selection of an extreme proximal component (55 or 105 mm) so as to have some reserve when placing the definitive implant.

Warning! During revision procedures, respecting the usual reference points (summit of the greater trochanter – centre of rotation with a ball head, neck size M) in order to calculate the correct length of the lower limb is not an absolute rule. It is always advisable to carry out several trials before making the final choice. The surgeon may be confronted with any of the three following situations:

The correct choice has been made

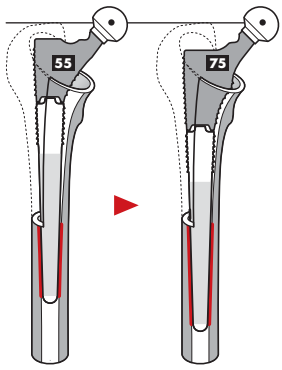
The length of the lower limb has been restored using one of the average-sized proximal components and the reduction can be carried out without any difficulty.
NB: To calculate the depth of penetration, measure the distance between the shoulder of the test prosthesis and the distal end of the flap (this distance corresponds to the length of the flap –2 cm, or –1 cm for the proximal component of size 55).



This situation may occur when the hip is still sufficiently lissom and when the shortening of the lower limb is not particularly significant.

Proximal component 55 (small)

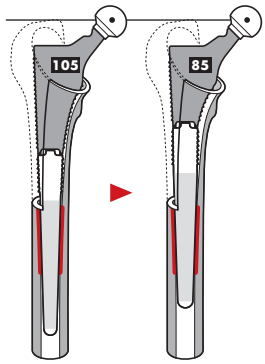
It will be necessary to choose a higher proximal component (65 or 75). In most cases, additional reaming will be carried out in order to increase the depth of penetration of the distal component, which can be achieved without any risks if there is a sufficient reserve of the conical anchorage area.
NB: If it is also necessary to increase the height of the proximal component and simultaneously decrease the length of the lower limb in relation to the usual reference points (difficult reduction due to stiffness of the joint), one may decrease the diameter of the distal component.



If a 140 mm long distal component has been selected, it is possible to decrease its diameter without running into any risks, since this implant has a conical proximal area that can take over the function of the distal conical area in the event of significant subsidence.
The same cannot be said of the 200 mm long distal components, as these have a cylindrical intermediate area that is not suited for the wedging effect.

Proximal component size 105 (high)

It will be necessary to decrease the degree of penetration of the distal component to be able to use a lower proximal component.
If the distal component is 140 mm long, it will be necessary to increase its diameter without changing its height. The same applies to the 200 mm long component. In both cases, additional reaming is not always necessary.



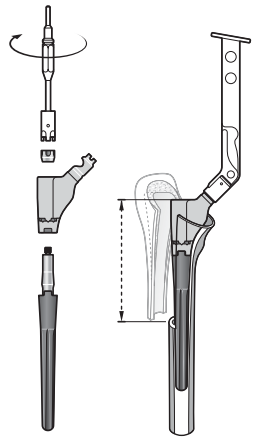
If the distal component is 200 mm long, it is frequently preferable to shorten its length while increasing its diameter, if necessary by +4 mm. In this case, additional reaming may be necessary.

Placing the definitive implant into place in two stages

The definitive implant is placed in two stages using a proximal trial part provided for this purpose and can only be carried out if a femoral flap has been cut.

Distal component

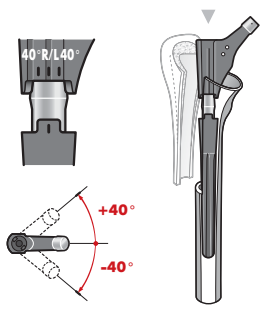
After having assembled the proximal trial part to the definitive distal component, impact the definitive distal component.
Carry out a trial reduction in order to determine the height of the definitive proximal component and verify the orientation that is necessary for the proximal component (antetorsion).



Depending on the quality of the cortical bone, a difference in penetration of ±5 mm compared to the test prosthesis is frequent (penetration of the fins into osteoporotic cortical bone may cause a difference of 10 mm or more).

Proximal component

Rinse carefully the morse taper, position the proximal component by hand with the required antetorsion. Tighten the assembly with the torque wrench and screw in the conical nut. Carry out the reduction and select the neck length of the ball head.



It is recommended to hold the handle of the stem tensioner very firmly while assembling the proximal component.

NB: See the appendix 1 for the assembly technique.

Important:
When assembling the proximal with distal implant component you **must not** apply hammer-blows. It is vital to follow the assembly procedure.

Incidents

1) Crack in the diaphyseal femur

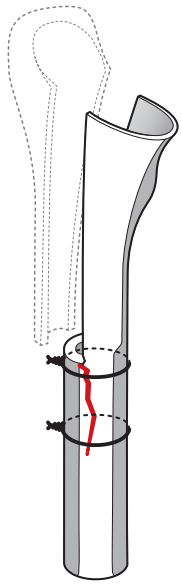
A crack may happen at the height of one of the two edges of the distal end of the flap if the latter has not been marked by two drilled holes.

2) Implant is too high

This may happen if the surgical protocol has not been complied with at the time of selecting the implant.

3) Movement of the implant at the time of assembly

This incident happens if the stem tensioner is not held firmly when assembling the proximal component.



1) Retrieve the implant from its seat, reduce the crack with one or more cerclages of the femur then proceed by impacting the implant back into place, constantly verifying that the crack is reduced.

2) Disassemble the proximal component and take a lower component, or remove the implant from its seat and carry out additional reaming.

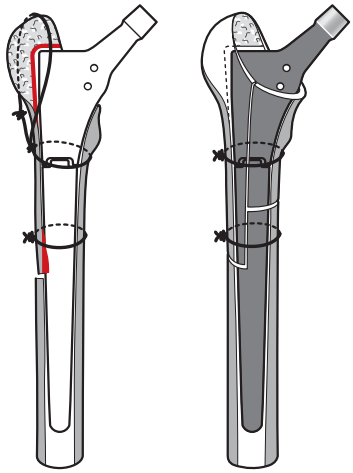
3) Remove the implant from its seat, correct its orientation and then wedge it back into place.

Putting the flap back into place

If the femur is straight in the frontal plane and slightly curved in the sagittal plane, a good preparation of the endomedullary surface of the flap is sufficient to reduce the gaps.
If the femur is curved, it is often necessary to carry out an osteotomy of the medial cortex in order to restore bone-implant contact.

Osteosynthesis of the flap is completed with two cerclages or more if required. If the greater trochanter has become fragile, use the proximal cerclage to carry out an additional mounting in the form of a lateral brace.

Bone defects or gaps of the flap may be ignored if they are not very significant. If they are more extensive it is suggested to add bone in the form of autologous cortico-cancellous bone grafts.



When putting the flap back into place, the obstacles, preventing a good contact at the level of the osteotomy cuts, are often located at the height of the greater trochanter (corticalisation of the cancellous bone) and at the distal end of the flap (endomedullary ossification).

Surgical Technique
Option 2: Endofemoral approach

This option is not the most frequently used. However, it should be chosen if possible whenever the femur is straight in the frontal plane and not excessively curved in the sagittal plane. In this situation, the objective is to achieve fixation in the metaphyseal-diaphyseal region or in the proximal diaphyseal area.

Main Objectives

Ensure a good exteriorisation of the femur. It is not possible to prepare the medullar cavity properly if the femur remains attached deep in the articular cavity.

Open the greater trochanter widely to be sure of being in the axis of the femoral diaphysis and avoiding placing the implant in a varus position.

The cement must always be removed completely. A perfect view of the medullary canal is required for this stage of the surgery, and a femorotomy as a femoral window may be indicated.

At the time of selecting the implant: the objective must be to ensure fixation in the metaphyseal-diaphyseal area of the femur. If this is not possible, try to achieve a short diaphyseal fixation. In any case, use a 120 or 140 mm long distal component.

