MENTORS IN ORTHOPEDICS

ACETABULAR REAMING: ROUTINES OR CONVICTIONS?

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AUTHORS

Jean-Louis Prudhon - Centre Ostéo Articulaire, Grenoble, France
André Ferreira - Clinique du Parc, Lyon, France
Thierry Aslanian - Groupe Lépine, Genay, France

SUMMARY

Background: Total hip arthroplasty (THA) rates continue to rise globally, necessitating precise surgical techniques to optimize long-term outcomes. Acetabular reaming is a critical step in THA, as it dictates component positioning, restoration of the hip's center of rotation, and the stability of cementless press-fit fixation. However, variability in reamer design, manufacturing tolerances, and the effects of instrument wear present challenges to achieving anatomical reconstruction.

Objective: This study evaluates the technical determinants of acetabular reaming, assesses current surgical practices among French orthopedic surgeons, and examines the clinical and logistical implications of utilizing single-use reaming instruments.

Key Points: Anatomical studies indicate that the acetabulum is subhemispherical and elliptical, requiring reaming that respects the articular area while avoiding excessive medialization into the acetabular fossa. Sequential reaming often leads to distal and medial displacement of the center of rotation. A survey of 102 surgeons revealed that 74.5% utilize sequential reaming, despite risks of bone stock depletion. Biomechanical data suggest that used reamers are less efficient, generate potentially osteonecrotic heat, and produce smaller-than-nominal diameters. Single-use reamers offer a high-performance alternative, ensuring consistent sharpness and precision while simplifying decontamination protocols and reducing the institutional carbon footprint.

Conclusion: Optimal acetabular preparation requires 3D planning and anatomical reaming that preserves the quadrilateral lamina. The adoption of single-use reamers may improve the reproducibility of cup positioning and primary fixation stability by eliminating the variables associated with instrument degradation and sterilization cycles.

KEYWORDS

Arthroplasty, Replacement, Hip; Acetabulum; Hip Prosthesis; Bone Cements; Surgical Instruments

INTRODUCTION

All major national records show a regular annual increase in the number of total hip replacements (THRs). [1-4]

Anticipating complications and improving outcomes in the short, medium or long term have been the principal concerns of orthopaedic surgeons for several decades. The importance of acetabular positioning has long been recognized as a determining factor for mobility [5], osteolysis and wear [6-8], the risk of dislocation [9] and the risk of impingement [10].

Cementless fixation of an acetabular cup demands rigorous preparation of the acetabular socket with drills or 'reamers' before placement of the final implant. Competence in reaming the acetabular socket to achieve the correct diameter and the optimal position should allow the acetabular cup to be placed as close as possible to the planned 'target', or with a degree of tolerance that should avoid any detrimental impact on mobility, stability or fixation.

The surgeon should pay particular attention to the tool used for reaming.

A recent survey of more than 130 French surgeons, who are members of the Société Française de Chirurgie de la Hanche et du Genou [SFHG, French Society of Hip and Knee Surgery] and experts in prosthetic hip surgery, enabled us to take stock of current reaming practices during placement of a THR.

The aim of the study was to answer four important questions that surgeons must ask themselves during a THR:

1- Is reaming the main determining factor in positioning the cup?

2- Are the reamers currently on the market all identical and what are their manufacturing features?

3- What routines do hip surgeons follow in France?

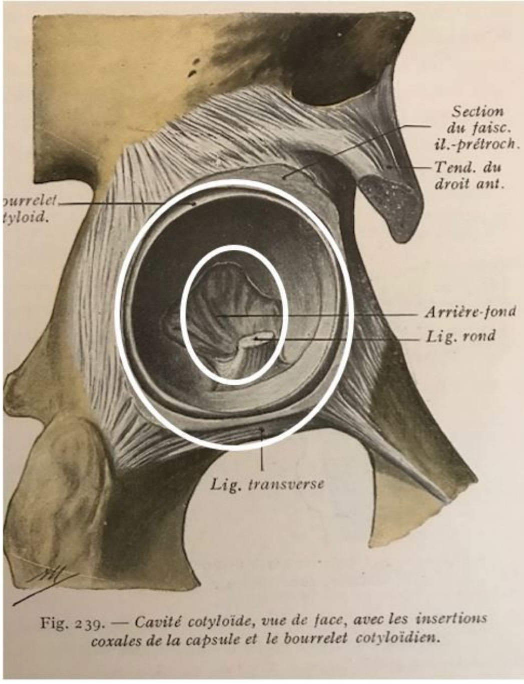
4- Is there any place for single-use reamers?

