Endoscopy for Cement Removal in Revision Arthroplasty of the Hip

Govaers K, Meermans G, Neyt J

Introduction

Today arthroscopy and endoscopic techniques are part of the everyday work of an orthopedic surgeon. The indications for minimal invasive and endoscopically assisted surgery seem to be unlimited. Orthopedic surgeons have always been attracted to endoscopic inspection of the medullary canal. Intramedullary bone endoscopy, intraosseous endoscopy, bone marrow endoscopy and medulloscopy are synonyms to describe visual inspection of the intramedullary canal. Most of the clinical experience so far focuses on endoscopically assisted cement removal in revision hip arthroplasty. Endoscopy has also been used to assist pedicle screw placement, core decompression, autogenous bone grafting, canal preparation in primary hip arthroplasty and inspection of the medullary canal in septic nonunions of long bones.

Experimental Studies

Köster G and Willert H. were the first to report on an autopsy study in which 8 femoral canals were inspected after removal of the femoral stem. The endoscopically analyzed implant beds in the failed cemented prosthesis showed cracks or fractures of the cement mantle in all cadaver specimens. Cement defects came out to be an origin of the cracks. Köster observed that granulomatous tissue was protruding into the cement fissures. The endoscope was introduced additionally from distal to proximal via an approach prepared through the intercondylar fossa. The canal was simultaneously visualized from both the proximal and distal ends. An experiment has been described by Oberst in which he used a modified endoscope initially constructed for endoscopic varicotomy to perform endoscopic control in 4 tibias of above knee amputations. They combined this with measurement of the intramedullary pressure during intramedullary bone endoscopy. The highest peak pressure during placement of the scope in the tibial canal was 125 mm Hg.

Roberts and co-authors assessed the ability of 3 standard endoscopic instrument sets to access the length of the intramedullary canal. To our knowledge, they are the first to introduce the term "medulloscopy." They tested the ability of a standard knee arthroscope, a hip arthroscope and a flexible rhinolaryngoscope to visualize the intramedullary canal of the tibia. The best visualization was obtained using the flexible scope (inspection of 84% of the canal). They conclude that the proximal aspect of the intramedullary canal of the tibia can be visualized using standard knee and hip arthroscopic equipment. A flexible rhinolaryngoscope was required to access the distal tibia.
At the University of Cologne a modified intracorporeal lithotripter (Swiss OrthoClast®) was tested for the removal of bone cement. They designed an endoscope (the OrthoScope) to position this chisel in the femur. Conventional removing techniques with mallets and chisels were compared to this pneumatically powered chisel on formalin fixation human femora. In their experiments the intrafemoral pressure distally to the device and the cement layer was also tested. An effective fragmentation of the cement was achieved. On their cadaver femora no bone damage occurred microscopically and radiologically. There was no development of heat or toxic products and the intrafemoral pressure was the lowest possible (7 mbar).

Few research papers describe the use of bone endoscopy in an animal model. Stauber et al.9 performed intraosseous endoscopy to assist placement of pedicle screws in three adult sheep. Using a fiber optic endoscope direct examination of the interior of 22 pedicle screw holes was performed. Nine deliberate and two unintentional perforations were easily recognized. Defects as small as 2 mm in diameter, not detected on palpation with a standard probe, were able to be closely inspected. They conclude that intraosseous endoscopy may serve as a useful adjunct in the placement of pedicle screws. Vascular catheterization techniques were used by Sans10 to allow access to the entire marrow cavity through a minimal percutaneous approach. They developed a device to reach the epiphysis of the long bone and performed both animal and human anatomical cadaver experiments. They described it as an alternative technique when a direct approach to the lesional site in long bones is dangerous or impossible. They promoted this in cases of preventive cement injections in “weak end bones”. Recently Oberst11 from Freiburg reported on endoscopically assisted fracture reduction of long bones. An artificial tibial shaft fracture was created on three human tibial cadaveric bones. The endoscope was inserted at the standard entry portal for intramedullary nailing. At the level of the fractures, the surgeons achieved a closed reduction by “looking around” for the distal part of the fracture by using the stiff endoscope similarly to a joy-stick. The endoscopic tool was pushed down the medullary canal into the distal fragment in the way that a guidewire would be placed.11 The experimental results on medulloscopy are summarized hereafter in Table 16.1.