NB: It is never recommended to implant a 200 mm long distal component if the endofemoral approach has been selected.

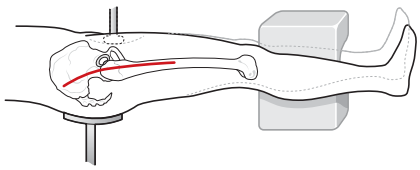
The definitive stem is placed in a single stage, after assembling the two components of the prosthesis outside of the femur.

Articular approach(es)

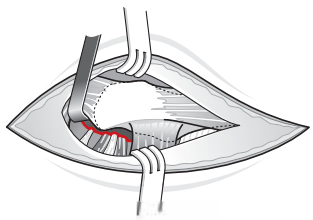
Postero-lateral approach

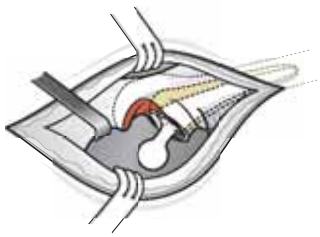
Place the patient in the lateral decubitus position.
Make a skin incision centred on the greater trochanter and curved slightly backwards at the level of the pelvis.
Make an incision in the fascia lata and the M. gluteus maximum along the muscular fibres.

Identify and retract the posterior edge of the M. gluteus medius before carrying out a posterior capsulotomy, resecting the pyramidal, obturator and gemellus tendons at the level of the bone.
Free the proximal femur in order to ensure a perfect exteriorisation of the femur.



Immobilise the pelvis posteriorily with a sacral support and anteriorily with a pubic support, making sure that the femoral blood vessels are not compressed. Keep the lower limb in an horizontal position with a pad that can be easily removed.



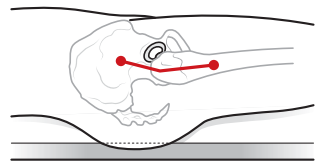


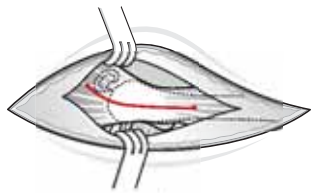
It may be necessary to cut through the crural square and the aponeurotic extension of the M. gluteus maximus.
Before explanting the implant it is often necessary to open the greater trochanter.

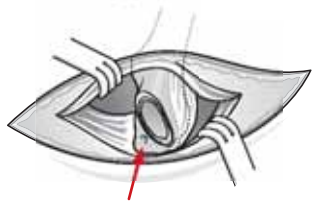
Antero-lateral approach

Place the patient in the dorsal decubitus position.
Make a skin incision centred on the greater trochanter, slightly angled upwards and forwards at the level of the pelvis.

Transgluteal incision and incision of the M. vastus lateralis in the digastric area.
After removing the prosthesis, free the proximal femur by resecting the pyramidal tendon and the posterior capsule at the level of the bone to ensure good exteriorisation of the femur.







Immobilise the pelvis with a wedge resting against the counter-lateral hip. The hip to be operated must protrude slightly from the operating table.

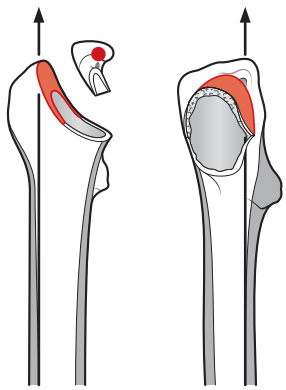
Avoid making the transgluteal incision too far forward to respect the anatomical continuity between the M. gluteus medius and the M. vastus lateralis.
Remember that the point of penetration of the instruments is at the height of the trochanteric fossa.

Femoral approach(es)

Opening the greater trochanter

If the endofemoral approach is selected, a **wide lateral and posterior opening** in the greater trochanter will be necessary.

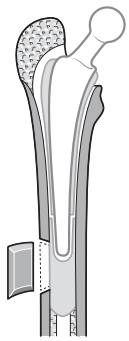
This stage of the surgery is completed with the aid of the forceps and hollow chisel as the bone is frequently corticalised and sclerotic on this part of the femur.



Complete the opening of the greater trochanter with the aid of a conical reamer when preparing the medullary canal (see “Preparation of the femur and the correct choice of implant”).

Femoral window

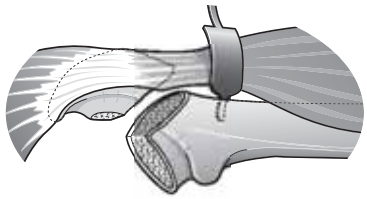
If the endofemoral approach has been selected, a femoral window may be indicated in order to remove a cement plug.
The window may be either lateral or antero-lateral and if the cortical bone is thick, it will be made in the form of a wedge, which will make it easier to put it back into place without osteosynthesis.



A femoral window enables good centring of the instruments used to extract a cement plug (see below).

Trochanterotomy

It is suggested to carry out a digastric trochanterotomy preserving the insertions of the M. vastus lateralis.

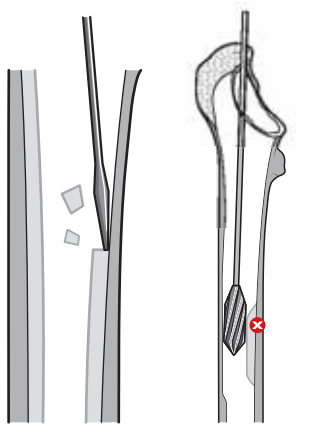


When a trochanterotomy is indicated, it combines both the articular and the femoral approach.

Removal of the cement

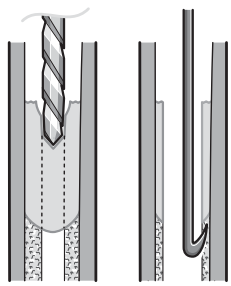
This stage of the surgery is often long and laborious, and even the use of a mechanical cement extractor does not prevent from a via falsa if the femur is curved.

In the intermediate area: remove the cement breaking it piece by piece, carefully controlling the bone-cement interface.



Beware of residual fragments of cement, as these could mislead to off-axis reaming or to a via falsa.

Cement plug: Drill a hole in the plug with a 6 mm drill bit, then enlarge the opening, up to 10 or 11 mm, to pass a cement extraction curette through it.



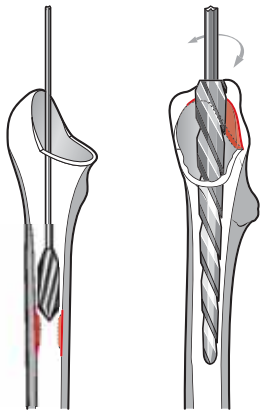
Proceed with the removal of the cement plug after complete excision of the intermediate cement.
If the femoral stem is off axis, beware of following a via falsa.

Preparation of the femur and the correct choice of implant

Calibrate the femur and adjust the opening of the greater trochanter.

Calibrate the femur with a cylindrical reamer and adjust the opening of the greater trochanter with a conical reamer having a diameter smaller than the medullary canal.

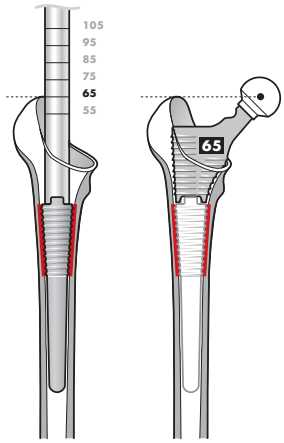
Following this first stage of the surgery, aim to achieve fixation in the metaphyseal-diaphyseal area and if this fixation mode is not possible, to a short diaphyseal fixation.



A long conical reamer will enable to verify the alignment of the proximal femur in relation to the diaphyseal femur.

