How to manage acetabular bone defects with TrabecuLink Augments

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Introduction

Acetabular revision surgery is based on three fundamental principles. The first is a stable primary fixation of the new revision cup in the acetabular bone bed, the second principle is bony reconstruction[1]. Finally, and the third principle is the restoration of the center of rotation to avoid instability and maintain stability in the long term.

Presence of acetabular bone defects necessitates an appropriate management in revision surgery. Small, contained defects can be successfully treated with an uncemented cup and supplemental fixation, in most cases screws, with or without cancellous bone grafting[2,3]. An alternative is the use of a cemented cup with the impaction bone grafting technique. In cases of uncontained and/or larger bone defects that limit adequate contact with the acetabular rim and affect stability of the revision cup, it is necessary to increase stability with the use of augments. It has been suggested that, in general, the cup should have an uncovered area of no more than 30 % in order to obtain primary stability[4]. If this is not achieved, the use of augments can help to place the acetabulur cup in the correct center of rotation, improve implant stability, and increase the porous surface area that is in contact with healthy bone[5,6].

Porous titanium alloy augments have a surface structure that resembles the structure of the trabecular bone. Although the modulus of elasticity (Young's modulus) of titanium still strongly differs from that of cortical bone (Ti ≈ 110 GPa, cortical bone ≈ 20 GPa), the constructive elasticity of TrabecuLink due to the mesh-type structure is much closer to that of bone than that of solid material is. Furthermore, TrabecuLink provides a high coefficient of friction that allows an impressive initial pressfit. The surface porosity promotes the rapid osseointegration necessary for long-term stability and mechanical support, due to the reduction of relative movement between the components and the native bone[7]. This primary stability also depends on bone mineral density (BMD), which determines the strength of the press-fit, the „snug fit" between the cup and the acetabulum.

However, despite significant improvements in implant surface and augmentation design, there are many situations where there is confusion as to how to use them and where to best place them.

This paper is intended as a guide to the use of trabecular titanium augments in conjunction with a modern acetabular reconstruction system.

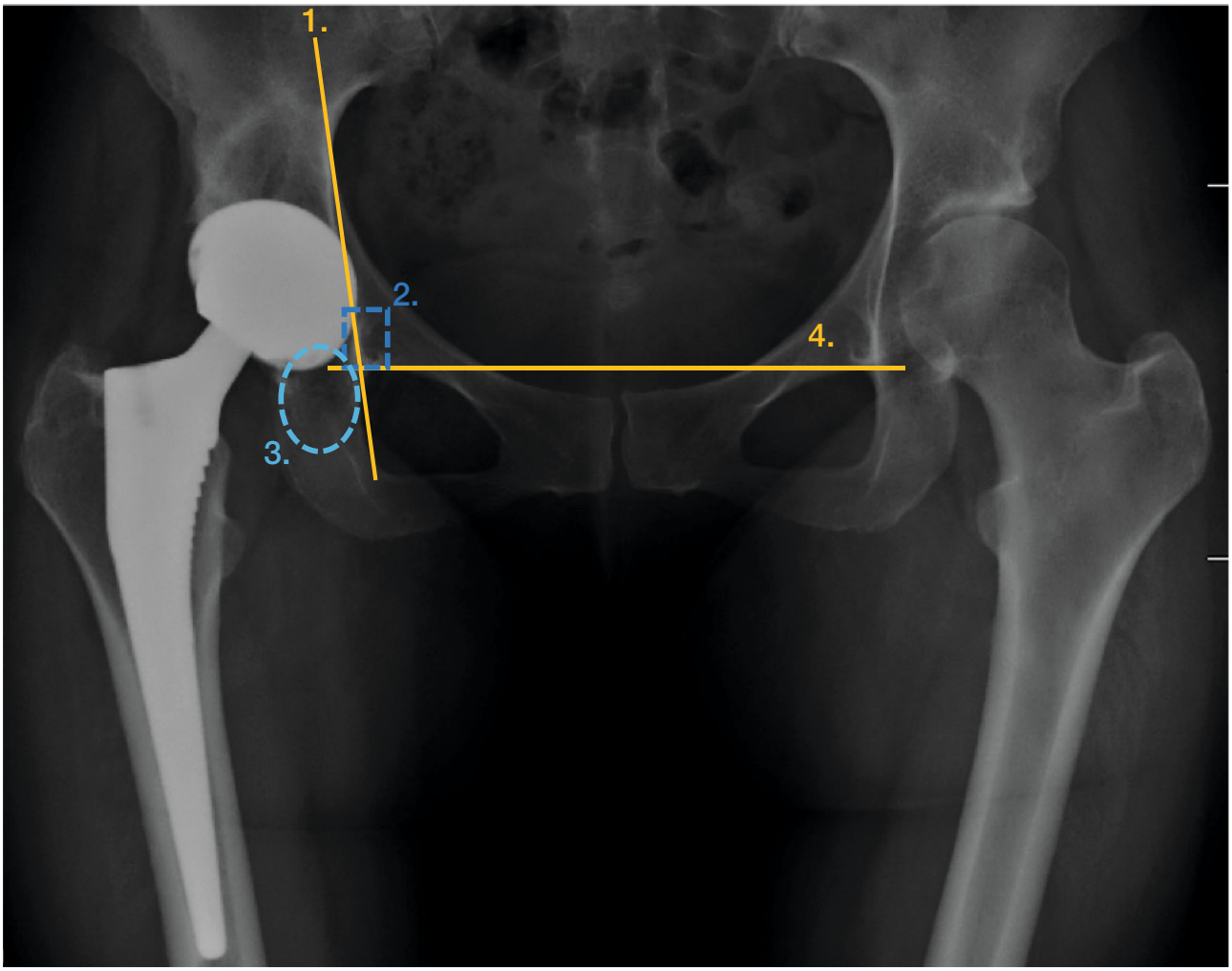
Algorithm for treatment with augments

Although the final decision must be made in the operating room, it is necessary to begin any surgical revision with a plan focused on the type of reconstruction. The most practical way to do this is based on Paprosky's classification of acetabular bone defects[9]. This classification reflects the severity of the bone defect and the chance of obtaining a stable fixation depending on the degree of acetabular bone defect.

Paprosky's classification

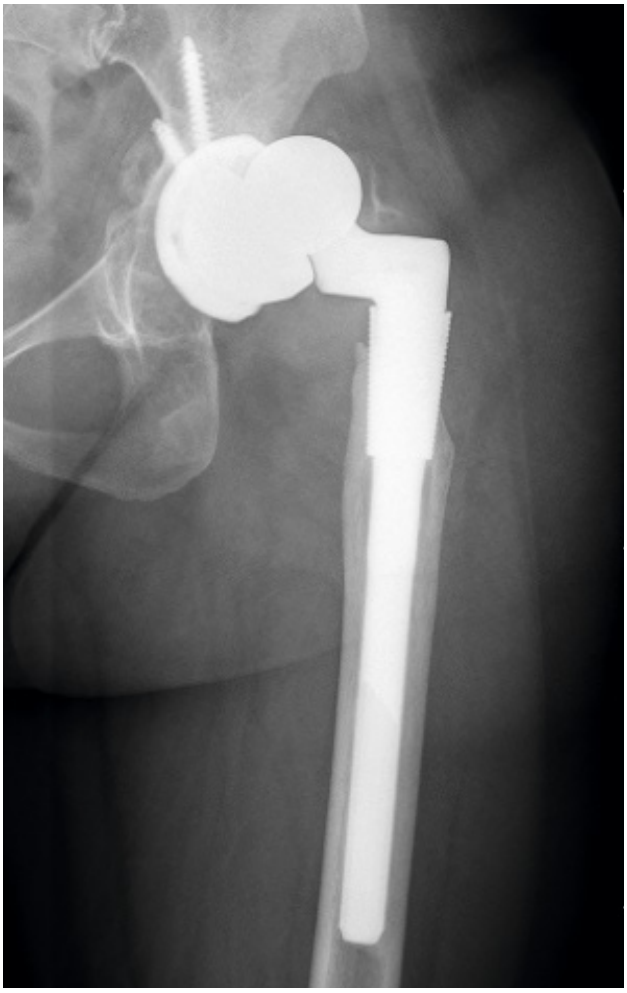
Table 1: Paprosky classification of acetabular defects[10]