### Medulloscopy in Primary and Revision Hip Arthroplasty

#### PRIMARY TOTAL HIP ARTHROPLASTY

Preparation of the femoral shaft in primary total hip arthroplasty (THA) is routinely performed without direct visualization of the endomedullary canal. Endoscopy of the femoral

<table>
<thead>
<tr>
<th>Author</th>
<th>N° Specimens</th>
<th>Indication</th>
<th>Scope used</th>
<th>Experimental findings</th>
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<td>Oberst³</td>
<td>4 cadaver tibiae</td>
<td>Varicotomy endoscope</td>
<td>No intramedullary peak pressure.</td>
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<tr>
<td>Oberst, Bosse, Holz²²</td>
<td>2 femurs, 2 tibias</td>
<td>Medulloscopy</td>
<td>Wolf endoscope</td>
<td>Neocavum can be made in which endoscopy manipulation is possible.</td>
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<tr>
<td>Roberts⁷</td>
<td>Cadaver tibia</td>
<td></td>
<td>Hip arthroscope Knee arthroscope Rhinolaryngoscope</td>
<td>Flexible scope best for distal inspection.</td>
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<tr>
<td>Stauber¹³</td>
<td>3 adult sheep</td>
<td>Pedicle screw placement</td>
<td>Scope used 3 mm, 30° angled arthroscope</td>
<td>11 perforations out of 22 pedicle screw holes.</td>
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<tr>
<td>Köster⁶</td>
<td>6 autopsy femurs</td>
<td>Cement removal</td>
<td>6.5 mm, 30° angle Hopkin’s telescope with rinse-suction shaft</td>
<td>Cement cracks seen in well-fixed stems</td>
</tr>
<tr>
<td>Oberst¹¹</td>
<td>3 cadaver tibia’s</td>
<td>Endoscopic fracture reduction</td>
<td>Intramedullary bone endoscope</td>
<td>Scope used as ‘joystick’ for fracture reduction without fluoroscopy</td>
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Table 16.2: Clinical studies