Metaphyseal-diaphyseal fixation

The preparation of the femur is realised with a rasp that will also be used as a test prosthesis. It is suggested to perform a preparation of the femur in two stages.
In a first stage, impact the distal rasp of length 120 mm with the graduated cylindrical handle, until a perfect primary stability is achieved. Evaluate its depth of penetration in order to choose the proximal part of the rasp.
In a second step, assemble the two parts of the rasp together and impact the assembled rasp down to the level determined in the first step.
Trial reductions: see below.

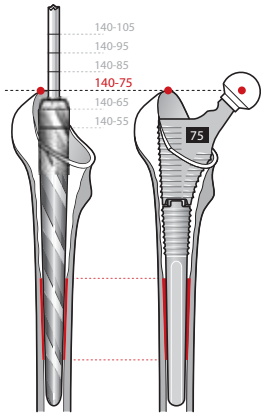


If it is difficult to impact the assembled rasp, then it is possible to perform a separate preparation of the metaphysis with a proximal rasp component without using a distal rasp component.

It is possible to ensure a fixation in the metaphyseal-diaphyseal area with a distal component of length 140 mm, which might be indicated when a femoral window was done in order to remove the cement plug.

Diaphyseal fixation

If it is not possible to ensure stability in the metaphyseal-diaphyseal area, it is necessary to aim for a diaphyseal fixation.
In this case, the preparation of the diaphyseal femur is carried out with the reamers, and it is necessary to increase the diameter of the reamers to end up, in any case, in sector 1, corresponding to a distal component of a length of 140 mm.
The implant is selected using the rasp, which in any case is only used here as a test prosthesis.



Example opposite: a reference mark of **140 –75** means a distal component of the same diameter as the reamer and 140 mm long (digit 140) coupled with a proximal component of a height of **75**.
Reminder: The references provided by the reamer are indicative only.

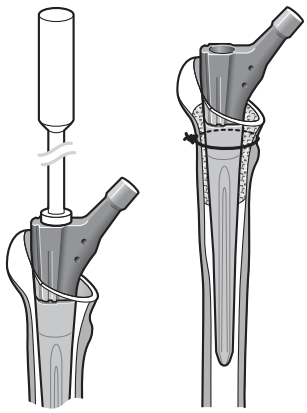
Trial reduction: during revision procedures, respecting the usual reference points (summit of the greater trochanter – centre of rotation with a ball head, neck size M) in order to calculate the correct length of the lower limb is not an absolute rule. It is suggested to carry out several trial reductions before making the final choice and to exploit the modular nature of the implant (it might be appropriate to change the height of the proximal component). The trial reductions should be carried out using a femoral head with a neck size M in order to keep some flexibility when putting the definitive implant into place.

Placing the definitive prosthesis

If the endofemoral approach has been selected, the two components of the prosthesis are assembled outside of the femur. If the femoral preparation is carried out correctly, the implant will be wedged into place over a height of 3 to 4 cm after having introduced it manually into the medullary canal.

After assembling the two parts of the prosthesis, introduce the implant oriented in the correct antetorsion, with the help of the impactor screwed on the proximal component.

Continue impaction until a cortical sound is obtained. Then wait for a few seconds and verify once again that the implant is set.
Carry out the trial reduction and make the final choice of the ball head neck length.



Do not correct the antetorsion of the implant while impacting it.

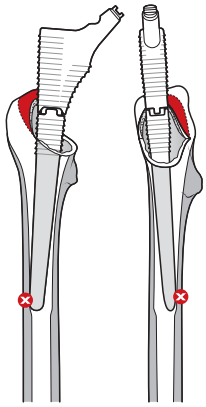
Adding bone in the medullary canal enables the control and limitation of the depth of penetration of the prosthesis. Simultaneously it enhances the stability.

Important:
When assembling the proximal with distal implant component you **must not** apply hammer-blows.
It is vital to follow the assembly procedure.

Incidents

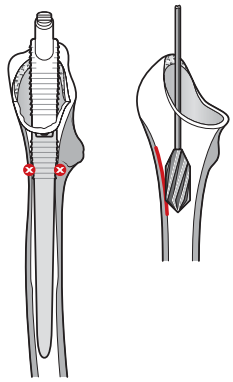
Incidents may occur when preparing the femur and usually consist of difficulties in impacting the rasp.

An insufficient lateral or posterior opening of the greater trochanter will lead to a wrong positioning of the rasp, and any attempt to correct that position or to impact it further by force could lead to a fracture of the greater trochanter or, if this does not happen, to a varus position of the implant.



The same type of incident may occur if a varus curvature of the femur has not been considered.

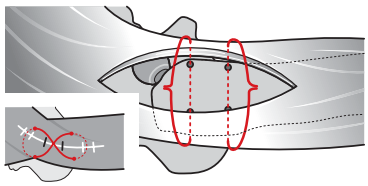
A narrow femur in the sagittal plane in the proximal region can be an obstacle to the penetration of the rasp or cause excessive antetorsion. An additional reaming is often necessary.
The same applies if the femur is narrow in the diaphyseal region.



In the proximal region, use a cylindrical reamer, diameter 16 to 18 mm, while keeping contact with the lateral cortical bone.
In the diaphyseal area, increase the inner diameter of the medullary canal to 11 or 12 mm.

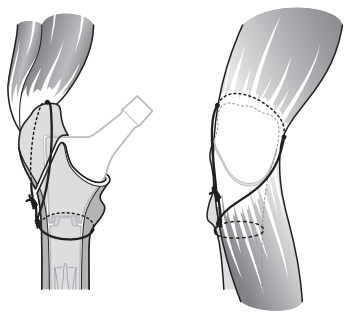
Closure of the joint

Antero-lateral approach: reattach the anterior digastric muscle using 2 transosseous points.
Postero-lateral approach: Whenever possible, reattach the pelvi-trochanterics and the posterior capsule.



It is advisable to carry out an additional mounting in the form of a lateral stay from the base of the greater trochanter with a trans-osseous point.

Digastric trochanterotomy: perform a lateral and posterior stay maintained by a cerclage on the proximal femur.



If this is a traditional trochantero-tomy: create a mounting with 3 metal wires and a lateral stay.

Post-Operative Treatment

As far as the instructions to be given to the patient for the period immediately following the surgery are concerned, it is advisable to keep them both simple and pragmatic. It is possible to distinguish between two different situations:

The prosthesis is stable, since it has been wedged perfectly into place in the femur, featuring cortical bone with high mechanical strength and a conically shaped medullary canal.
In this situation, loading is authorised straight away, using two forearm crutches that have a dual role: taking the weight off the hip and avoiding incorrect movements, in the expectation of a complete healing of the soft tissues. Immediate physiotherapy is functional only, and it aims to teach the patient what movements should be avoided in order not to have rotational stresses to the prosthesis, in particular when standing up from a seated position or when going up- or downstairs.
The patient will undergo a follow-up examination, including an X ray control, two months after the surgery. At this time a more active physiotherapy may be prescribed. Use of any aid will be abandoned progressively as a function of the recovery of the muscular strength, with the awareness that, generally speaking, there should be no hurry to cease using the crutches.