Type of defect	Radiographic and intraoperative findings
Type-I	Acetabular rim, anterior-posterior column intact Implies near primary situation with >90% host bone support of cup
Type-II	Less than 3 cm superior migration Distorted acetabular rim. Intact anterior and posterior columns Adequate stability with Trial. Greater than 50% contact surface
IIA	Superior and medial cavitation defect. Intact rim
IIB	Segmental supero-lateral defect (less than 1/3 of circumference)
IIC	Medial defect with cup medial to Kohler's line (Protrusio)
Type-III	Greater than 3 cm superior migration Non-supportive acetabular rim for biological fixation
IIIA "Up and Out"	Lateral to Kohler's line. Intact medial support Moderate ischial lysis (<15 mm below superior obturator line) Medial limb of teardrop is intact Superior and lateral migration "up and out" Contact of trial with bone over 40–60% Intact ilioischial and iliopubic
IIIB "Up and In"	Broken Kohler's line. No medial or superior supportn Extensive ischial osteolysis (>15 mm below superior obturator line) Complete destruction of tear drop Superior and medial migration "up and in" Under 40% contact surface. High risk of occult pelvic discontinuity
Pelvic discontinuity	Fracture line through columns Broken Kohler's line or obturator foramen asymmetry on AP pelvis Superior and inferior hemipelvis separation



1. Köhler's line: Integrity of the medial wall and anterosuperior column. Its involvement indicates loss of medial support and risk of failure due to medialization of our new implant.
2. Acetabular teardrop: Medial wall and both columns integrity at the lower level. Its impairment means loss of inferior support (medial wall and support ring), increasing the risk of failure due to medialization and adduction (up-and- failure).
3. Ischial lysis: Posterior column and wall integrity. Its involvement increases the risk of failure due to retroversion of the cup.
4. Vertical migration: Integrity of the acetabular roof. Its impairment denotes loss of upper support that could be partial (less than 3 cm of elevation or completely >3 cm). Its loss increases the risk of failure due to verticalization and abduction (up-and-out failure).

Up-and-out failure: vertical elevation higher than 3 cm, with severe bone defect in the acetabular roof.



Up-and-in failure: Medial migration associated with ischial and acetabular teardrop bone loss. Medial Khöler line was disrupted.

Reconstruction options

Depending on the degree of stability and bone contact, there are four reconstruction options to be considered.

- Containment acetabulum with adequate contact: Trabecular titanium cup with screws (e.g. MobileLink)

- Partial containment acetabulum: Trabecular titanium cup with screws (e.g. MobileLink) with trabecular augment (usually one, e.g. TrabecuLink Augment)

- Non-containment acetabulum: Trabecular titanium cup with screws (e.g. MobileLink) with trabecular augment (one or more, e.g. TrabecuLink Augment), buttress plate augment or partial pelvis replacement.

- Non-reconstructable acetabulum: Custom-made stem triflange cage

How to use augments?

The function of the augment is to increase stability of the cup until the cup is integrated. To this end, it is not necessary to have complete contact between the augment and the cup (one point of contact is sufficient if it stabilizes the cup).

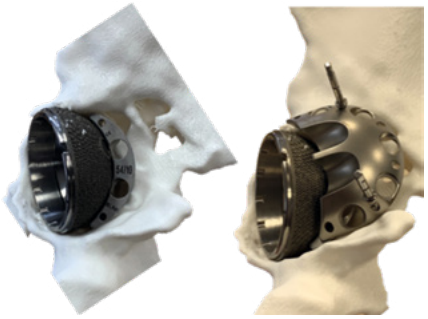
In addition, since the priority of any acetabular revision is to achieve good acetabular fixation, it is necessary to understand about the location of the augment and its screws, and how these may affect the direction of additional acetabular screws. To avoid complications, it is recommended to place the augmentation after positioning the cup whenever possible. If there are concerns that a possible conflict with the augment screws may happen, it is recommended to use thinner 4.5 mm screws for augment fixation, reserving the larger 6.5 mm screws for the acetabular fixation.

The function of the augment will depend on how it is placed:

Type 1: Buttress configuration: Commonly used in segmental defects (Paprosky IIB/IIIA) and intended to increase the rotational stability of the cup, but can also be used to achieve translational stability. It May be inserted before or after the cup, depending on the intrinsic stability of the cup.

Type 2: Oblong configuration: Commonly used in cavitary defects (Paprosky IIA/IIIA), with the aim to increase the translational stability and bone contact of shell. It is usually implanted prior to the cup.

Type 3: Footprint configuration: Used in cavitary or segmental defects of the medial wall to avoid medial protrusion, as well as in ischial lysis. The augment is fixed without screws, and it should be impacted prior to the cup and can be used in conjunction with a second augment.



Suggested reconstruction according to the acetabular defect

Type I

Definition

- Köhler's line: Intact
- Tear drop: Intact
- Ischial lysis: Minimal to none
- Vertical migration: Minimal to none

Intraoperative findings

- Rim: Complete
- Acetabular cavity: Spherical
- Stability: Appropriate
- Bone contact: More than 90 %

Solution

- Hemispheric trabecular titanium cup (e.g. MobileLink TrabecuLink Cluster Hole)
- Primary cup can be used
- Two screws are recommended (in good bone with excellent press fit, screws can be dispensed with)

Type IIA

Definition

- Köhler's line: Intact
- Tear drop: Violated
- Ischial lysis: Mild
- Vertical migration: Mild (<3 cm)

Intraoperative findings

- Rim: Complete
- Acetabular cavity: Superomedial bone cavity
- Stability: Appropriate to moderate. Some translational instability may exist.
- Contact: More than 70 %

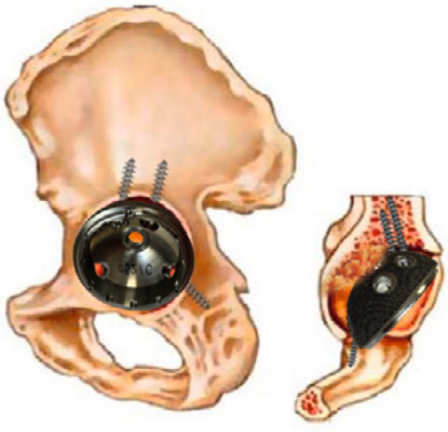
Solution

Option 1:

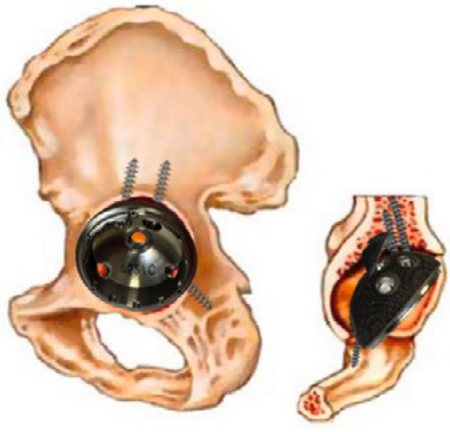
- Hemispheric trabecular titanium cup (e.g. MobileLink TrabecuLink Multi Hole) + cancellous allograft (no translational instability)
- Primary cup is not applicable
- Three screws are recommended (two into the iliac bone and one into the ischium to avoid lever arm moment)

Option 2 (poor bone quality):

- Hemispheric trabecular titanium cup (e.g. MobileLink TrabecuLink Multi Hole) + trabecular titanium augment (e.g. TrabecuLink Augment) in type-2 configuration
- Three screws are recommended (two into the iliac bone and one into the ischium to avoid lever arm moment)



Option 1



Option 2

Type IIB

Definition

- Köhler's line: Intact
- Tear drop: Intact
- Ischial lysis: Mild
- Vertical migration: Mild (<3 cm)

Intraoperative findings

- Rim: superior defect
- Acetabular cavity: Spherical cavity
- Stability: Appropriate to moderate. Upper edge of the shell is not covered. Some rotational instability may exist.
- Contact: More than 50 %, usually more than 70 %

Solution

Option 1 (good bone quality or more than 70 % intact rim):