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<td>Basset^14</td>
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<td>3 mm arthroscope</td>
<td>2 articular penetrations</td>
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<td>Berman^6</td>
<td>44</td>
<td>Revision hip arthroplasty</td>
<td>Needle arthroscope</td>
<td>50% reduction femoral penetration</td>
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<td>Bojkow WP,</td>
<td>350</td>
<td>Endoscopically assisted fracture reduction</td>
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<td></td>
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<tr>
<td>Karalin AN^15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Campbell^16</td>
<td>2</td>
<td>Cemented revision hip arthroplasty</td>
<td>Arthroscope</td>
<td>Use of pneumatically powered ballistic chisels</td>
</tr>
<tr>
<td>Drake C^17</td>
<td></td>
<td>Cement removal in revision hip arthroplasty</td>
<td>Orthoscope</td>
<td></td>
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<tr>
<td>Gerber SD^18</td>
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<td>Arthroscope</td>
<td></td>
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<tr>
<td>Govaers K^19-21</td>
<td>178</td>
<td>Canal preparation in primary total hip</td>
<td>10 mm laparoscope</td>
<td>Reduced need for trochanteric osteotomies</td>
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<td></td>
<td></td>
<td>arthroplasty</td>
<td></td>
<td></td>
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<tr>
<td>Govaers K^19-21</td>
<td>107</td>
<td>Cement removal in revision hip arthroplasty</td>
<td>5 and 10 mm laparoscope</td>
<td>Improved accuracy, one accidental perforation</td>
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<tr>
<td>Govaers K^19-21</td>
<td>30</td>
<td>Core decompression in osteonecrosis</td>
<td>5 mm laparoscope</td>
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<td>Härle^22</td>
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<td>Osteomyelitis septic revision THA</td>
<td>Ossoscope</td>
<td>Visually monitored removal of marrow cement</td>
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<td>Johnson LL^23</td>
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<td>5 tibial nonunions, 4 humeral nonunions</td>
<td>4 mm arthroscope</td>
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<td>Kim SJ^24</td>
<td>8</td>
<td>Endoscopic bone graft of 4 humeral shaft and 4 femoral shaft nonunions</td>
<td>Arthroscope</td>
<td>Refreshment of fracture + endoscopic bone grafting under direct vision</td>
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<td>Köster^4</td>
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<td>Stortz intraosseous endoscope</td>
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<tr>
<td>Lavenna CJ^25</td>
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<td>Arthroscope</td>
<td>Arthroscopic debridement of pelvic osteolyses</td>
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<tr>
<td>Lu^26</td>
<td>1</td>
<td>Replacement DHS</td>
<td>Arthroscope</td>
<td>Endoscopy of new portal of screw canal</td>
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<tr>
<td>Morgan-Jones RL</td>
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<td>Arthroscopic pin track debridement</td>
<td>Arthroscope</td>
<td></td>
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<tr>
<td>Roberts^9</td>
<td>28</td>
<td>Cement removal lost of reamer</td>
<td>Orthoscope</td>
<td>1 cortical fissuring</td>
</tr>
<tr>
<td>Porsch^28,31</td>
<td>7</td>
<td>Septic nonunion femur and tibia</td>
<td>5 mm laparoscope and 4 mm arthroscope</td>
<td>86 % visualization nonunion</td>
</tr>
<tr>
<td>Ruch DS^32</td>
<td></td>
<td>Core decompression of the hip</td>
<td>Hip arthroscopy</td>
<td>Placement of guidewire within the center of the infarct</td>
</tr>
<tr>
<td>Stricker SJ^33</td>
<td>3</td>
<td>Femoral head chondroblastoma</td>
<td>Video arthroscope</td>
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<tr>
<td>Toms AD^34</td>
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<td>Revision hip arthroplasty</td>
<td>Cystoscope</td>
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canal was used at our hospital to evaluate third generation canal preparation techniques with the use of a 10 mm Ø, 0° laparoscope (Figure 16.1). We inspected more than 250 femoral canals during canal preparation in revision hip arthroplasty.
Cement within Cement Revision THA

Cement within cement revision of the femoral component is occasionally used in revision hip arthroplasty provided the existing cement mantle is stable, intact and there is room for recementation of a new implant. Campbell reports on 2 cases in which a classic arthroscope is used to assist in the preparation of the cement mantle for cemented revision hip arthroplasty.

They described the use of an arthroscope for the assessment of the integrity of the cement mantle (Figure 16.2) to access the removal of the previously inserted distal cement centralizer and to assist in the preparation of the cement mantle for recementation. A 4 mm arthroscope was used to irrigate and simultaneously visualize the cement mantle. The arthroscope allowed excellent visualization of the cement mantle and confirmed the absence of cracks or defects in the two described cases. A high speed drill was used to roughen the cement mantle and to remove the corrosion and biological film from the interface. Under endoscopic control the drill was used to abrade the existing cement mantle. A new femoral component was inserted into the intact existing cement mantle.

Cement Removal in Revision THA

Arnold Berman is, to our knowledge, the first orthopedic surgeon who described in 1987 the use of an arthroscope to assist cement removal in revision hip surgery.

He used an arthroscope to enhance visualization during cement removal. Sixty-three total hip revisions were divided into two groups comparing 21 trochanteric osteotomised revisions to 44 with trochanteric sparing techniques. In the nonosteotomized group there was a 21% decreased blood loss, a 14% decrease in persistent abductor weakness and a 14% decrease in subluxation and dislocation. Furthermore, there was a 30% decrease in operating time and 50% reduction in intraoperative femoral perforation.

In a multicenter prospective study of 107 cases, we evaluated the usefulness of endoscopy in the reduction of complications during cement removal in revision hip arthroplasty. A detailed description of our findings is given below.