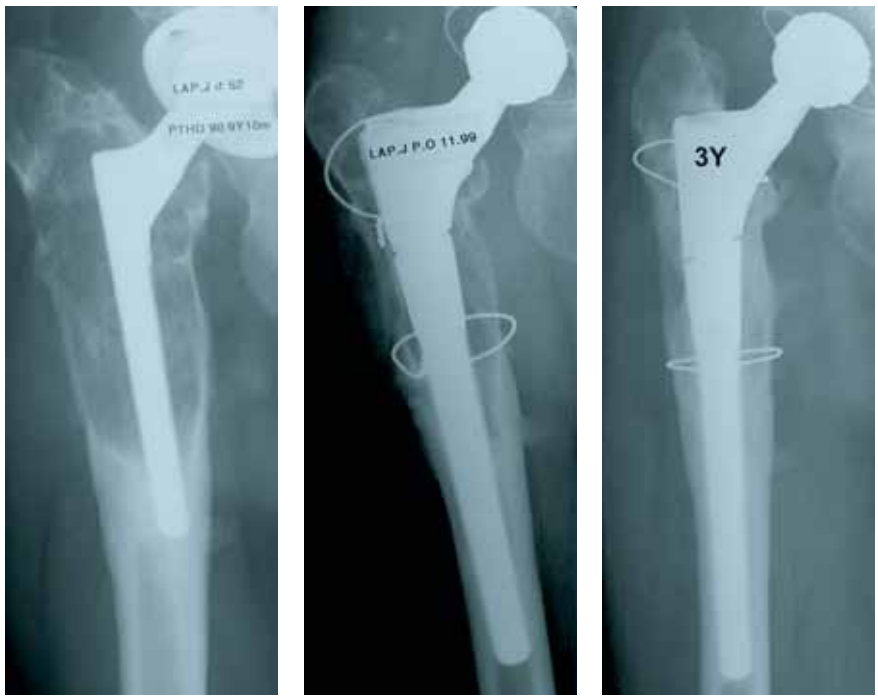
The prosthesis is not judged to be perfectly stable since the surgeon has some doubts on the quality of the wedging of the implant. Whatever may be the reasons for this concern, it is recommended to be cautious and not to authorise even partial loading for a period of 6 to 8 weeks.
During this period of non-loading, it is preferable to keep the patient under supervision and, if she/he is admitted to a specialised centre, order that she/he does not undergo any active physiotherapy throughout this period.
At the end of this period, and after a follow-up X ray, loading may be authorised. In principle this should be gradual, however it is in practice nearly always complete and immediate.

NB: This cautious attitude is recommended in the early stages of experience with the implant.
Moreover it should be stressed that each patient is a unique case and that the period for which loading should be avoided can very often be shortened to about 4 weeks.

Case Studies (Femoral Flap)

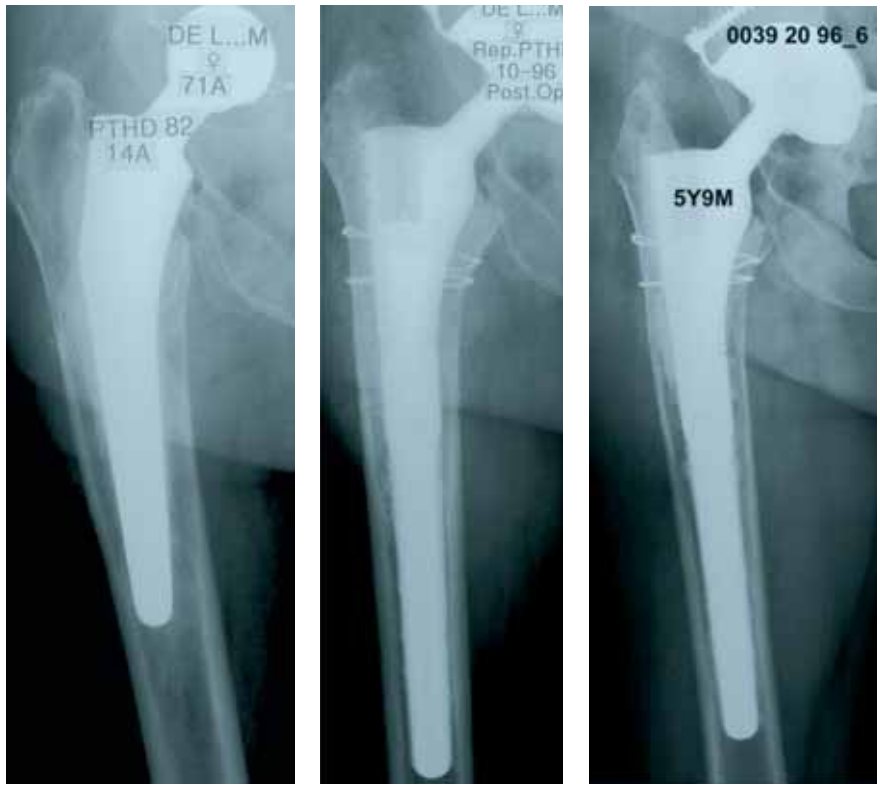
65-year-old male patient, left THP (15 years). Loosening with granulomas +. Corticalised femur (no osteoporosis). Varus deviation of the proximal femur. Lateral flap with pedicle and medial cortical osteotomy, PFM-revision stem with short diaphyseal fixation and a cementless St. Nabor cup. Flap with gap + and medial cortical defect. Results after 49 months: very good bone regeneration and perfect osteointegration. (Dr. P. Schuster's patient)

52-year-old male patient. Right cementless THP in 1990 (10 years) on a dysplastic hip. Significant bone destruction due to granulomas. Valgus deformation of the femur (not very frequent). Lateral flap, short diaphyseal fixation, no bone grafts. Results after three years: excellent bone regeneration (minor lateral cortical defect) and perfect osteointegration.

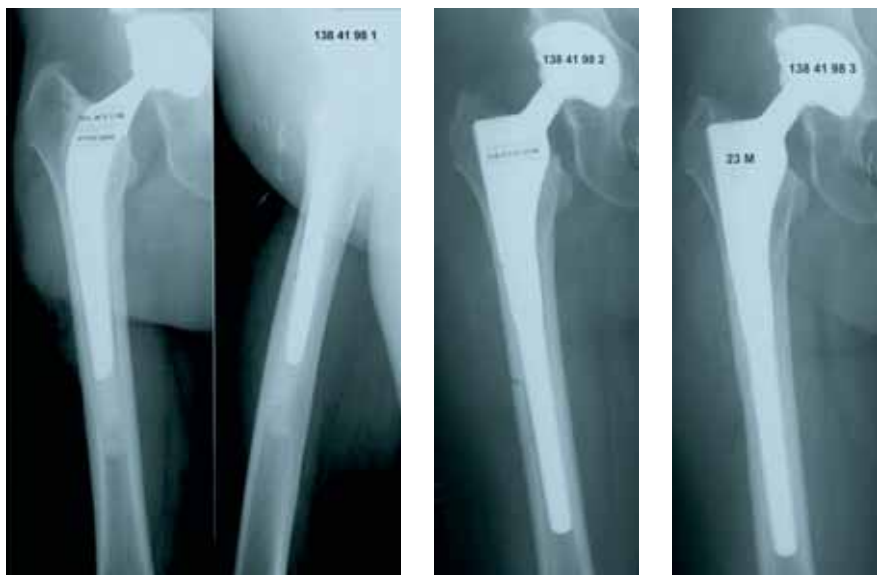


Case Studies (Endofemoral Route)

71-year-old female patient, right THP 1982 (14 years). Only slight loosening but with medial cortical granulomas and varus stem. Straight femur and osteoporosis +/–. Revision via the endofemoral route: proximal fixation with endomedullary bone graft and cerclage of the proximal femur. No diaphyseal fixation. Results after 5 years and 9 months: moderate atrophy of the proximal femur but no significant modification of the cortical bone, good proximal osteointegration.



66-year-old female patient. Right THP, early aseptic loosening. Bone stock retained, femur straight in the frontal plane and slightly curved in the sagittal plane, cement plug. Endofemoral approach and window for removing the distal cement. Fixation in the metaphyseal-diaphyseal area. Results after 23 months: good osteointegration and no modifications of the cortical bone.



Conclusions

What to do!