WHY IS REAMING OF THE SOCKET A DETERMINING FACTOR IN CORRECT POSITIONING OF THE ACETABULAR CUP?

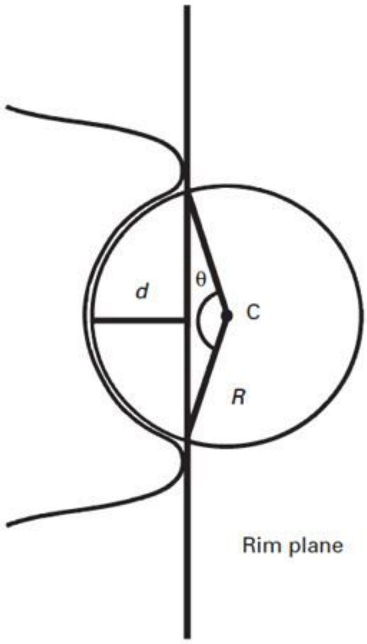
1-1 Anatomy of the acetabulum.

The acetabulum is described by Rouvière [9] in his survey of limb anatomy as 'a roughly hemispherical cavity' made up of two distinct parts: one is articular and crescent-shaped; the other, which sits further back than the first and is non-articular, is called the acetabular fossa and forms the basis of the acetabular cavity.

On a frontal view the overall shape of the socket is that of an ellipse whose major axis is vertical; in the sagittal and coronal planes the shape is subhemispherical, and the overall container shape is completed by the acetabular labrum (Fig. 1).



1-a In the frontal plane the acetabulum is shaped like an ellipse whose major axis is horizontal. Rouvière: Anatomy of the Limbs.1-b In the sagittal plane the socket is subhemispherical.



1-a In the frontal plane the acetabulum is shaped like an ellipse whose major axis is horizontal. Rouvière: Anatomy of the Limbs.1-b In the sagittal plane the socket is subhemispherical.

Only the peripheral part of the acetabulum is articular; the more medial fossa should not be included in the hip's centre of rotation [11]. Its positioning is not affected by hip dysplasia or by primary arthritis.

Anatomical variants are common with the acetabulum and may be associated with gender, developmental anomalies or pathological insults (medical, degenerative or trauma).[12,13].

1-2 Restoring the hip's centre of rotation.

This is the foremost goal of prosthetic reconstruction of the hip. Using 100 CT scans, Bonnin et al. [14] quantified the acetabular offset and analysed the displacement of the hip's centre of rotation, according to whether positioning was ‘conventional’ (cup in contact with the quadrilateral lamina) or ‘anatomical‘ (cup placed in the centre of the articular area of the hip) (Fig. 2). Medial displacement of the centre of rotation was 1.6 mm ± 1.2 with anatomical positioning and 4.8 mm ± 1.9 with conventional positioning ($p<0.0001$).

Anatomical positioning avoids excessive medialization of the acetabular implant.

Meermans et al. [15] analysed the impact of reaming technique on displacement of the hip’s centre of rotation. They demonstrate that gradual or sequential reaming, using reamers of a progressively larger size and starting from the acetabular depression, displaces the centre of rotation in a distal and medial direction. Moreover, taking the fossa into account in the circle of bone inscribed in the socket de facto increases the overall size of the socket and reduces the bone stock of the anterior and posterior columns (Fig. 2-b).