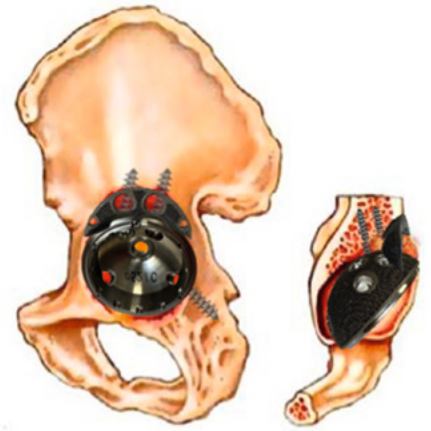
- Hemispheric trabecular titanium cup (e.g. MobileLink TrabecuLink Multi Hole). Bone graft at the top is optional.
- Primary cup is not applicable
- Three screws are recommended (two into the iliac bone and one into the ischium to avoid lever arm moment)

Option 1

Option 2 (poor bone quality or rotation instability with less than 70 % of rim intact):

- Hemispheric trabecular titanium cup (e.g. MobileLink TrabecuLink Multi Hole) + trabecular titanium augment (e.g. TrabecuLink Augment) in type-1 configuration (option A)
- In some cases, with a larger cavitary defect, augment in an oblong configuration can be used assuming some degree of cup uncovering (option B)
- Three screws are recommended (two into the iliac bone and one into the ischium to avoid lever arm moment)

Option 2A



Option 2B

Type IIC

Definition

- Köhler's line: Moderately affected
- Tear drop: Moderate lysis
- Ischial lysis: Minimal lysis
- Vertical migration: Absent

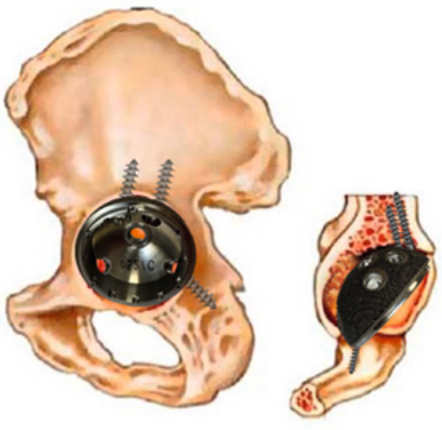
Intraoperative findings

- Rim: Complete
- Acetabular cavity: Medial cavity (medial wall defect but with both columns intact)
- Stability: Appropriate. Risk of medial protrusion if support columns are lost (avoid excessive reaming)
- Contact: More than 70 %

Solution

Option 1:

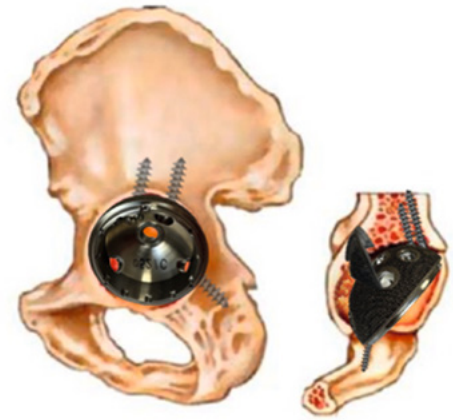
- Hemispheric trabecular titanium cup (e.g. MobileLink TrabecuLink Multi Hole) + cancellous allograft in the acetabular bottom
- Primary cup is not applicable
- Minimum of three screws recommended



Option 1

Option 2 (no complete rim support, medial translation with acetabular impaction)

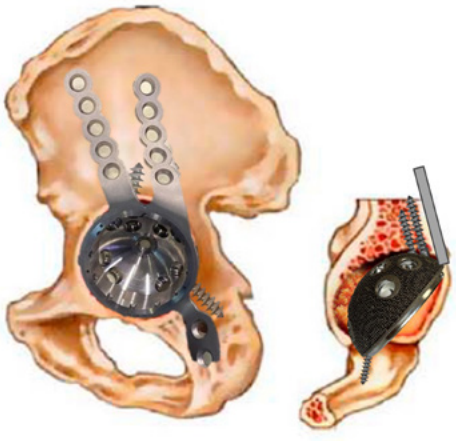
- Trabecular titanium augment (e.g. TrabecuLink Augment) in type-3 configuration (footprint). Keep in mind that the augment does not cover the cup hole.
- Hemispheric trabecular titanium cup (e.g. MobileLink TrabecuLink Multi Hole)
- Minimum of three screws recommended



Option 2

Option 3 (rim with no support and poor bone quality)

- Partial pelvis replacement cup with screws
- In spite of extra-acetabular fixation, cancellous allograft in the acetabular bottom recommended



Option 3

Type IIIA

Definition

- Köhler's line: Intact or partially affected (segmental defects)
- Tear drop: Minimal lysis
- Ischial lysis: minima to mild lysis
- Vertical migration: >3 cm

Intraoperative findings

- Rim: Severe impairment with around 50 % of bone contact. Loss of third contact point (the roof support).
- Acetabular cavity: Superolateral cavity with acetabular roof defect. Posterior wall is usually affected.
- Stability: Inadequate. Translational and rotational instability are present.

Solution

Option 1 (some translational stability)

- Hemispheric trabecular titanium cup (e.g. MobileLink TrabecuLink Multi Hole)
- Long trabecular titanium augment (e.g. TrabecuLink Augment, 20 or 30 mm) in type-1 configuration
- Several screws recommended

Option 1

Option 2 (no translational stability)

- Hemispheric trabecular titanium cup (e.g. MobileLink TrabecuLink Multi Hole)
- Short trabecular titanium augment (e.g. TrabecuLink Augment, 10 or 15 mm) in type-2 configuration as an oblong cup
- Long trabecular titanium augment (e.g. TrabecuLink Augment, 20 or 30 mm) in type-1 configuration
- Several screws recommended
- **NOTE**: Take care to leave some acetabular holes uncovered by the short augment

Option 2

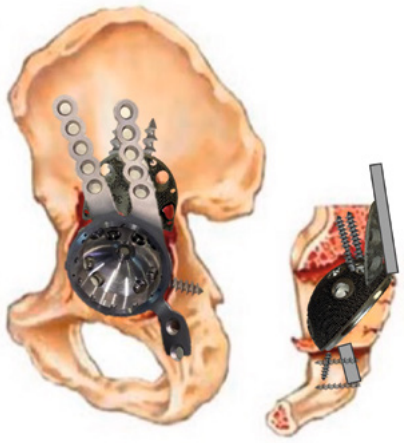
Option 3

- Hemispheric trabecular titanium cup (e.g. MobileLink TrabecuLink Multi Hole)
- Trabecular buttress augment plate (**NOTE**: this augment is available as a custom-made implant)
- Several screws recommended

Option 3

Option 4 (no translational stability and no posterior wall)

- Partial pelvis replacement cup
- Long trabecular titanium augment (e.g. TrabecuLink Augment, 20 or 30 mm) in type-1 configuration
- Cancellous allograft is also recommended



Option 4

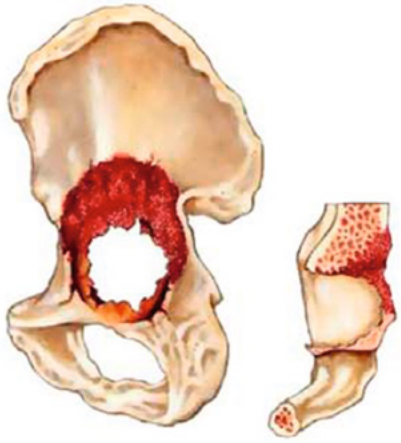
Type IIIB

Definition

- Köhler's line: Severely affected.
- Tear drop: Erased with severe lysis
- Ischial lysis: Severe
- Vertical migration: >3 cm

Intraoperative findings

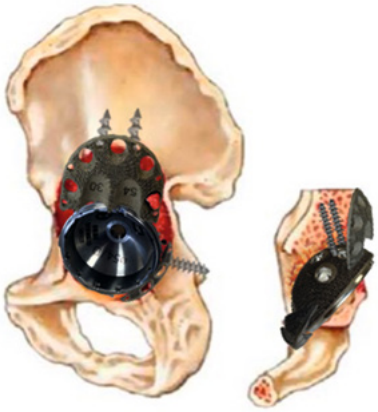
- Rim: Massive ring defect with less than 40 % contact
- Acetabular cavity: Superomedial cavity
- Stability: Inadequate. Complete translational and rotational instability.
- Contact: Less than 40 %