Porsch introduced a miniaturized chiselling system (Swiss OrthoClast®) that allows endoscopically controlled cement removal. It uses simple ballistic principles to fracture the bone cement. Inside the handpiece is a projectile accelerated that strikes the chisel head. In a prospective, international, multicenter study they published on their first 28 patients. The average duration of cement removal was 32 min (13 to 75 min). In all but one case, the cement was completely removed and they only had one case of cortical fissuring.

The same pneumatically-powered ballistic chisels under endoscopic control have been published by Drake and Ezzet. They described the use of this system in 15 complex...
femoral revision hip arthroplasty where normally an extended trochanteric osteotomy was anticipated. Fourteen cases had well fixed distal cement and 1 case was a well-fixed cementless component. In all 15 cases (100%), the femoral component was successfully revised without a trochanteric osteotomy. Three cases required a small single femoral window less than 1 cm. In total, 80% of the cases (that would normally require an osteotomy) were successfully managed without an osteotomy, a window or a perforation.

Acetabular Revision THA

Only one case report so far describes arthroscopic assisted revision of the acetabular component in total hip arthroplasty. Lavernia[26] described how an arthroscopic shaver was used to remove osteolytic lesions proximal to the acetabular cup during revision hip arthroplasty. Excellent debridement was obtained and cortical bone allograft was used to fill the void areas behind the cup.

Here we report on a multicenter prospective study on cement removal in both infected and non-infected hip arthroplasties using standard available endoscopy equipment.

Experience at Own Institute

INTRODUCTION

We have now performed more than 250 endoscopic assisted hip revisions. Our first published study includes 107 revision hip arthroplasties.[20] There were 73 aseptic cemented revisions, revised because of loosening at St. Blasius hospital and 34 septic cases performed at Pellenberg University Hospital. All aseptic revisions were performed as a one-stage procedure. All septic cases were operated on in two stages with the first stage essentially consisting of a girdlestone[19] procedure with removal of both the acetabular and the cemented femoral components. Preoperative radiographic evaluation consisted of Barrack’s classification[14] ranging from grade A (a complete filling of the medullary cavity by cement) to grade D (a failure to fill the canal with cement such that the tip of the stem was not covered) to evaluate the quality of the existing cement mantle. Endoklinik and American Academy of Orthopedic Surgeons (AAOS) classifications were chosen to grade the femoral bone deficiencies.

Bone defects were localized on the preoperative radiographs using the Gruen zone classification.[22] Total operating time, endoscopy time and endoscopy time relative to operating time were recorded, as well as blood loss and transfusion needs. Based on the operative notes and perioperative video recordings the number of fractures of the trochanteric region, femoral shaft fractures and perforations were recorded. The need for an extended trochanteric osteotomy, for the creation of windows and the completeness of cement plug removal were also recorded. Postoperative radiographs were reviewed by an individual unaware of the operative details. Especially in the infected cases a detailed analysis was made of the femoral radiographs after the first stage of the revision. Fractures, unnoticed perforations and the existence and localization of any remaining cement were recorded.

In the infected cases, a comparison was made between the preoperative and postoperative femoral deficiencies using the AAOS and Endoklinik classifications. Retained cement was localized according to the Gruen zone. A comparison was also made between the preoperative quality of the cement mantle and the risk of perforation.

SURGICAL EQUIPMENT

A 5 mm and a 10 mm Storz laparoscope were used to perform the medulloscopy (Figure 16.3). Cement splitting chisels (Revision Hip instrument set, Smith and Nephew, Memphis, USA) were used to remove the proximal cement. Plug perforation and distal cement removal was facilitated by an ultrasound-driven disposable 6.0 mm plug puller with a 7.0 mm Helix tip (Ultradrive model 50, Biomet, Warsaw, USA) (Figure 16.4). Diaphyseal
Surgical Technique

A similar cement removal technique was used for both infected and aseptic revisions. Patients were placed in the lateral decubitus position. Both an anterolateral, transgluteal approach and a standard posterior were used. Multiple cultures were taken after the incision of the fascia and arthrotomy of the hip and cultures were also obtained from the excised membrane and the medullary canal. The following sequential operative steps were used for implant and cement removal:

