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Introduction

With the likely increase in both primary and revision surgery expected in the coming years and the changing demographics of the patient population there is a greater emphasis on treating patients as conservatively as possible. The use of hydroxyapatite (HA) coated stems in both primary and revision surgery has provided positive, reproducible outcomes across the range of femoral defects and has shown fast implant-to-bone integration.

CORAIL Revision Stem

The CORAIL Revision Stem is an evolution of the KAR™ stem, specifically for revision surgery. Manufactured from forged titanium alloy, it shares the CORAIL hip’s design rationale of stereostability, macro and micro surface detailing, HA coating, ARTICUL/EZE® 12/14 Mini Taper and is compatible with the range of DePuy Synthes’ High Performance Bearing options. The CORAIL Revision Stem offers the surgeon a range of stems for mild to moderate situations (types 2 and 3A of Paprosky’s Classification) making it suitable for the majority of revision cases. The CORAIL Revision Stem is also indicated for primary implantation in a cavernous femur.

The surgical technique shares a similar procedure for implantation as the primary CORAIL stem. During femoral preparation, reamers are used to calibrate the distal cavity of the femur. Machined diamond-tooth broaches remove cement and/or debris and re-shape the metaphyseal region to a quadrangular envelope with the correct anteversion.

A trial stem is also used to allow verification of the correct preparation of the femur to allow insertion of the final stem.
**Achieving Stem Stability in the Proximal Femur**

As an evolution of the CORAIL primary and KAR revision stems, the CORAIL Revision Stem is designed to achieve secure initial and long term mechanical stability in the femur. It is shaped to resist both axial and torsional loosening forces. In the frontal plane, the stem’s pronounced lateral flare and medial curve provide axial and rotational stability. The lateral flare is fully supported by the infero-lateral aspect of the greater trochanter. In the lateral plane a progressive anterior to posterior tulip flare fills the metaphysis and, in combination with horizontal grooves around the circumference of the stem, further reinforces axial stability.

The well-defined rectangular section and vertical grooves confer rotational stability. The stem’s proximal collar acts as a support to improve axial stability. To compensate for weakness or absence of bone in the calcar region, the use of a structural horseshoe allograft is recommended. The calcar graft is compressed and stabilised by the stem’s collar and is loaded by its medial curve.9,10,11

**Proximal Load Transfer**

The CORAIL Revision Stem has been designed to transfer maximum load to the remaining bone in the proximal femur. As the metaphysis is not intact, stability is achieved through a combination of both metaphyseal and proximal diaphyseal support. The longer stem aids correct axial alignment. To avoid distal load transfer, slots in the coronal and the sagittal planes help to prevent the stem from locking in the isthmus.
Diamond-Tooth Broaches

Machined diamond-tooth broaches are designed to be more aggressive as this is often required during revision surgeries.

The stem is implanted line to line, therefore the femur is prepared using a broach of the same size which excludes the thickness of the HA coating.

HA Coating

The CORAIL Revision Stem is cementless and fully coated with hydroxyapatite to a thickness of 155 microns. The CORAIL stem has a propriety HA coating on the grit-blasted surface. The HA coated medial to lateral taper resists axial / torsional stresses and promotes osteointegration for optimum fixation.

Distal Stem Design

Two distal slots are designed to allow elasticity in the distal portion of the stem which helps in adapting to the patient’s femoral morphology. These distal slots allow fitting of the stem into the femoral canal and thus an insertion of the final implant. The increased flexibility may also minimise the potential for thigh pain and stress shielding in the proximal femur.
For total hip arthroplasty, a common defect categorisation, like Paprosky’s Classification\(^8\), can be used to specify the indications and the surgical strategy.

For Type 1 defects, the standard CORAIL stem is used, except in the case of insufficient primary stability, in which case the CORAIL Revision Stem prosthesis should be used.

The CORAIL Revision Stem is indicated in Paprosky defects Types 2 and 3A.

There are two situations in which the CORAIL Revision Stem is used in primary surgery:

- When dealing with very large cylindrical femurs with thin cortical walls in which the CORAIL stem would not achieve optimum stability – in such cases the CORAIL Revision Stem would be selected as it is longer and enables good primary stability
- In very old patients with osteoporotic bone, the CORAIL Revision Stem makes it possible to achieve good primary stability

(For guidance on primary neck resection please consult the CORAIL primary stem surgical technique.)

For revision total hip arthroplasty, the indication should be confirmed during the procedure after removal of the implant and all cement debris.

In all cases, the stability of the stem must be achieved prior to inserting bone graft. Therefore, the bone graft serves only to fill defects and not to ensure the stability of the stem. A wedge bone graft would fail to achieve sufficient stability and therefore would lead to potential failure of the stem. If insufficient primary stability is observed, a longer, distally locked stem should be used to achieve primary stability.