Solution

Option 1

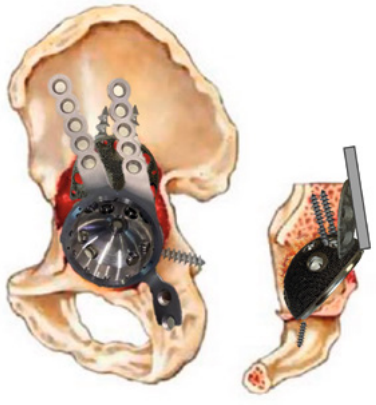
- Hemispheric trabecular titanium cup (e.g. MobileLink TrabecuLink Multi Hole)
- Short trabecular titanium augment (e.g. TrabecuLink Augment, 10 or 15 mm) in type-3 configuration as footprint in the ischium (**NOTE**: Make sure that the augment leaves some free holes for acetabulur screw fixation to the ischium).
- Long trabecular titanium augment (e.g. TrabecuLink Augment, 20 or 30 mm) in type-1 configuration (as buttress or buttress plate augment).
- Cancellous bone allograft and as many screws as possible are recommended.



Option 1

Option 2

- Partial pelvis replacement cup.
- Long trabecular titanium augment (e.g. TrabecuLink Augment, 20 or 30 mm) in type-1 configuration (as buttress or buttress plate augment).
- Cancellous bone allograft and as many screws as possible are recommended (especially in the acetabular cup).



Option 2

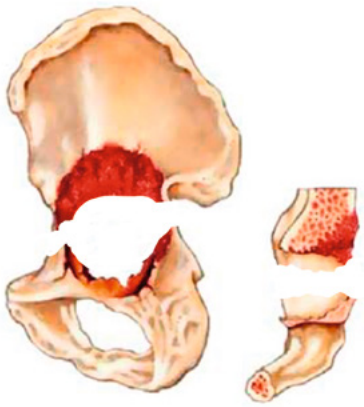
Pelvic discontinuity

Definition

Dissociation between the upper part of the pelvis (ilium) and the lower part (ischium and pubis) as a consequence of a bony defect with no possibility of consolidation.

Intraoperative findings

- Rim: Massive ring defect. Minimal contact
- Acetabular cavity: Nonexistent
- Stability: Inadequate. Impossible to obtain minimal stability with hemispherical cup



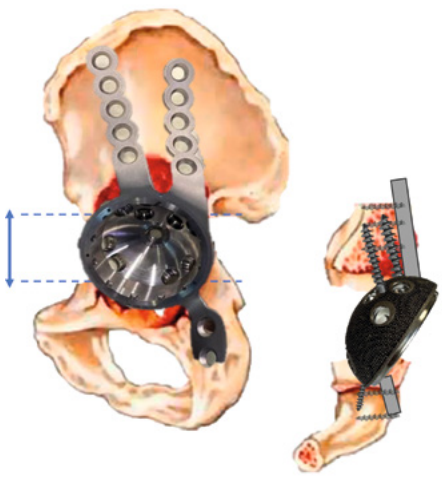
Solution

Option 1: With or without pelvic distraction

- Partial pelvis replacement cup with or without pelvic distraction
- Cancellous bone allograft and as many screws as possible are recommended (especially in the acetabular cup)

Option 2

- Custom-made triflange cage with iliac stem



Option 1

Option 2

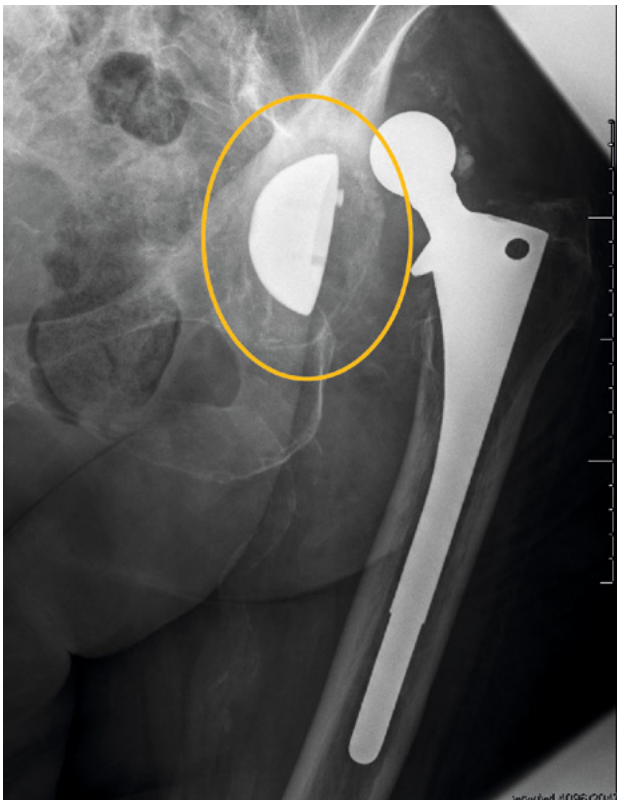
Clinical examples

Clinical case 1

Initial situation

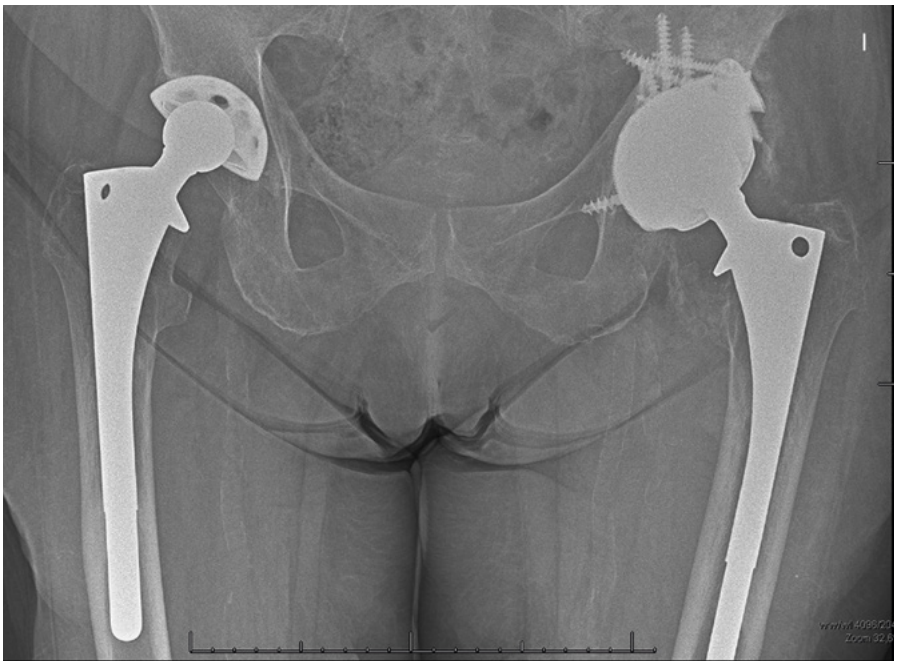
86-year-old female with recurrent dislocation of the left hip. Massive acetabular bone loss around cup due to polyethylene induced osteolysis.

Long femoral head had been used before. Excessive medialization was to be avoided.