- Have suitable X-rays available before the surgery, in order to carry out a radiological analysis enabling the “correct” femoral approach to be selected, considering the imperatives imposed by the press-fit concept.
- Do not hesitate to choose a femoral approach in the form of a pedunculated lateral flap. This is an excellent way to ensure a straightforward revision and an effective press-fit.
- Remove all the cement without damaging the bone lesions further. This requires a perfect view of the endomedullary canal.
- Undertake preparation of the implant area with the rasps or reamers, once there is a certainty of working on a straight segment of the femur and after removing all intramedullary obstacles.
- If an endofemoral approach has been selected, it is necessary to create a large opening in the greater trochanter. Further, diaphyseal fixation will be aimed to only if proximal fixation in the metaphyseal-diaphyseal area is not possible.
  – First of all, it is necessary to prepare the area for receiving the implant using the rasps; if diaphyseal fixation should be necessary, the reamers will have to be used.
  – The selection of the implant, which is done using the rasp that also serves as test prosthesis, is a very important stage of the surgery and entails exploiting the modular nature of the implant properly. The definitive implant will be selected after carrying out one or more trial reductions and it is advisable to keep a safety margin with the modular ball heads by carrying out the trial reductions with a ball head with a neck size M.
  – The definitive stem is implanted in a single stage, after assembling the two components of the prosthesis out of the femur. If the depth of penetration of the definitive prosthesis does not correspond exactly to that of the trial prosthesis, the length of the neck of the ball head can be used to get an offset.
- If a femoral flap has been selected, fixation must necessarily be diaphyseal. In this situation, the reamers are used to give the medullary canal a conical shape and not for the selection of the implant, which will always be done with the test prosthesis.
  – In order to ensure primary stability, it is necessary to use the conical area of the implant and to keep some reserve of the conical anchorage area when wedging the implant into place. With a press-fit stem, it is always suggested to give priority to the diameter of the implant instead to its length.
  – When choosing the implant, it is advisable to avoid choosing an extreme proximal component (sizes 55 or 105), keep a margin when introducing the definitive implant, which is always carried out in two stages.
- When a femoral flap has been carried out, this must be carefully put back into place, in particular if fixation in the diaphyseal region is a borderline case; if the greater trochanter is fragile, it is necessary to carry out cerclage with a lateral stay.
- During the post-operative treatment, give clear instructions to the patient. If complete loading is not possible or risky, it is preferable to keep the patient under supervision during the period of non-loading.

What not to do!

- Do not start the surgery without carrying out a radiological analysis that would highlight the major obstacles to place a straight press-fit stem, in particular the existence of a femoral curvature.
- Do not believe that all the cement can be removed without damaging the bone lesions further, if the cortical tissue is fragile due to stress-shielding or osteoporosis. In such situations there is a risk of incomplete removal of the cement.
- Do not insist on implanting a straight stem in a curved femur using the endofemoral route, when a femoral flap is required; or, similarly, believe that it would be possible to straighten a femoral curvature while preparing the femur with conical reamers.
- Do not aim to ensure a diaphyseal press-fit with a long stem via the endofemoral approach only: this is always risky, if not impossible. The quality of a press-fit does not depend on the length of the implant but on how well the implant is wedged into place. It is always easier to ensure good wedging with a shorter and thicker implant, being near to the anchoring area.
- Do not select an implant on the basis of the references provided by the reamer as this would frequently lead to the choice of an implant longer than necessary.
- Do not forget to keep a safety margin when choosing the height of the proximal component or the neck size of the ball head. This would lead to the risk of insufficient wedging at the time of implanting the definitive stem into place.
- Do not opt for implanting in two stages after choosing an endofemoral route.
- Do not impact the test prosthesis or the definitive stem by applying strong hammer blows, without verifying its progression, or try to impact it in at all costs even when its progression is stopped. This may lead to a fracture or the enclosure of the implant.

Appendix 1
Assembly of the two implant components

The assembly of the two components of a Revitan Straight stem is realised with a torque wrench providing a constant tightening force. It is performed in a different manner depending on the strategy selected by the surgeon. Assembly in one stage (extrafemoral) if an endofemoral approach was chosen or an intrafemoral assembly in two stages if a femoral flap was performed.

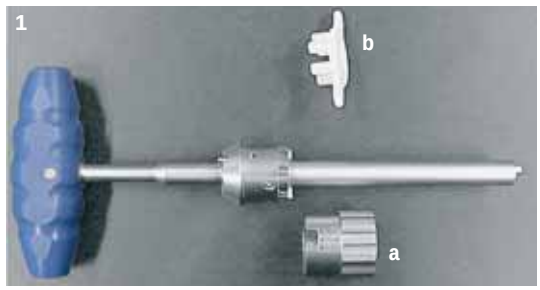
N.B.: The torque wrench is also used for the tightening and untightening of the safety nut during the implantation and extraction of the implant respectively.

Principle of operation and directions for use of the torque wrench

The operating principle of the torque wrench key is based on using a cutting blade to split a polyethylene pin, the diameter of which has been determined such that it is always necessary to exert a torque of about **10 Nm** to achieve this splitting.

Thanks to the new system composed of PE shear pins, the torque wrench doesn't need to be recalibrated and offers a high level of safety to the user.

1) Loading of the torque wrench.
- Remove the cover (a) of the torque wrench (fig. 5, 6 and 7).
- Unpack the loader (b). The polythelene loader holds 6 shear pins.



With a shear pin loader, a torque of about 10 Nm can be applied three times. Under normal condition this is enough to perform the implantation of the stem. Should additional shear pins be needed, the torque wrench must be re-loaded with a new shear pin loader (available separately).

NB: A shear pin loader is packed with each proximal component of the implant. The shear pins should neither be implanted nor be resterilised.

2) Place the pins into the recesses of the torque wrench and turn the loader to free the shear pins.

3) Remove the empty loader.

4) Put the cover back in place (position "Close") and lock it in position "Lock".

5) After use, unlock the cover by pushing the button.

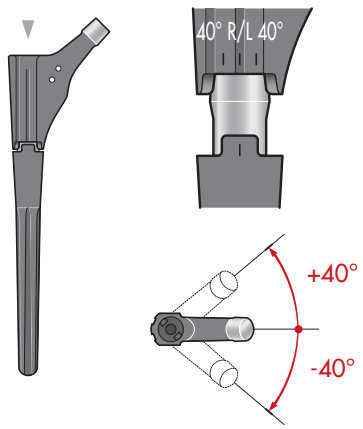
6) Turn the cover to the "Open" position.

7) Remove the cover and extract all the shear pins from the recesses.

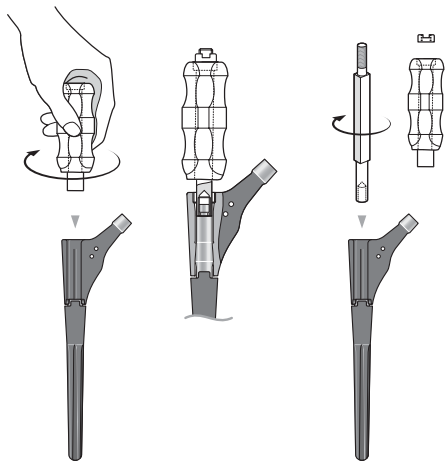
NB: To enable the sterilisation of the torque wrench, make sure that there is no shear pin or cut-off part of them remaining in the recesses of the torque wrench.

Appendix 1
Assembly of the stem in one stage (extrafemoral)

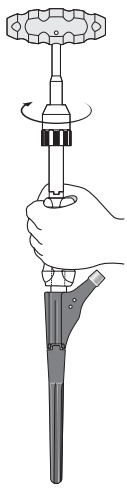
1) Position the definitive proximal component
Before starting with the assembly of the two implant components, position the proximal component onto the morse taper of the distal component by hand and set the desired antetorsion of the proximal component. This step must be done before any assembly force is applied to the stem. Once the antetorsion is chosen, push the two parts together by hand to give them stability before continuing with the assembly.