In the case of defects Type 3B and 4, it is often impossible to achieve primary stability with a CORAIL Revision Stem and therefore a longer, distally locked prosthesis must be used.
Pre-operative Planning

Pre-operative planning is essential for precise reconstruction of the hip joint. The CORAIL Revision Stem prosthesis comes with a comprehensive set of X-ray templates which include a clear indication of the scale used and both standard and high offsets for all sizes of the range. These are used with radiographs showing the AP view of the pelvis and AP and lateral views of the affected femur, covering the full length of the prosthesis to be revised, as well as any occlusion in the distal femoral canal.

The AP view provides the necessary information needed to determine:

- Implant alignment and the size of component required for combination fixation in the metaphysis and diaphysis: in accordance with the philosophy of three-point-contact to ensure good primary stability
- The type of implant, Standard or High Offset. Associated with neck length, this choice allows restoration of the offset, leg length and patient’s natural anatomy
- Dedicated witness marks on both the X-Ray templates and the trial stems define the required level of implantation, described as the ‘minimal embedding level’ – this ensures adherence to the three-point-contact design philosophy.
- Where necessary, the appropriate height of calcar bone grafting required
- Make note of anatomical landmarks (e.g. pelvic tear drop, greater trochanter etc) in relation to the templated stem for implant and trial intra-operative reference points

The lateral view may then be used to confirm implant version and alignment, to identify any defects that cannot be seen on the AP view and to check the compatibility of the stem with the femoral curvature.

A transfemoral approach to retrieve the femoral implant is not a contraindication for the CORAIL Revision Stem. The level must be defined using x-ray templates and be above the longitudinal distal slots.
Step 1: Surgical Approach

Any of the standard surgical approaches may be used to implant the CORAIL Stem or CORAIL Revision Stem.

The CORAIL Revision Stem can be implanted using either of two instruments sets – the full/stand-alone CORAIL Revision Stem instrument set which comprises both the Core Instrumentation and Femoral Preparation Instruments; or the CORAIL Revision Stem upgrade set, which is opened alongside a standard CORAIL instrument set and contains only the Femoral Preparation Instruments.

*Note* Prior to surgery, the instruments should be checked for damage or wear. All assembly/dissassembly instructions should be tested to avoid any peri-operative issues related to the use of instruments.
Step 2: Femoral Canal Preparation

Distal Reaming
Once the failed implant has been retrieved, the femur is cleared of any remaining cement or debris, if present. Rigid reamers are available in a range of sizes that should be used sequentially to prepare the distal femoral canal.

Reaming should begin in a central position in alignment with the intramedullary canal. A 10 mm reamer can be used as a starter to allow the easy introduction of the 11 mm reamer. It may be necessary to increase the size of the reamer to a 12mm or 13mm to allow free passage of the trial stem to the desired depth. In all cases, trialling should be performed to evaluate stem seating and stability.

Each rigid reamer has mechanical engravings showing the desirable depth of reaming, corresponding to each stem length (lengthened by 10 mm to take into account the tapered shape) as referenced from the tip of the stem to the shoulder of the stem.

Note: The use of a transfemoral approach can be used during the implantation of a CORAIL Revision Stem. Generally, the femoral tube is closed by cerclage wiring to reconstruct the femoral shaft, and then the femoral preparation is carried out as it would be for a closed femur procedure. The primary stability of the stem inside the host bone is the limiting factor.
**Step 3: Metaphyseal Preparation**

Access to the femoral canal should be enlarged laterally into the greater trochanter, using a box chisel, to ensure that the broaches do not enter the femur in varus. The first broach, with a size adapted to the defect, is attached to the broach handle and the proximal femur is prepared by progressively increasing broach sizes.

The CORAIL Revision Stem instrument set contains both size 8 and size 9 diamond-tooth broaches which can be used as ‘starter’ broaches.

The preparation of the proximal femur requires the metaphyseal region to be re-shaped to a quadrangular bone cavity aiming for the correct pre-operatively planned anteversion by using the broaches. It is essential that the final broach is completely rotationally and axially stable in the femur in order to ensure stem stability in the metaphysis. To test for appropriate stability, rotational and axial pressure should be applied to the broach handle without movement of the broach inside the femoral canal. Distal stem stability alone is not sufficient.

If necessary, the calcar mill can be used carefully on the remaining calcar in order to produce a flat surface upon which to seat the implant collar & prevent the formation of stress raisers.

**Important note:** The Revision broaches are intended for preparation of CORAIL Revision stems only.

**Recommendation:** To ensure correct seating and no distal restriction a trial reduction should be performed using the corresponding trial stem.