Procedure

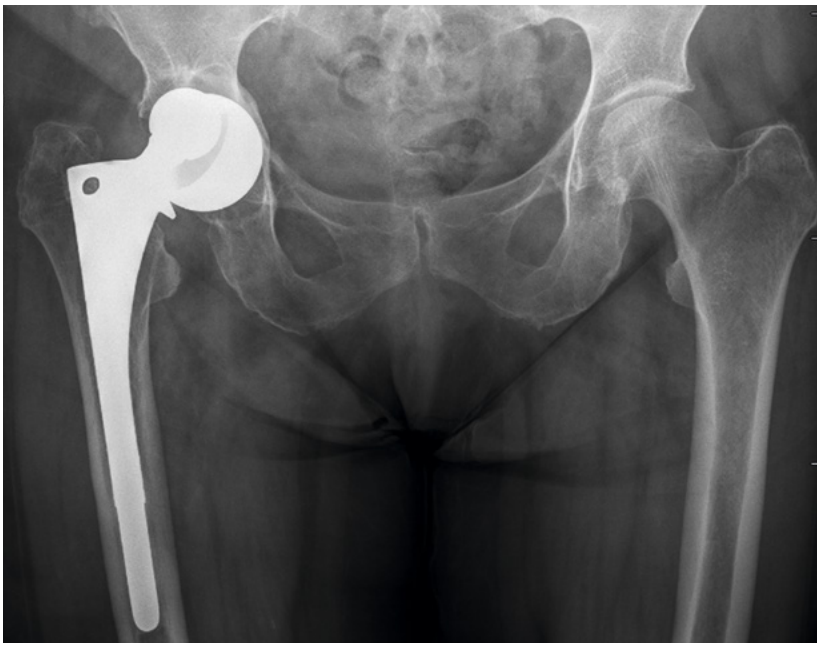
- Reconstruction was carried out with a MobileLink TrabecuLink Multi Hole Cup with several screws. After that, due to uncovering in the superoposterior area, a TrabecuLink Augment was used as buttress fixed with two 4.5 mm screws.
- Face Changer + 4 mm Offset was used to achieve proper tension of the head.
- A Dual Mobility Insert was used to improve stability and reduce the risk of dislocation.



Clinical case 2

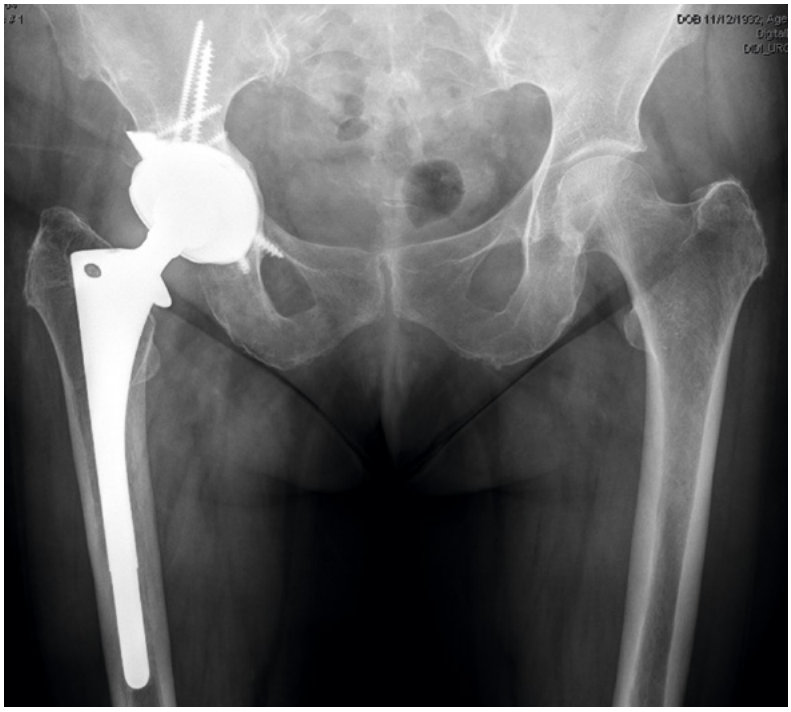
Initial situation

88-year-old female with bipolar head dissociation with medial bone erosion and ischial bone defect.



Procedure

- Reconstruction was carried out with a MobileLink TrabecuLink Multi Hole Cup with several screws. Due to failure of coverage in the superior area, a TrabecuLink Augment was used as oblong cup fixed with two 4.5 mm screws before placement of the cup.
- Face Changer + 4 mm Offset was used to achieve get the proper tension of the head.
- A Dual Mobility Insert was used improve stability and to reduce risk of dislocation.

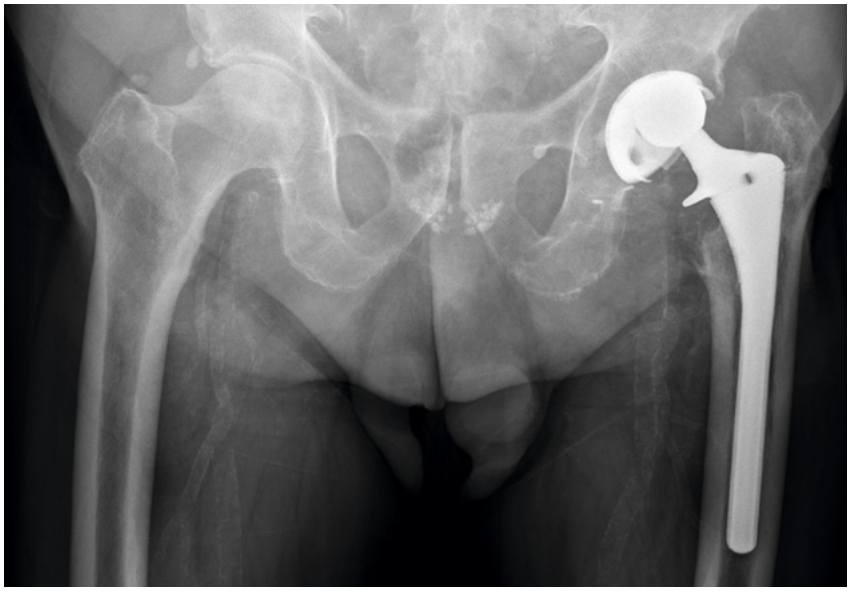


Clinical case 3

Initial situation

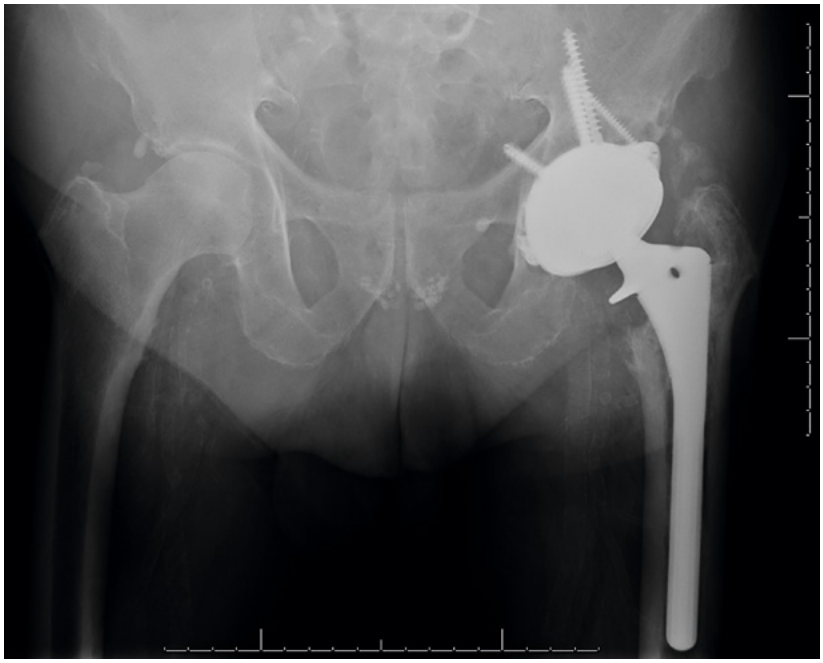
86-year-old male with massive polyethylene wear and metallosis (metal head against metal acetabular cup).

After debridement, severe ischial and posterosuperior bone loss was found.



Procedure

- After reaming, ischial bone loss was resolved with TrabecuLink Augment in type-3 configuration.
- Reconstruction was carried out with a MobileLink TrabecuLink Multi Hole Cup with several screws.
- To avoid translational instability, one TrabecuLink Augment was used as oblong cup fixed with two 4.5 mm screws before placement of the cup.
- A Dual Mobility Insert was used to improve stability and reduce risk of dislocation.