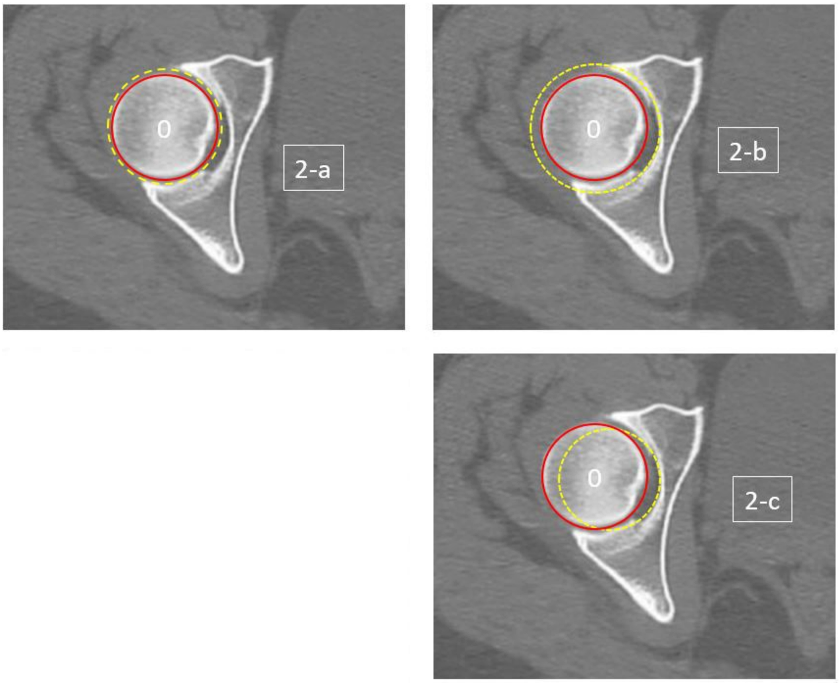


Figure 2: 2-a: Anatomical positioning:The centre of the socket is defined, taking only the ‘articular’ part into account (excluding the fossa).2-b: Conventional positioningThe centre of the socket is defined, taking the bony part of the socket into account (including the fossa).There is a risk of over-reaming in order to achieve optimal bone contact.2-c: Medialization of the centre of rotation and reduced bone contact if reaming is sparing.

Influence of the approach route.

Reamer positioning may be influenced by the approach route: anterior routes may favour preferential reaming of the posterior column, while posterior routes may favour preferential reaming of the anterior column (Fig. 3).

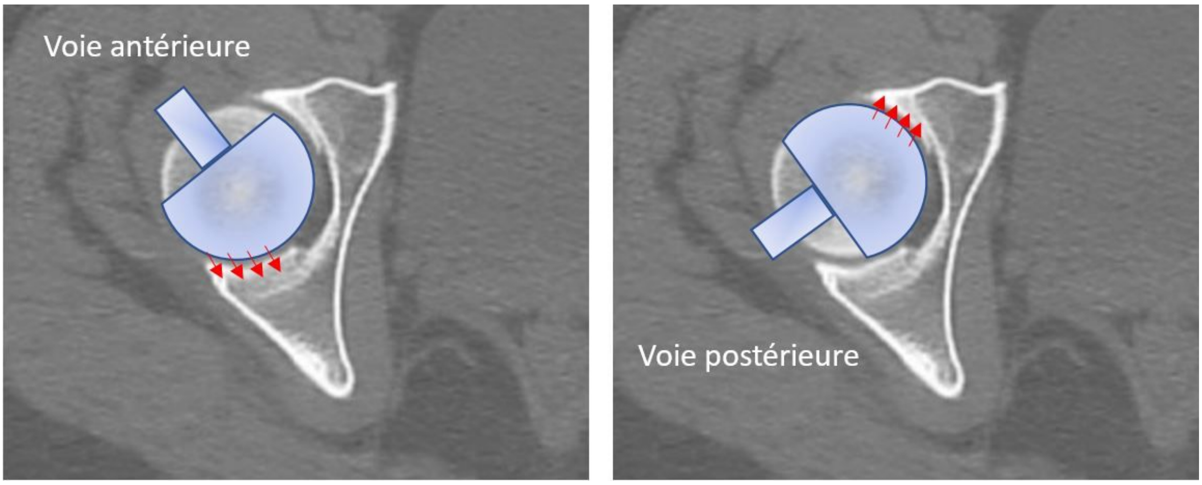


Figure 3: Impact of the approach route on reaming of the acetabulum.

1-3 Acetabular cup anatomy.

The current design of acetabular cups is subhemispherical. This influences the stability of primary bone fixation of the implant and has an effect on prosthesis size, which may create a risk of impingement (soft tissues, or impingement between the femoral and acetabular components).

Most of the acetabular cups in current use are fixed without cement. Design of the metal back must take both of these factors into account.

The advent of dual mobility cups should add another factor to the mix: stability of the mobile bearing. The majority of modern dual mobility cups are hemispherical, cylindrical–hemispherical or anatomical in design [16,17]. Consequently, reaming of the acetabulum has to take the implant's larger size into account when it is being put in place. In order to avoid protrusion of a cylindrical–spherical cup, medialization of the acetabular cup is required.

1-4 Cementless fixation and the press-fit concept.