1. Removal of cement from between the greater trochanter and the shoulder of the prosthesis to allow for stem extraction.
2. Extraction of the implant stem using standard extraction instruments.
3. Endoscopic evaluation of the existing cement mantle (Figure 16.5).
4. Removal of all accessible proximal cement using narrow osteotomes and chisels of various sizes and thicknesses.
5. Radial and longitudinal splitting of the metaphyseal cement and removal of it using a variety of grasping instruments. At this stage, a 10 mm laparoscope was used as an additional light source.
6. Positioning of the ultrasound tool with helical tip (Biomet, Warsaw) under endoscopic control (Figure 16.6).
7. Perforation of the distal cement plug using ultrasound (Figure 16.7).
8. Inspection of plug perforation with a 5 mm 0° forward looking laparoscope after cleaning and washing out of the canal using pulsed lavage.
9. Advancement of a ball-tipped guidewire (as for Kuntscher intramedullary nailing) into the distal part of the femur (Figure 16.8).
10. Checking of the guidewire position using the image intensifier.
11. Reaming of the well-fixed distal and diaphyseal cement mantle in 0.5 mm increments using a standard flexible cannulated low pressure intramedullary reamers (Figure 16.9). The canal was washed out after every reamer passage and the canal was inspected using the 5 mm laparoscope.

**Figure 16.6:** Positioning of ultrasound tip with endoscopic assistance

**Figure 16.7:** Distal plug perforation

**Figure 16.8:** Guidewire positioning for cannulated reamers

**Figure 16.9:** Flexible cannulated low pressure reamers (golden boys, Zimmer, Warsaw) for cement reaming
12. Ultrasonic-driven curettes were used to remove remaining cement from side walls (Figure 16.10).
13. After the cement had been completely removed, the membrane lining the medullary canal was meticulously curetted out under the endoscopic control.
14. Before placement of cementless revision stems with distal fixation, reaming and sizing of the femoral isthmus were performed under the endoscopic control (Figure 16.11).

**RESULTS**

The average age of the patients was 70.6 years and the time between the primary procedure and revision was 69.2 months on average. The average perioperative blood loss was 1.362 units of packed cells and the average total amount of transfusion was 2.561 units of packed cells.

Endoscopic inspection of the cement mantle after removal of the femoral component often shows cracks and cement defects not seen on the preoperative radiograph. There were seven cases where we found clear fluid penetrating through the cement defects and pulsating at the heart rate of the patient.

Positioning of the ultrasound tools to perforate the distal plug was possible in all cases. We found ultrasound to be a reliable and atraumatic method for distal cement and plug perforation and removal. Although we routinely used saline to cool the ultrasound tip, we found in many cases a blackened and burned appearance of the endosteal canal as a result of the ultrasound instruments (Figure 16.12). Therefore, the use of a thin helical ultrasound tip followed by reaming of the cement with flexible reamers is recommended.

Flexible reamers, used to remove the cement from the side walls, tended to ream more soft bone than the hard cement.

In case of eccentric migration of the femoral component, endoscopy could be used to find the femoral canal and avoid perforation at the prosthesis tip (Figures 16.13A and B). After all cement remnants had been removed, endoscopy was found to be a useful tool to define what type of revision stem (cemented versus cementless) could be used.

In our practice, we tried to avoid cementing femoral stems in femoral canals with completely flat side walls as there would be no cement interdigitation. Endoscopy of the distal femur helped to size the cementless (revision) hip stem (Figure 16.14). We used endoscopy to help retrieve three broken ultrasound tips (Figure 16.15) and also found one case of a pandiaphyseal infection in the femoral canal.