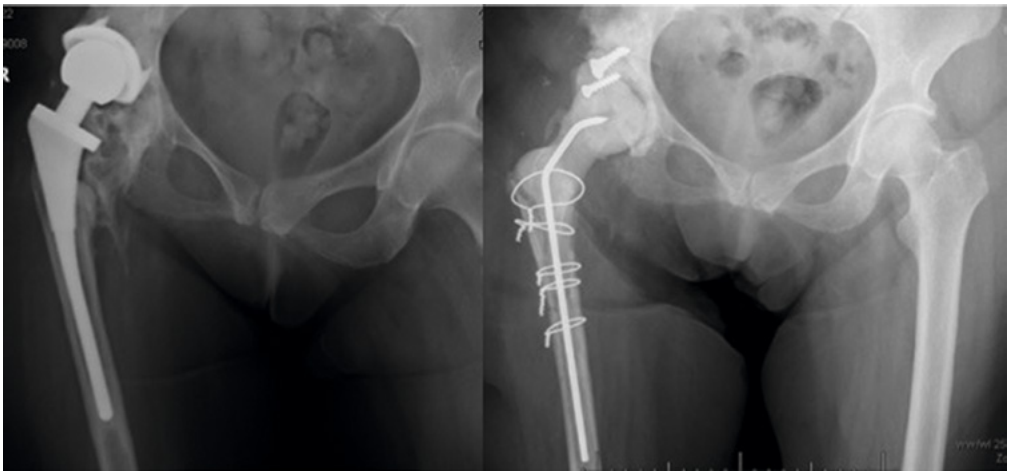


Clinical case 4

Initial situation

49-year-old female with infected total hip prosthesis implanted in a condition of dysplasia, with high center of rotation. Bone ankylosis between lesser trochanter and ischium was present.

First the previous implant was removed. Due to the ankylosis, the transfemoral approach was used. After removal of the amkylotic bone, the true acetabulum was reamed to accommodate the spacer head. Due to a massive superoposterior bone loss necessitated bone cement tectoplasty to improve the stability of the spacer.



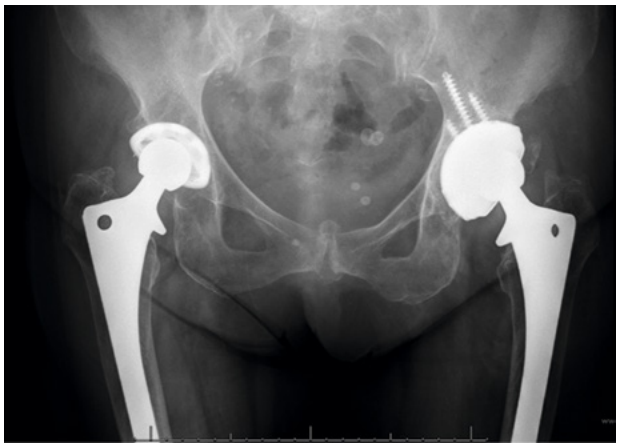
Procedure

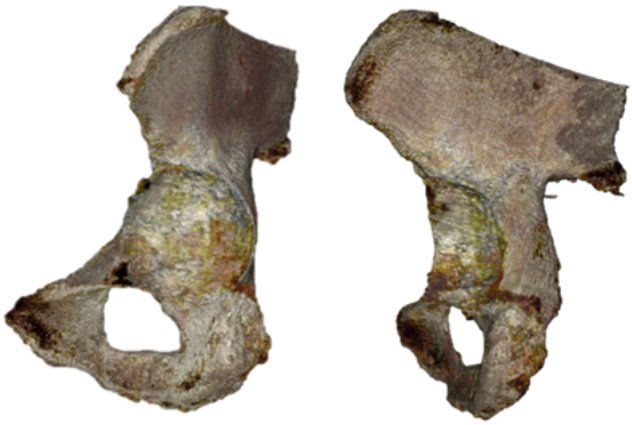
- Reconstruction was carried out with a MobileLink TrabecuLink Multi Hole Cup with several screws.
- A massive segmental bone defect was observed in the posterosuperior part of the acetabulum between 9 and 1 o'clock.
- No translation stability was obtained with the TrabecuLink 54 mm cup.
- TrabecuLink Augment 52/30 mm was fixed prior with two 4.5 mm screws in buttress configuration to restore the segmental defect.
- After augment placement, initial stability was obtained upon cup impaction. Three additional screws in the cup were placed to improve fixation.

Clinical case 5

Initial situation

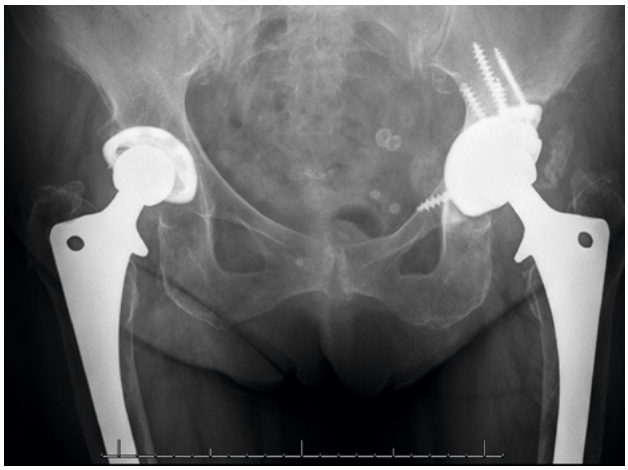
81-year-old male with aseptic loosening of previously implanted acetabular cup due to verticalization. The segmental bone defect in the roof was expected.

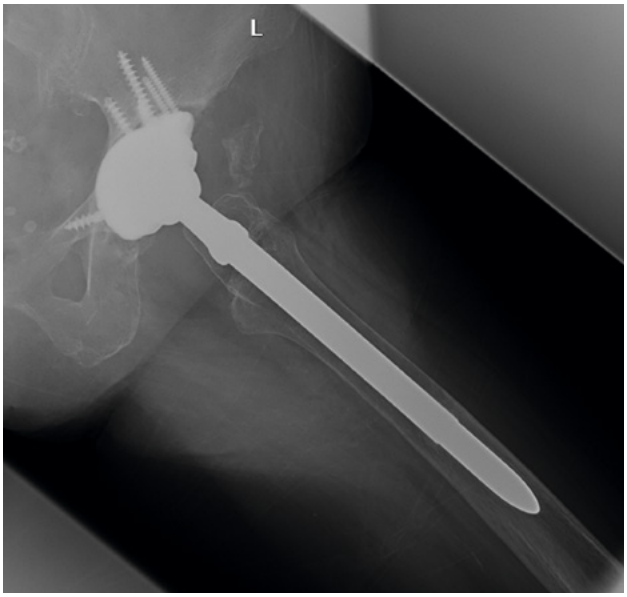




Procedure

- Some medialization is expected to increase bone coverage.
- Reconstruction was carried out with a MobileLink TrabecuLink Multi Hole Cup with several screws.
- Paprosky type IIB was observed. Before cup impaction, a TrabecuLink Augment was fixed with two 4.5 mm screws. Afterwards cup was put in place and secured with three 6.5 mm screws to the ileum and ischium.
- A Dual Mobility Insert was used to improve stability and to reduce risk of dislocation.