It is several decades since cemented fixation of acetabular cups was replaced by cementless fixation. Whatever the cup is coated with, primary fixation makes use of the 'press-fit' technique, first described by Morscher [18]. For primary fixation of the acetabular cup to be optimized, the nominal diameter of the implant must be 2 mm greater than the size of the acetabular socket prepared by reaming.

1-5 Does a hip prosthesis necessarily entail a compromise?

When a THR is being performed, preparation of the acetabular socket must take four basic factors into account:

- Reproducing the hip's centre of rotation by restoring prosthetic joint anatomy and kinematics such that it is close to the native anatomy.

- Adapting a hemispherical cup to an elliptical socket.

- Ensuring long-lasting fixation.

- Limiting the risks of impingement.

High-quality acetabular reaming is a prerequisite if these aims are to be achieved [19-25].

Reaming of the socket is the cornerstore of success in fixing the acetabular implant.

2- «REAL-LIFE» MANUFACTURE OF ACETABULAR REAMERS

2-1 History.

Mechanical reamers were first used to prepare a joint socket during a THR reported by Charnley in 1972 [26]. A hole created in the middle of the acetabulum enabled the reamer to be centred throughout the process of preparing the socket (Fig. 4). Three radially expanding cutting blades permitted gradual abrasion of the cartilage and subchondral bone, while retaining the reaming device in its original position around the hip's centre of rotation (Fig. 5).

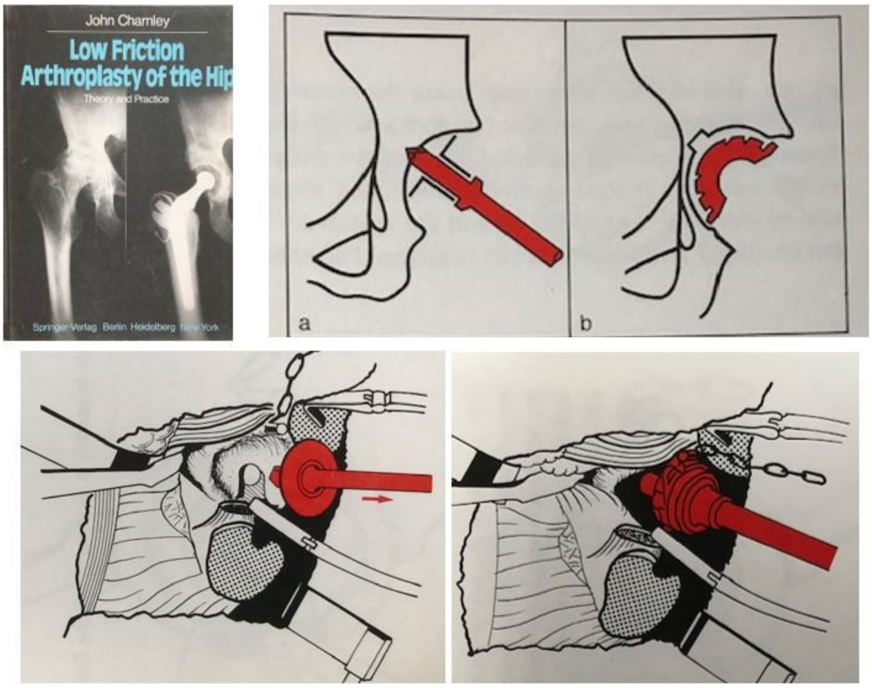
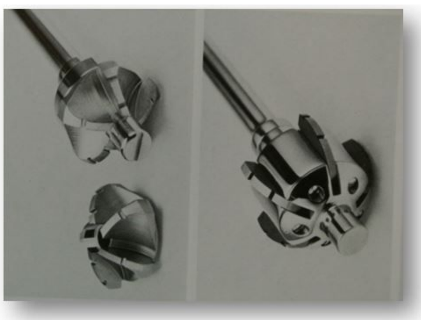


Figure 4: Technique for acetabular preparation, after Charnley [26]



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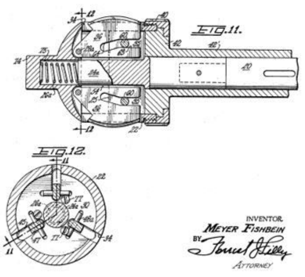