This occurred in a total hip arthroplasty infected with tuberculosis (Figure 16.16).
Figure 16.12: Blackening of endosteal surface and thermal damage caused by ultrasound use without proper cooling of the tip

Figures 16.13A and B: (A) Posterior migration of femoral component tip; (B) Old prosthesis bed (right) and new canal (left)

Figure 16.14: Scratch fit of cementless stem in femoral isthmus
COMPLICATIONS

Perforation was defined as an intraoperative iatrogenic defect in the femoral cortex integrity. A false passage was defined as an intraoperative distal femoral perforation with passage of instruments through the iatrogenic defect. Fractures of the greater or lesser trochanter and metaphyseal and diaphyseal fractures were all classified as intraoperative fractures. There were many more complications in the septic than in the aseptic group. In the aseptic group there were four perforations (5.97%), two false passages of instruments (2.99%) and three intraoperative fractures (4.48%). This results in an intraoperative complication rate of 13.44%. In the septic group the intraoperative complications rate was much higher. There were six perforations (17.65%), three false passages (8.82%) and four intraoperative fractures (11.76%).

With the numbers studied, we were unable to predict the risk of complications by the use of Barrack’s preoperative rating of the quality of the cement mantle. Similarly, neither the AAOS nor the Endoclinic classification of femoral defects correlated with the number of perforations or fractures. Because of technical difficulty during cement extraction the exposure was converted to an extended trochanteric osteotomy in six aseptic revision cases. In four aseptic cases, additional femoral windows were made. There were no conversions to an extended osteotomy, and no windows were created in the septic cases.

In two septic revisions the cement plug was longer than 10 cm and was intentionally left in place (Figure 16.17). There was a significant correlation (p<0.05) between the amount of residual cement on the postoperative radiograph and the risk of perforation. In these difficult septic cement extractions the total operating time was significantly increased by the duration of endoscopy (p<0.05). A second review of the cases showed a strong correlation (p < 0.05) between cement plug length and the risk of perforation.

There are, however, limitations and disadvantages to endoscopy assisted cement removal. It requires a great amount of extra equipment in the operating room. High quality video equipment, ultrasound, flexible reamers, pulsatile lavage pistols and an image intensifier are essential to make this a successful procedure.

Radiolucent cement, severe femoral bowing and long cement plugs make it almost impossible to remove cement without performing some kind of osteotomy. Although there was no correlation between endoscopy time and blood loss in our study, there was a significant correlation between endoscopy time and overall operating time (p<0.05).
SURGICAL TRICKS

1. The 5 mm and 10 mm laparoscopes with a 0° lens angle are the best choice when standard equipment is used for medulloscopy. Endoscopes with angled lenses (like arthroscopes) can cause incorrect orientation of instruments inside the canal and increase the risk for perforation.

2. Spinal epidural anaesthesia with controlled hypotension reduced the amount of intramedullary bleeding and improved visualization of the medullary canal.

3. Washing out the medullary canal with a pulsed lavage of cold saline appeared to have a hemostatic effect.

4. Inspection of the femur during cement reaming is helpful to achieve symmetry and avoid perforations (Figures 16.18A to C).

5. Eccentric reaming of the medullary canal can occur easily as the cortical bone is softer than the cement.

6. Ultrasound-driven reverse curettes are recommended to remove last remnants of cement from the side walls after the central canal has been reamed.

7. Although medulloscopy during the use of the ultrasound is impossible due to the smoke generated by the ultrasound, drill positioning of the tools is possible under endoscopic control (Figure 16.19).

8. Even after an extended trochanteric osteotomy, medulloscopy is useful to inspect the distal femur for completeness of cement removal and sizing of the final implant.

Bone Endoscopy Equipment

Orthopedic surgeons have often tried standard arthroscopes to perform medulloscopy of the femoral canal. Our own cadaver studies show a very disappointing visualization of the femoral canal when a standard arthroscope is used. The fiberoptic light source in an arthroscope is insufficient to illuminate the intramedullary canal. The 20–30° angled lens gives a distorted view of the femoral canal and insufficient distinction between bone and cement. All the existing bone endoscopes are summarized in Table 16.3.