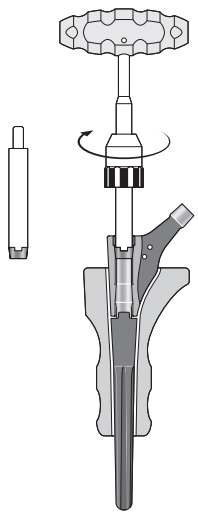
2) Screw on the stem tensioner
Screw the threaded rod of the tensioner onto the threaded part of the morse taper.
To screw on the tensioner, hold it in the hand so that the threaded rod protrudes from the tensioner. Alternatively, the threaded rod can be removed out of the tensioner, screwed onto the threaded part of the morse taper and eventually the tensioner is reassembled. Tighten by hand the nut of the stem tensioner.



3) Assemble of the two prosthetic components
Hold firmly the stem tensioner and tighten the assembly of the two components with the torque wrench. For this process the request of assistance is strongly recommended.
Further, don't use the stem holder to maintain the implant in order to keep control of the antetorsion.

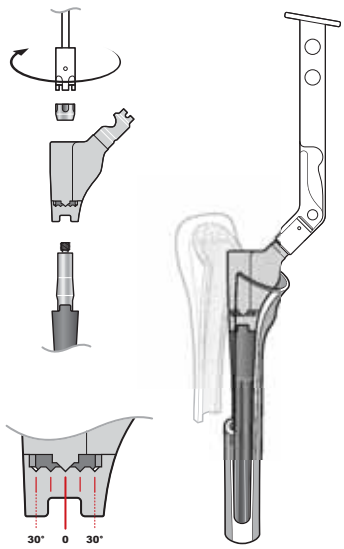


4) Screw on the conical nut
Finally the conical nut is screwed onto the threaded part of the morse taper with the help of the setting instrument and tightened with the torque wrench. For the tightening, the implant is placed into the stem holder for an easier control of the rotational stresses.

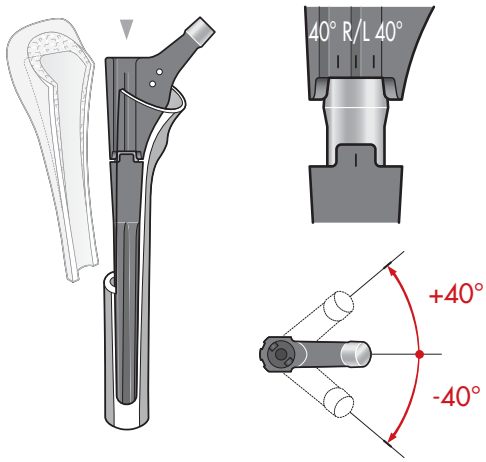


Appendix 1
Assembly of the stem in two stages (intrafemoral)

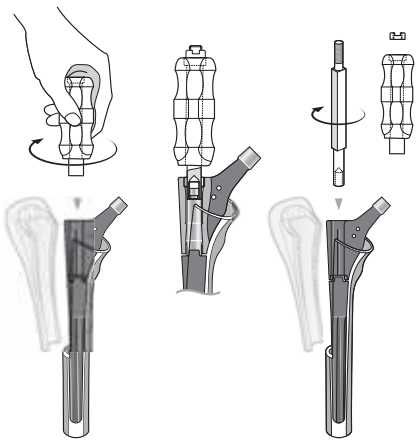
1) Assembly of the proximal trial part and implantation of the definitive distal component
After wedging in the definitive distal component, further trial reductions can be carried out if necessary by changing the sizes of the proximal trial part and changing its antetorsion (up to +/–30 °).



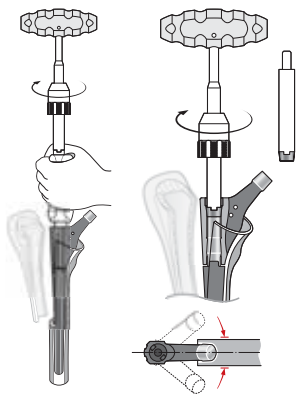
2) Position the definitive proximal component
Before starting with the assembly of the two implant components, wash the taper, position the proximal component onto the morse taper of the distal component by hand and set the desired antetorsion of the proximal component. This step must be done before any assembly force is applied to the stem. Once the antetorsion is set, push the two parts together by hand to give them stability before continuing with the assembly.



3) Screw on the stem tensioner
Screw the threaded rod of the tensioner onto the threaded part of the morse taper.
To screw on the tensioner, hold it in the hand so that the threaded rod protrudes from the tensioner. Alternatively, the threaded rod can be removed out of the tensioner, screwed onto the threaded part of the morse taper and eventually the tensioner is reassembled. Screw tight by hand the nut of the stem tensioner.



4) Assembly of the definitive proximal component and screw on the conical nut
Hold firmly the stem tensioner and tighten the assembly of the two components with the torque wrench. For this process the request of assistance is strongly recommended.
Finally the conical nut is screwed onto the threaded part of the morse taper with the help of the setting instrument and tightened with the torque wrench. When tightening the conical nut, neutralise the torsion stresses caused by the torque wrench exerting counter-pressure on the neck in the opposite direction to the tightening by hand or with the specially provided handle positioned over the neck of the implant.



Appendix 2
Removal of a Revitan Straight stem

The possibility of extraction must be provided for every implant. Although this statement is true, it is nevertheless often difficult to fulfil it. In particular, a cementless stem can be very demanding to extract when it is not loosened.In the Revitan Straight system, the development of disassembly instruments for the proximal component allows to some extent to overcome this disadvantage as its removal is always possible without difficulties. On the other hand, the extraction of the distal component is often demanding, especially if it is well osteointegrated or has a long stem.

Indications
The removal of a Revitan Straight stem can involve the proximal part or the entire implant.

Removal of the proximal part
The distal part of the implant is stable but it is necessary to remove the proximale part in order to:
- Allow articular access either to carry out cleansing of the joint cavity (sepsis) or to work on the cup (changing it or placing an anti-dislocation device).
- Change the proximal component to replace it mostly with a higher one for reasons of a secondary subsidence of the implant. Less frequently the antetorsion has to be modified (recurrent dislocation).

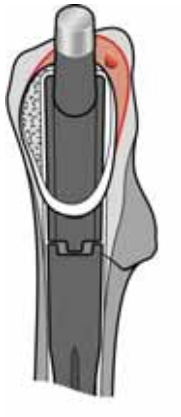
Example attached. Bipolar loosening: revision with PFM revision stem and St. Nabor cup. Radiography after 6 months: significant subsidence of femoral stem. Expanded trochanterotomy and replacement of the proximal component with a component of greater height with extra-long neck. The distal component, which had not loosened, was left in place.

Removal of both components
Two different situations can be identified:
- There is a loosening with abnormal mobility of the implant: in this case, removal of the stem does not pose any problems. The stem can be removed in one piece using a simple extractor.
- The stem is not loosened but it is necessary to remove it in order to carry out cleansing of the medullary canal (sepsis) or because of secondary subsidence, which cannot be compensated by changing the proximal part. In this situation, the implant should be extracted in two stages: removal of the proximal part and then removal of the distal part.

Example attached. Revision of PFM revision stem and dual-mobility cup, for repeated bipolar loosening (radiography after 3 years).
Revision, pseudarthrosis of trochanter major: simple removal, monobloc, of the femoral stem (distal component, 200 mm in length) which was replaced by a shorter stem with a large diameter. Replacement of dual-mobility cup with a cementless St. Nabor cup.

Femoral access route

Endofemoral route. If the stem is loose, endofemoral access alone is possible with care being taken to eliminate obstacles at the level of the greater trochanter.



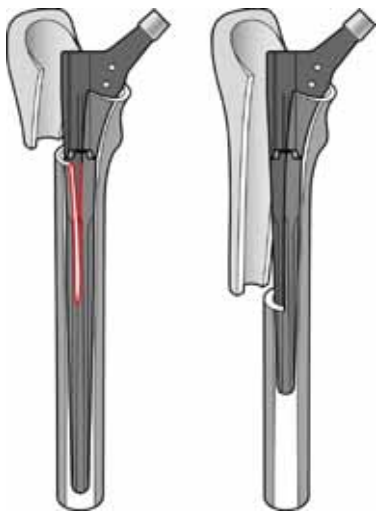
Choosing endofemoral access requires wide lateral and posterior opening of the greater trochanter.