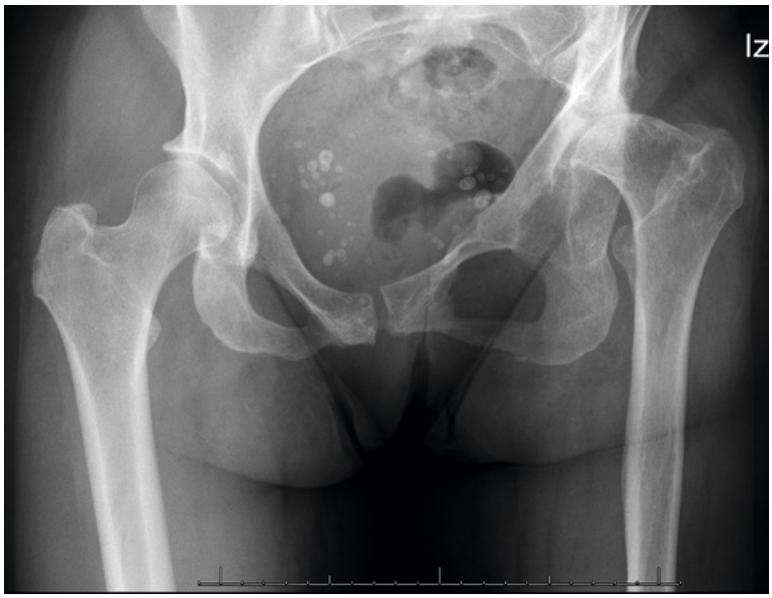




Clinical case 6

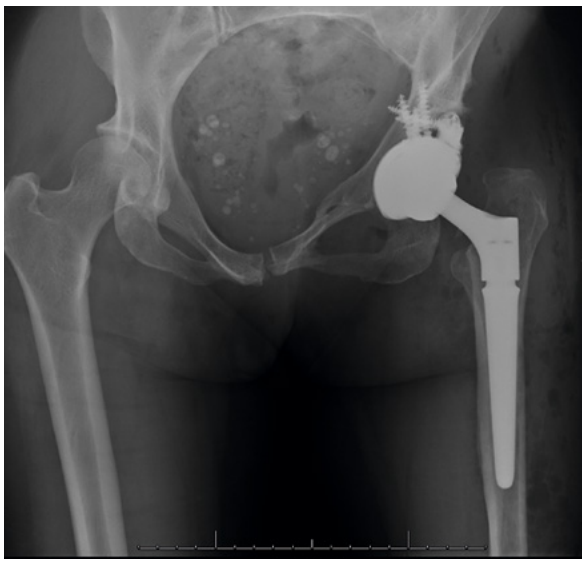
Initial situation

48-year-old female with dysplasia in her left hip, type III Crowe. Elevation of the center of rotation more than 3 cm. The segmental anterosuperior defect was expected.



Procedure

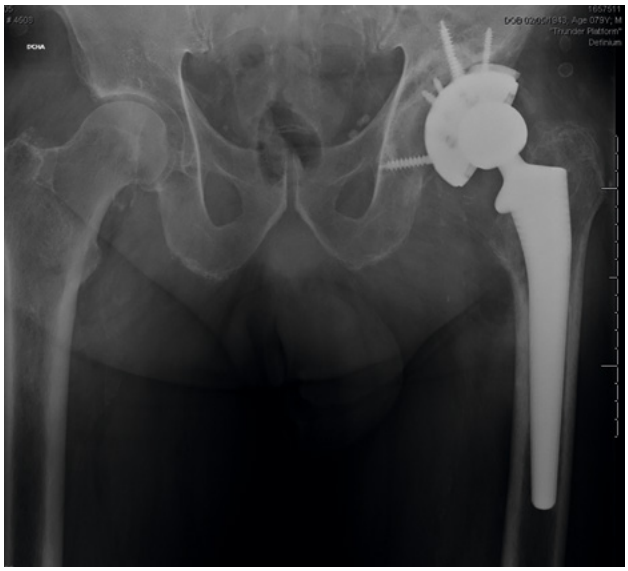
- After reaming in the true acetabulum, the anterosuperior defect was confirmed. Around 40 % of the cup was not covered.
- Reconstruction was carried out with a 48 mm MobileLink TrabecuLink Cluster Hole Cup with three ileum screws.
- Some translational stability was obtained after placement of the cup, so after cup fixation, a 50/30 mm TrabecuLink Augment was used to increase acetabular stability.
- Ceramic-on-ceramic bearing with 32 mm femoral head was used.

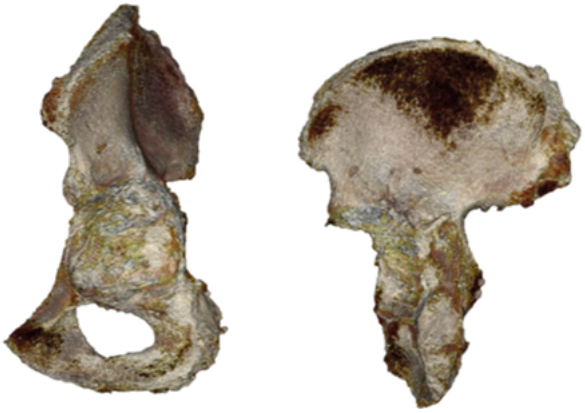


Clinical case 7

Initial situation

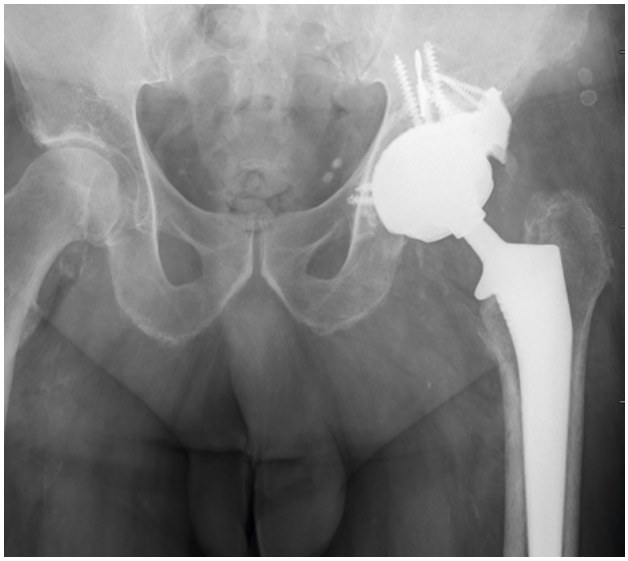
79-year-old male with acetabular loosening of a previously implanted revision cup with titanium augment. Medial and superior bone loss were expected.

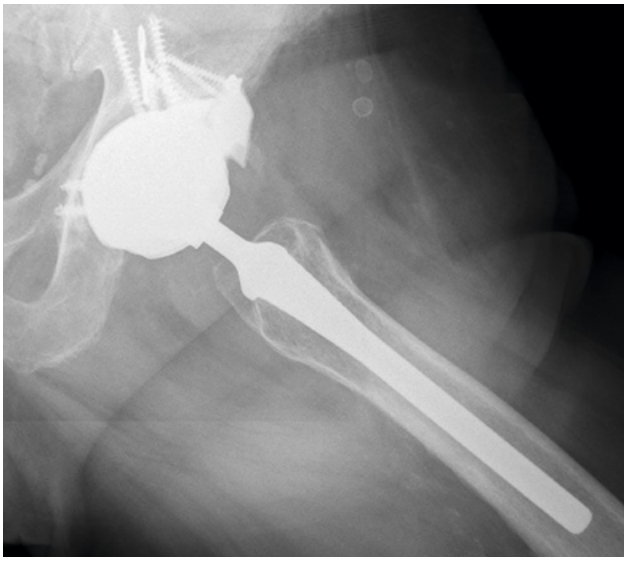




Procedure

- After removal of the old implant (titanium augment was broken), a IIIA bone defect was observed with a segmental defect between 11 and 3 o'clock.
- Reconstruction was done with partial acetabular medialization using a MobileLink TrabecuLink Multi Hole Cup with two augments.
- To get translational stability, one 58/10 mm Trabeculink Augment was placed in the roof with two 4.5 mm screws. After that, the acetabular cup was placed and fixed with three 6.5 mm screws to the ileum and two 6. 5 mm screws to ischium. Due to the extent of the denudation, one 58/30 mm TrabecuLink Augment was used in buttress configuration in order to reconstruct the posterosuperior wall.
- Due to some medialization of the cup, one Face Changer +4 mm offset and 10° inclination was used to reconstruct the center of rotation. Finally, a Dual Mobility Insert was put in place.





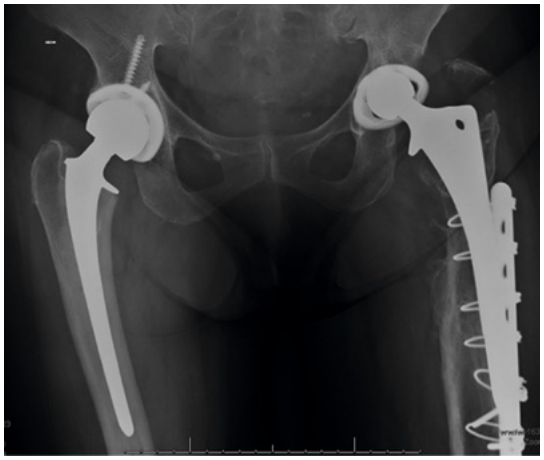
Clinical case 8

Initial situation

77-year-old female with massive acetabular polyethylene wear. The patient had a history of femoral periprosthetic fracture and varus deformity of the proximal femur.