**Note:** The Revision broaches are intended for preparation of CORAIL Revision stems only.
Step 4: Trial Stem Introduction

The final broach is extracted and the trial stem of the same size is attached to the broach handle. The trial stem is lightly inserted into the femoral canal using a hammer. It should be stable at the level defined during pre-operative planning relative to the greater and lesser trochanter.

It may be necessary to ream distally using the 12 mm or 13 mm reamers to allow free passage of the trial stem to the desired depth.

If the trial stem is not stable, a trial stem one size larger can be tried in order to obtain stability at the correct level. In case visual access is available, it can be useful to check that the ‘minimal embedding level’ is reached using the dedicated witness groove on the trial stem.

**Note:** The trial stem should seat at the same height as the broach. If it seats higher it may then be necessary to use the 13 mm reamer to open the canal distally.
Step 5: Neck and Head Trialling

The required trial neck is then attached into the trial stem. Two options are available, standard (STD) and high offset (KHO).

The high offset variant offers up to 7 mm of direct lateralisation, depending on the size and will increase soft tissue tension without affecting leg length.

A trial head is placed on the neck of the trial stem, and the hip is reduced and assessed for stability, through a full range of motion.

Note: When using the CORAIL Revision Stem upgrade set, care should be taken not to use the coxa-vara trial neck (KLA) which is available as part of the CORAIL primary instrument set.
Step 6: Definitive Stem Introduction

Important note: The protective covers should be left on until the components are ready to be implanted. Before implanting a femoral head, the male taper on the femoral stem should be wiped clean of any blood, bone chips or other foreign materials.

The definitive implant of same size as the trial stem and same offset as the trial neck is inserted into the femoral canal. The introduction is managed using the stem impactor while ensuring the correct restored anteversion is applied.

The stem is cautiously impacted using a hammer while avoiding any impact on the neck.

Where a horseshoe-shaped structural allograft is used, this should be placed to fill the defect before final impaction. The graft will be stabilised by the collar after final impaction. The goal of this calcar graft is to ensure the right level of implantation and minimise the potential for subsidence.

An optional reduction using a the trial head can be done at this stage.

Note: Primary stability of the implant at this stage is crucial.
Clean and dry the stem taper carefully to remove any particulate debris. Place the femoral head onto the taper and lightly tap using the head impactor. Ensure bearing surfaces are clean and avoid any damage to the bearing surface during reduction.

**Note:** A DePuy Synthes 12/14 ARTICUL/EZE modular head must be used.

### Step 8: Post-operative Protocol

The post-operative management of the patient, including the extent to which weight bearing is permitted, is defined by the surgeon according to quality of the bone stock and the stability of the implant. Immediate weight bearing can thus be considered for primary or revision surgery if adequate bone stock remains.

In all the cases, the duration of protected weight bearing is dependent upon the condition of the femur and radiological evidence of osteointegration and if applicable, the consolidation and/or healing of the transfemoral osteotomy or the femoroplasty. This is generally reached after 45 days.
Case Study 1
Pre-op: Revision of a loose cemented femoral stem (Paprosky Type 3A) was performed in 1992. Subsidence of the loose stem and thinning of the lateral cortex are observed.

6-months post-op: Follow-up shows good alignment of the KAR prosthesis and placement of a calcar graft under the collar.

5 years post-op: The patient is satisfied with his hip replacement. The prosthesis is stable. Extensive regeneration of both cortices with endosteal ossification is evident.

Case Study 2
Pre-op: Revision of a loose cemented femoral stem (Paprosky Type 2) was performed in 1991.

Post-op: The radiograph at 12-months shows a good result achieved with the KAR femoral stem both in terms of stability and restoration of the centre of rotation.

10 years post-op: The patient is asymptomatic and is satisfied with the hip replacement. Restoration of bone density is satisfactory and implant stability is confirmed.

Case Study 3
Pre-op: Revision of a loose cemented femoral stem (Paprosky Type 2) was performed in 1993.

Post-op: A radiograph taken at 2 weeks follow-up shows good stability of the KAR femoral stem, both in the proximal and distal regions. A cortical window has been used to remove the cement restrictor. The metaphysis has been bone grafted, and the calcar reconstructed using a substantial allograft.