Expanded trochanterotomy. If it is intended to remove only the proximal component, articular access is strongly recommended in the form of an expanded trochanterotomy at the lateral cortex up to the point at which the proximal and distal components join.

Perform a digastric trochanterotomy, preserving the insertions of the musculus vastus lateralis at the base of the greater trochanter.

If it is intended to remove both components of the prosthesis (proximal and distal components), apart from any loosening, two options are available to the surgeon:

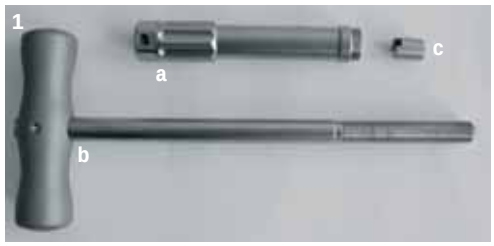
- **Lateral flap.** If the stem is short (length of distal component 140 mm), create a lateral flap, with a length of between 15 and 20 cm.
- **Expanded trochanterotomy or flap and diaphyseal partition line.** If the stem is long (length of distal component 200 mm): after having performed an expanded trochanterotomy or a flap, use an oscillating saw to create a diaphyseal partition line.



Creation of a femoral flap is the most reliable option and it is worth bearing in mind that if the implant has not loosened it is always easier to remove a short stem.

Appendix 2
Removal of a Revitan Straight stem

The disassembly of the Revitan Straight is performed following an analogous process as with the first generation stem (PFM-R), with the sole difference that the instruments changed somewhat due to the presence of a thread at the level of the shoulder.
For the disassembly of a proximal component of the first generation [PFM-R (REF: 21.16.09-XX, 20.16.XX-XX, 01.0007X.XXX)] different instruments are required and available in a separate instrument set.



1) Disassembly instruments
a) Disassembly instrument (REF 01.00409.801)
b) Threaded rod for disassembly instrument (REF 01.00409.803)
c) Disassembly sleeve (REF 01.00409.816)

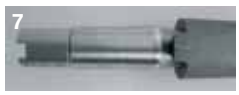
2) The torque wrench is in the "Lock" position.

3) Removal of the conical nut with the torque wrench.

4) Screwing the disassembly sleeve (REF 01.00409.816) onto the distal implant component, using the setting instrument (01.00409.815)

5) Screw the disassembly instrument (REF 01.00409.801) into the threat on the shoulder of the proximal component.

6) The threaded rod with T-handle (REF 01.00409.803) is screwed into the disassembly instrument. By firmly turning, the threaded sleeve, and thus the distal implant component is pressed downward; and pressure is exerted simultaneously on the proximal component with the disassembly instrument.



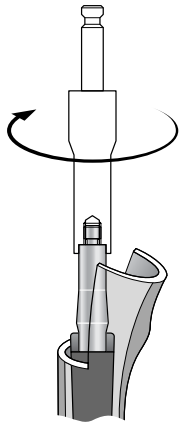
7) Decoupling of the proximal component.

8) Removal of the disassembly sleeve using the setting instrument.

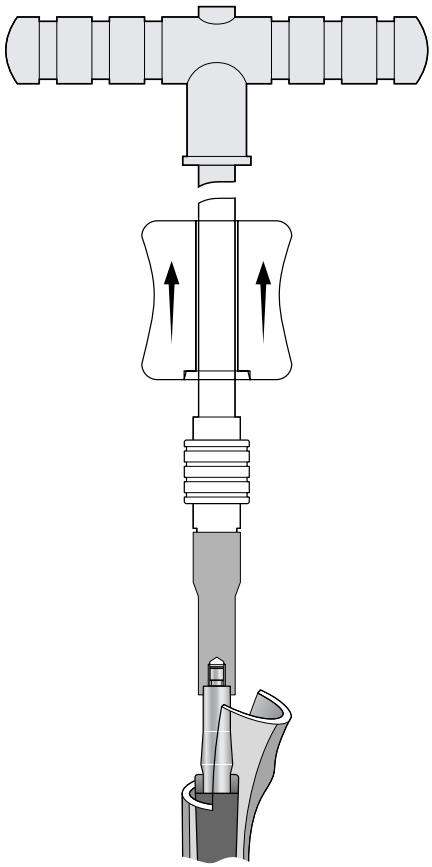
Removal of the distal component

The removal of the distal component is done after having removed the proximal component. It is performed with the extraction instrument (01.00079.011) that is screwed onto the connection taper and the slap hammer (01.00129.190). This allows striking with sharp taps in the axis of the distal component.

If the distal stem cannot be extracted from the femur with a few hammer-blows additional measures have to be taken, like longitudinal osteotomies, a window, a flap or the introduction of flat chisels along the stem to faciliate the extraction of the distal component.



Screwing of the extraction instrument (01.00079.011) onto the connection taper.



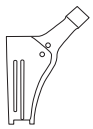
Extraction of the distal component with the slap hammer.

Revitan® Straight – Implants
PFM-Revision of the Second Generation

Proximales Teil, konisch[1]
Proximal part, spout[1]
Partie proximale, tulipée[1]

Protasul®-100
Taper 12/14
uncemented

STERILE R

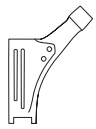


L mm	REF
55	01.00401.055
65	01.00401.065
75	01.00401.075
85	01.00401.085
95	01.00401.095
105	01.00401.105

Proximales Teil, zylindrisch[1]
Proximal part, cylindrical[1]
Partie proximale, cylindrique[1]

Protasul®-100
Taper 12/14
uncemented

STERILE R



L mm	REF
55	01.00402.055
65	01.00402.065
75	01.00402.075
85	01.00402.085
95	01.00402.095
105	01.00402.105

Auf Anfrage
On request
Sur demande

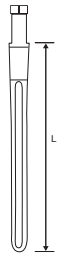
Konusmutter, steril
Conical nut, sterile
Ecrou conique, stérile

REF
01.00405.000

Distales Teil, gerade
Distal part, straight
Partie distale, droite

Protasul®-100
Protasul®-21 WF
uncemented

STERILE R



ø mm	L mm	REF
14	120	01.00405.014
14	140	01.00405.114
16	140	01.00405.116
18	140	01.00405.118
20	140	01.00405.120
22	140	01.00405.122
24	140	01.00405.124*
14	200	01.00405.214
16	200	01.00405.216
18	200	01.00405.218
20	200	01.00405.220
22	200	01.00405.222
24	200	01.00405.224
26	200	01.00405.226*
28	200	01.00405.228*
16	260	01.00405.316
18	260	01.00405.318
20	260	01.00405.320
22	260	01.00405.322
24	260	01.00405.324
26	260	01.00405.326*
28	260	01.00405.328*

[1] Mit Abscherstiften und Ladehilfe verpackt
[1] Packed with shear pins loader
[1] Emballée avec chargeur de broches sécables

* auf Anfrage
* on request
* sur demande

Revitan® Straight – Basic Instruments
PFM-Revision of the Second Generation

Sieb Basisinstrumente (komplett)
Tray for base instruments (complete)
Plateau pour instruments de base (complet)

REF
ZS 01.00408.100

Sieb Basisinstrumente (leer)
Tray for base instruments (empty)
Plateau pour instruments de base (vide)

REF
01.00408.101

Einsatz zu Sieb Basisinstrumente (leer)
Insert for tray for base instruments (empty)
Insert pour plateau pour instruments de base (vide)

REF
01.00408.102

Standard Siebdeckel, grau
Standard tray cover, grey
Couvercle standard pour plateau, gris

REF
01.00029.031

Handmarkraumbohrer
Hand reamer
Alésoir à main

REF
79.10.46

Handgriff mit Schnellkupplung
Handle with quick coupling
Poignée à verrouillage rapide