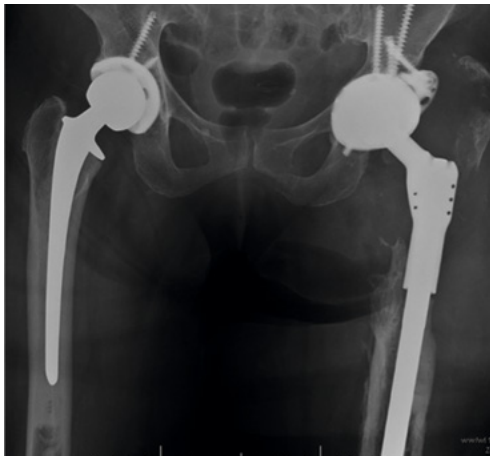
In addition, the patient is undergoing suppressive treatment for low-grade periprosthetic infection (Staphylococcus epidermidis)

Osteolysis was seen in the greater trochanter and its fracture.



Procedure

- All the implants were removed, and the wound was correctly debrided. After that, one stage with intramedullar total femur replacement was planned.
- For the acetabular side, a segmental posterosuperior bone defect was observed with some medial and ischial bone deficiency. A big cup was put in place; however, some translational instability was seen. Therefore a 58/10 mm TrabecuLink Augment was placed and fixed with two screws. Finally, a MobileLink TrabecuLink Multi Hole Cup was implanted and fixed with three screws to the ileum and two to the ischium.
- A Dual Mobility Insert was used without any Face Changer.

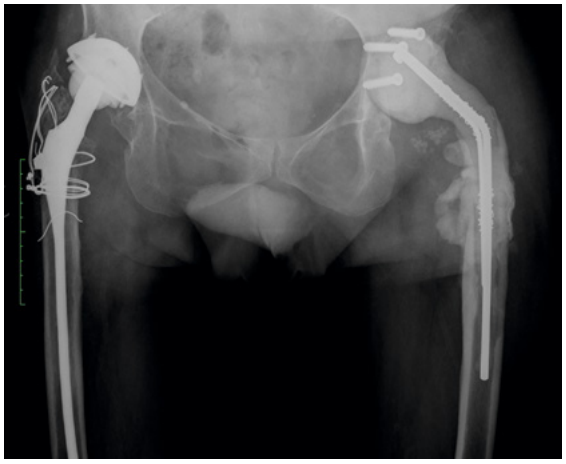


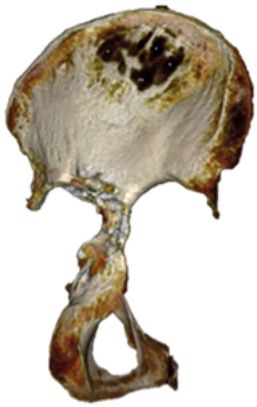
Clinical Case 9 Buttress

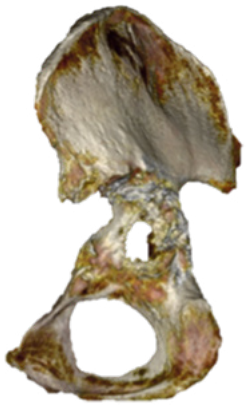
Initial situation

58-year-old male with chronic periprosthetic joint infection in his left hip, with suppression treatment for more than 20 years.

A two-stage procedure was planned. After radical debridement and removal of previous implants, a handmade femoral spacer was put in place. Due to a big segmental posterosuperior bone defect (from 11 to 4 o'clock), the spacer was instable. A tectoplasty creating a cement wall was applied with three screws.

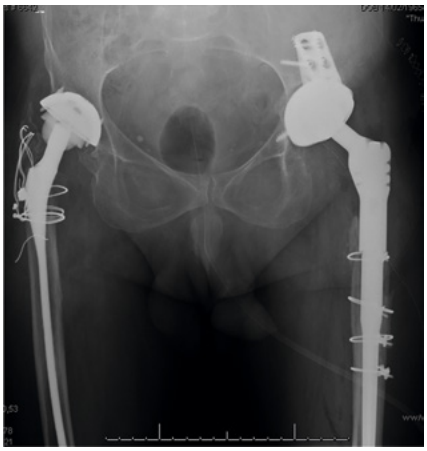






Procedure

- In the second stage, after removal of spacer and cement wall, the bone defect was classified as IIIA affecting especially the superior roof, anterior and posterior wall (see 3D reconstruction scanner).
- The trial cup was completely instable. A normal augment in the buttress configuration failed to get sufficient coverage or anchorage for fixation in healthy bone. This possibility had been assessed pre-operatively, and a custom-made buttress column augment was ordered.
- With a 56 mm trial cup in place, the buttress augment was placed in the position with more coverage and fixed to the ileum with two 4.5 mm screws. After that, bone cement was placed on the interface to establish contact with the cup, and a 56 mm MobileLink TrabecuLink Multi Hole Cup was implanted and secured with two 6.5 mm screws to the ileum, and one to the ischium. No other screws were placed as there was no bone contact in the other cup holes. Another 4.5 mm screw was used in the buttress augment, and the other two screws were finally tightened.
- Due to absence of the greater trochanter a Dual Mobility Insert was used.



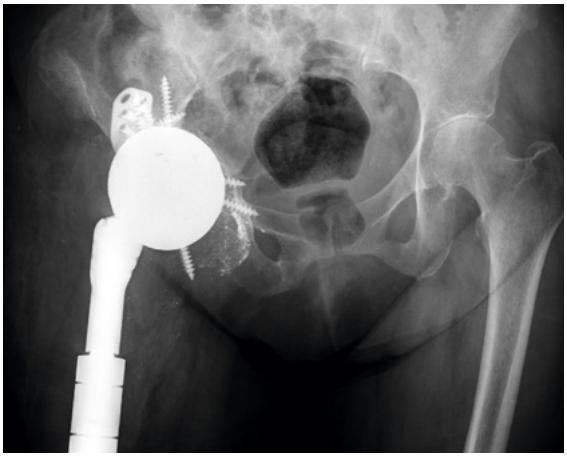
Clinical case 10

Initial situation

79-year-old female with rheumatoid arthritis and history of more than ten hip surgeries. The latest intervention had been a two-stage revision after acute hematogenous infection of cup-cage acetabular reconstruction and proximal femoral replacement.

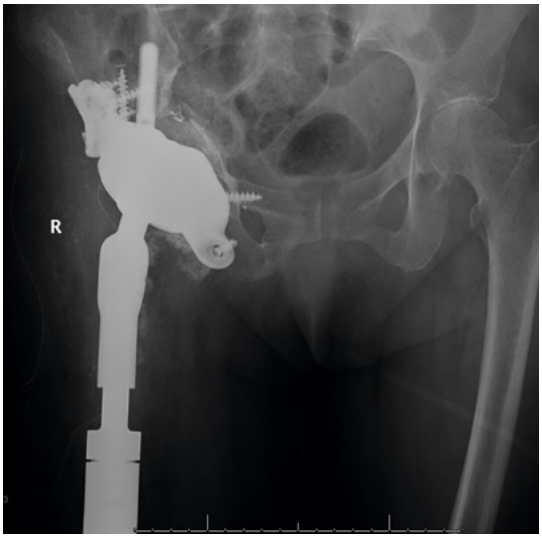
A femoral defect of type IV and type IIIB with pelvis discontinuity was observed, and total femoral replacement and pelvis distraction with a hemicup-cage implant was performed.

Three years later, after getting up from the chair, severe acute groin pain started, and acetabular mobilization was diagnosed.



Procedure

- Massive bone loss with pelvic discontinuity was diagnosed. After the failure of previous options (cup-cage and pelvis distraction), a custom-made triflange was planned.
- No bone support existed in either column. To increase stability of the cage, a trabecular titanium stem was planned to resist the lever arm moment. The inner surface was made modular with MobileLink Inserts and Face Changer. Additional silver coating was requested to decrease the infection risk.
- After removal of the implant, the custom-made triflange cage was used and pre-secured with three screws (one ileum, one pubis and one in the ischium), and the triflange stem was implanted into the ileum bone. Finally, the rest of the screws were fixed.
- A Dual Mobility insert was implanted without the need to use any Face Changer.



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