5 years post-op: The patient is satisfied with his hip replacement. Good bone ingrowth can be noted, with signs of endostomal bone formation and restoration of adequate cortical density. No radiolucency is observed.
### Ordering Information: Implants

<table>
<thead>
<tr>
<th>CORAIL Revision Stem</th>
<th>ARTICUL/EZE BIOLOX® delta Heads</th>
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<tbody>
<tr>
<td>L98010 CORAIL Revision Stem STD 10</td>
<td>1365-28-310 ARTICUL/EZE BIOLOX delta Head 28 mm +1.5</td>
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<td>L98011 CORAIL Revision Stem STD 11</td>
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<td>L98120 CORAIL Revision Stem HO 20</td>
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All 12/14 heads available in the DePuy Synthes portfolio are compatible with the CORAIL Revision Stem with a maximum offset of 13 mm:

- “Classical” heads: all 12/14 ARTICUL/EZE, 12/14 CoCr, 12/14 BIOLOX femoral heads, aSPHERE ARTICUL/EZE 12/14
- In case of ceramic head revision, BIOLOX delta TS heads should be used, as these are designed for revision of BIOLOX ARTICUL/EZE heads.
### Ordering Information:

#### Instruments

#### Femoral Preparation Instrument Trays

- **L98704** CORAIL Revision Set Femoral Preparation - Lid
- **L98703** CORAIL Revision Set Femoral Preparation - Top
- **L98702** CORAIL Revision Set Femoral Preparation - Middle
- **L98701** CORAIL Revision Set Femoral Preparation - Bottom
- **L98700** CORAIL Revision Set Femoral Preparation - Base

#### Femoral Preparation Set Parts

- **L98610** Reamer - Diameter 10 mm
- **L98611** Reamer - Diameter 11 mm
- **L98612** Reamer - Diameter 12 mm
- **L98613** Reamer - Diameter 13 mm

Note: Revision broaches are not intended for use with the Primary stem.

- **L98408X** Diamond-tooth Broach - size 8
- **L98409X** Diamond-tooth Broach - size 9
- **L98410X** Diamond-tooth Broach - size 10
- **L98411X** Diamond-tooth Broach - size 11
- **L98412X** Diamond-tooth Broach - size 12
- **L98413X** Diamond-tooth Broach - size 13
- **L98414X** Diamond-tooth Broach - size 14
- **L98415X** Diamond-tooth Broach - size 15
- **L98416X** Diamond-tooth Broach - size 16
- **L98418X** Diamond-tooth Broach - size 18
- **L98420X** Diamond-tooth Broach - size 20

- **L98510** Trial Stem - Size 10
- **L98511** Trial Stem - Size 11
- **L98512** Trial Stem - Size 12
- **L98513** Trial Stem - Size 13
- **L98514** Trial Stem - Size 14
- **L98515** Trial Stem - Size 15
- **L98516** Trial Stem - Size 16
- **L98518** Trial Stem - Size 18
- **L98520** Trial Stem - Size 20

#### Core Instrument Trays

- **L98706** CORAIL Revision Set Core Instrument - Lid
- **L20503** Superior Thermoformed Tray
- **L98705** CORAIL Revision Set Core Instrument - Middle Tray
- **L20501** Inferior Thermoformed Tray
- **L98707** CORAIL Revision Set Core Instrument - Base

#### Core Instrument Set Parts

- **1524-00-000** Hudson Müller Adaptor
- **2001-65-000** Head Impactor
- **2002-31-000** Osteotome
- **2530-69-000** Trial Head 22,2 mm +4
- **2530-70-000** Trial Head 22,2 mm +7
- **2530-81-000** Trial Head 28 mm +1,5
- **2530-82-000** Trial Head 28 mm +5
- **2530-83-000** Trial Head 28 mm +8,5
- **2530-84-000** Trial Head 28 mm +12
- **2530-91-000** Trial Head 32 mm +1
- **2530-92-000** Trial Head 32 mm +5
- **2530-93-000** Trial Head 32 mm +9
- **2530-94-000** Trial Head 32 mm +13
- **2570-04-100** Calcar Mill Small
- **2570-04-200** Calcar Mill Large
- **2598-07-570** Straight Two-Piece Impactor
- **2570-05-100** Stem Impactor
- **9522-11-500** Curved Broach Handle
- **9653-68-000** Anteversion Axis
- **L94005** CORAIL Neck Segment 135° Standard Offset (STD)
- **L94006** CORAIL Neck Segment 135° High Offset (KHO)
- **L20440** Neck Resection Guide
- **L93205** Bone Impactor
- **L93606** Bone Tamp

#### X-Ray Templates

- **CALQ430** CORAIL Revision Stem - Scale 100%
- **CALQ431** CORAIL Revision Stem - Scale 115%
- **CALQ432** CORAIL Revision Stem - Scale 120%

#### DNIs

- **L98714** DNI CORAIL Revision Stem STD 14 HA

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Chemin du Pré Fleuri, 3,  
CH-1228 GENEVA - Plan les Quates  
Switzerland*
## Technical Specification

### CORAIL Hip System - Revision Standard Offset Stem

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### CORAIL Hip System - Revision High Offset Stem

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References


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