Future

Femoral cement extraction without windows or extended osteotomy has been out of favour because the high risk of canal perforation. Stem position, femoral cortex quality and plug anatomy can be evaluated by preoperative CT scan. A detailed analysis of the cement mantle and 3D reconstruction (Figures 16.20 to 16.22), can be produced based on this CT scan.
Figure 16.18A to C: (A) Asymmetric reaming of the canal is prevented by careful medulloscopy during cement removal. Some cement left at lateral borders (arrows); (B) Asymmetric reaming (arrows) of cement mantle; (C) Intraoperative image intensifier view of asymmetric reamed mantle (arrows)

Figure 16.19: Endoscope used as extra light source during ultrasonic-assisted cement extraction
Table 16.3:

<table>
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<th>Scope</th>
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<th>Commercial partner</th>
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<td>Ossoscope</td>
<td>Häle</td>
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<td>Storz (Germany)</td>
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<td>Porsch</td>
<td>EMS (Switzerland)</td>
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<td>Fig. 35</td>
<td>Intramedullary bone endoscope</td>
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<td>Wolf (Germany)</td>
<td>2002</td>
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<td>Fig. 36</td>
<td>Adjusted ureteroscope</td>
<td>Sans</td>
<td>Olympus (Germany)</td>
<td>2004</td>
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<tr>
<td>Fig. 37</td>
<td>Bone scope</td>
<td>Govaers</td>
<td>Olympus (Germany)</td>
<td>2010</td>
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Figure 16.20: 3D reconstruction of existing cement mantle based on preoperative CT scan (left). Color map of the bone thickness of the femoral shaft (right)

Central plug perforation is facilitated by 3D printing of a custom-made cannulated drill guide (Mobelife, Belgium) which mimics the shape of the removed femoral stem (Figure 16.23). This technique becomes even more reliable when the trademark and size of the removed stems are known to the surgeon (Figures 16.24 and 16.25). The exponential increase in camerachip quality improve the details and depth of field for the surgeon hereby improving the safety of the procedure (Figures 16.26 and 16.27).

Conclusion

Advances in minimal invasive and endoscopic techniques have dramatically changed the surgical care of our patients. Generally spoken many surgical procedures have become minimal invasive and, if possible, endoscopically assisted. The purpose of these endoscopic
**Figure 16.21:** Sagittal sections of the femur show the 3-dimensional shape of the cement mantle and are used to print the custom drill guide.

**Figure 16.22:** Sterile custom-made cannulated drill guide mimicks shape of removed stem.

**Figure 16.23:** More accurate 3D reconstruction when trademark and size of removed femoral stems are known.
Figure 16.24: Frontal view of used custom-made drill guides

Figure 16.25: Back view of used femoral drill guides

Figure 16.26: Endoscopic view inside the custom-made drill guide shows roof of the guide (A) and cement mantle (B)

Figure 16.27: Flexible endoscope to perform medulloscopy

Techniques is to minimize exposure, soft tissue damage and to improve the precision and safety of the surgical procedures. The majority of surgical interventions on joints has now become arthroscopically assisted. So it is no surprise that surgeons have also tried to perform orthopedic procedures inside the bone under endoscopic visual control. Most experiences are anecdotally and small published series, based on orthopedic surgeons using their standard available knee arthroscopes to inspect the inside of the bone. Surgeons from all over the world, the majority from the German speaking orthopedic community, have published on their initial findings using various equipment to perform endoscopy of the bone.

Endoscopy in revision hip arthroplasty is possible using standard laparoscopy equipment and it can reduce the need for an extended trochanteric osteotomy.

There is a need for better endoscopes and instruments to prevent perforations and avoid leaving cement remnants behind. Prospective randomized studies should be conducted to compare cement removal using an extended trochanteric osteotomy with endoscopy assisted cement removal. Based on others and on our experience, medulloscopy assisted orthopedic surgery is here to stay. Medulloscopy assisted procedures will become part of the daily practice of orthopedic surgeons. This will, in the future, be facilitated by technical advances in the endoscopic equipment: endoscopes become smaller in diameter, better
in quality, more flexible and even disposable. Hopefully, bringing together all the scattered experience on this novel approach will encourage surgeons to adopt and further explore this fascinating endoscopic techniques in a more scientific way.

References


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