REF
75.00.25

Steckschlüssel 3,5 mm
Hexagonal wrench 3,5 mm
Clé à embout hexagonal 3,5 mm

REF
79.15.84

Griff für modulare Raspeln
Handle for modular rasps
Poignée pour râpes modulaires

REF
70.00.94

Langer Querstab
Long bar
Barre longue

REF
70.00.01

Mutter zu Manipulierteil
Nut for proximal trial part
Ecrou pour pièce d'essai

REF
01.00079.001

Schlüssel zu Mutter
Wrench for nut
Clé pour écrou

REF
01.00079.002

Revitan® Straight – Basic Instruments
PFM-Revision of the Second Generation

Griff zu Schaftspanner
Handle for stem tensioner
Poignée pour tendeur

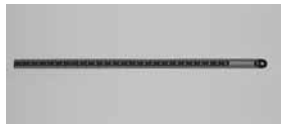
REF
01.00409.804

Gegenhalter
Handle for counterforce
Manche de retenue

REF
01.00409.809

Gewindehülse für Demontage-instrument
Threaded sleeve for disassembly instrument
Manchon fileté pour instrument de démontage

REF
01.00409.816



Massstab, 30 cm
Ruler, 30 cm
Réglette, 30 cm

REF
75.11.30

Gewindestange zu Schaftspanner
Threaded rod for stem tensioner
Tige filetée pour tendeur

REF
01.00409.805

Setzinstrument für Konusmutter
Setting instrument for conical nut
Instrument de pose pour écrou conique

REF
79.15.82

Gewindestange für Demontageinstrument
Threaded rod for disassembly instrument
Tige filetée pour instrument de démontage

REF
01.00409.803

Manipulierkugelkopf
Trial ball head
Tête d'essai

Grösse/Size/Taille	ø mm	REF
S	28	01.01559.128
M	28	01.01559.228
L	28	01.01559.328
XL	28	01.01559.428
S	32	01.01559.132
M	32	01.01559.232
L	32	01.01559.332
XL	32	01.01559.432
S	36	01.01559.136*
M	36	01.01559.236*
L	36	01.01559.336*
XL	36	01.01559.436*

Mutter zu Schaftspanner
Nut for stem tensioner
Ecrou pour tendeur

REF
01.00409.806

Einschläger
Impactor
Impacteur

REF
01.00409.800

Führungshülse für Hohlfräser proximal
Guiding sleeve for hollow reamer proximal
Manchon de guidage pour fraise creuse proximale

REF
01.00409.802

Setzinstrument Demontagehülse
Setting device for disassembly sleeve
Porte douille de démontage

REF
01.00409.815

Drehmomentschlüssel
Torque wrench
Clé dynamométrique à barillet

REF
01.00409.808

Demontageinstrument
Disassembly instrument
Instrument de démontage

REF
01.00409.801

Extraktionsinstrument für distales Teil
Extraction instrument for distal part
Pièce de démontage pour partie distale

REF
01.00079.011

Haltegriff für Schaft
Stem holder
Manche de maintien pour tige

REF
01.00409.807

* auf Anfrage
* on request
* sur demande

Revitan® Straight – Basic Instruments
PFM-Revision of the Second Generation

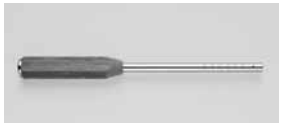
Auf Anfrage
On request
Sur demande

Abscherstifte mit Ladehilfe, steril
Shear pins loader, sterile
Chargeur de broches sécables, stéril

REF
01.00409.810

IMT Raspeladapter
IMT Rasp adapter
Barre pour râpe avec IMT

REF
01.00409.813



Einschlaginstrument distal
Impactor distal
Impacteur distal

REF
01.00409.811

IMT Raspeladapter proximal
IMT Rasp adapter proximal
Connexion pour râpe avec IMT

REF
01.00049.083

Hohlfräser proximal
Hollow reamer proximal
Fraise creuse proximale

REF
01.00409.812

Revitan® Straight – Instruments Proximal
PFM-Revision of the Second Generation

Sieb für Instrumente proximal konisch (komplett)
Tray for instruments proximal spout (complete)
Plateau pour instruments proximaux tulipés (complet)

REF
ZS 01.00408.300

Raspel proximal konisch
Rasp proximal spout
Râpe proximale tulipée

Grösse/Size/Taille	REF
55	01.00409.155
65	01.00409.165
75	01.00409.175
85	01.00409.185
95	01.00409.195
105	01.00409.105

Sieb für Instrumente proximal konisch (leer)
Tray for instruments proximal spout (empty)
Plateau pour instruments proximaux tulipés (vide)

REF
01.00408.301

Kleiner Siebdeckel, grau
Small tray cover, grey
Petit couvercle pour plateau gris

REF
01.00029.032

Manipulierteil proximal konisch
Trial part proximal spout
Pièce d'essai proximale tulipée

Grösse/Size/Taille	REF
55	01.00409.156
65	01.00409.166
75	01.00409.176
85	01.00409.186
95	01.00409.196
105	01.00409.106

Sieb für Instrumente proximal zylindrisch (komplett)
Tray for instruments proximal cylindrical (complete)
Plateau pour instruments proximaux cylindriques (complet)

REF
ZS 01.00408.200

Raspel proximal zylindrisch
Rasp proximal cylindrical
Râpe proximale cylindrique

Grösse/Size/Taille	REF
55	01.00409.255
65	01.00409.265
75	01.00409.275
85	01.00409.285
95	01.00409.295
105	01.00409.205

Sieb für Instrumente proximal zylindrisch (leer)
Tray for instruments proximal cylindrical (empty)
Plateau pour instruments proximaux cylindriques (vide)

REF
01.00408.201

Kleiner Siebdeckel, grau
Small tray cover, grey
Petit couvercle pour plateau gris

REF
01.00029.032

Manipulierteil proximal zylindrisch
Trial part proximal cylindrical
Pièce d'essai proximale cylindrique

Grösse/Size/Taille	REF
55	01.00409.256
65	01.00409.266
75	01.00409.276
85	01.00409.286
95	01.00409.296
105	01.00409.206

Revitan® Straight – Instruments Distal Straight
PFM-Revision of the Second Generation

Sieb distal gerade (komplett)
Tray distal straight (complete)
Plateau distal droit (complet)

REF
ZS 01.00408.500

Sieb distal gerade (leer)
Tray distal straight (empty)
Plateau distal droit (vide)

REF
01.00408.501

Standard-Siebdeckel, grau
Standard tray cover, grey
Couvercle standard pour plateau, gris

REF
01.00029.031

Handreibahle distal gerade
Conical reamer distal straight
Alésoir conique droit

Ø mm	REF
14	01.00409.014
16	01.00409.016
18	01.00409.018
20	01.00409.020
22	01.00409.022
24	01.00409.024
26	01.00409.026*
28	01.00409.028*

Revisionsführungsteil
Guide distal straight
Guide distal droit

Ø mm	L mm	REF
14	140	01.00409.512
16	140	01.00409.513
18	140	01.00409.514
20	140	01.00409.515
22	140	01.00409.516
24	140	01.00409.517*
14	200	01.00409.522
16	200	01.00409.523
18	200	01.00409.524
20	200	01.00409.525
22	200	01.00409.526
24	200	01.00409.527
26	200	01.00409.528*
28	200	01.00409.529*
16	260	01.00409.533
18	260	01.00409.534
20	260	01.00409.535
22	260	01.00409.536
24	260	01.00409.537
26	260	01.00409.538*
28	260	01.00409.539*

Raspeladapter mit Längenmarkierung
Rasp adapter with length markings
Barre graduée pour râpe

REF
01.00409.501

Raspel distal gerade
Rasp distal straight
Râpe distale droite

Ø mm	L mm	REF
14	120	01.00409.502

* auf Anfrage
* on request
* sur demande

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