United States Patent [15] **3,702,611**
Fishbein [45] **Nov. 14, 1972**

[54] **SURGICAL EXPANSIVE REAMER FOR HIP SOCKET**

[72] Inventor: **Meyer Fishbein,** 12020 Saltair Place, Los Angeles, Calif. 90049

[22] Filed: **June 23, 1971**

[21] Appl. No.: **155,718**

[52] **U.S. Cl.** **128/305,** 82/1.2, 408/154, 408/157, 408/159

[51] **Int. Cl.**....**A61b 17/32,** A61b 17/16, B23b 51/00

[58] **Field of Search**..82/1.2; 128/305, 312; 408/154, 408/157, 158, 159

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Primary Examiner—Channing L. Pace
Attorney—Forrest J. Lilly

[57] **ABSTRACT**

An expanding reamer is provided for surgical reaming of the acetabulum in hip surgery. The reamer includes a head with a convex end adapted to seat in a previously prepared concavity in the central part of the acetabulum. This head pivotally mounts a set of radially expansive blades. It is telescopically mounted on the end of a rotary drive shaft, and the drive shaft mounts a cam actuator which engages cam elements to expand the cutters progressively in response to axial thrust exerted on the drive shaft by the surgeon with the reamer head seated in the acetabulum. A spring is used to contract the cutters when the reaming operation is interrupted.

7 Claims, 13 Drawing Figures

5-b

Figure 5: 5-a Charnley's reamers in Low Friction Arthroplasty of the Hip [26]5-b Patent, 1972

The second generation of acetabular reamers came along in the 1980s. It followed the principle adopted by most of the acetabular reamers that are currently available on the orthopaedic market. A hollow half-sphere studded with holes that have cutting edges is mechanically rotated about its axis.

2-2 Manufacture.

Reamers are manufactured from an embossed metallic sheet in the shape of a half-sphere. Holes of a pre-determined, fixed diameter are punctured in the cup following a rhumb line or two crossing rhumb lines (Fig. 6).

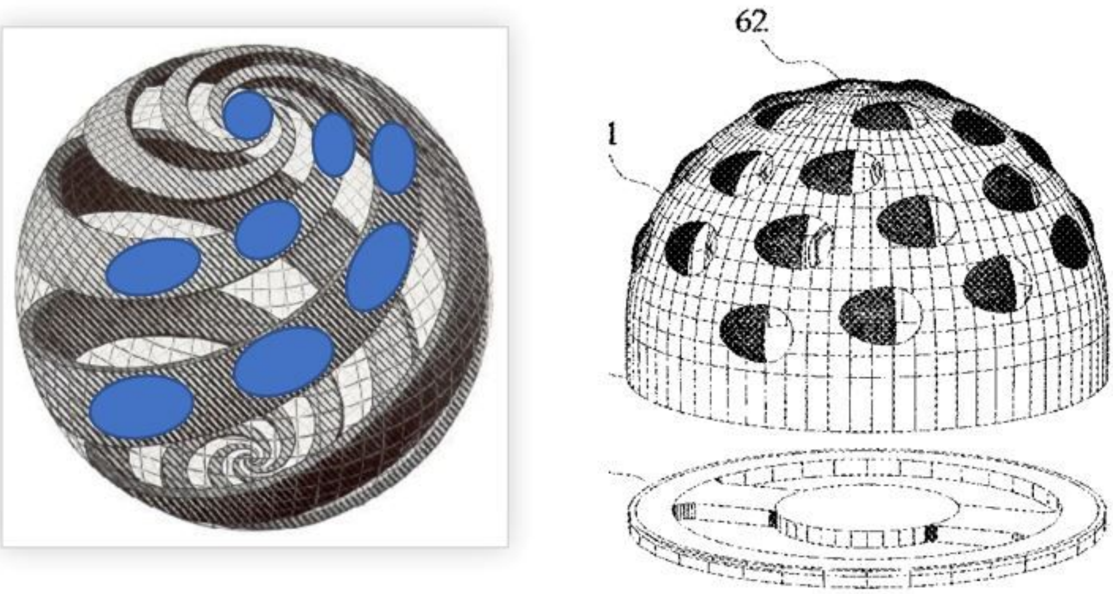

Figure 6: Positioning the holes in accordance with a rhumb line.

Depending on the size of the holes and the orientation of the rhumb lines, the extent of the abraded areas will be greater or smaller. The holes are then distorted in a fixed degree of tilt and the raised edge of the hole is sharpened (Fig. 7).

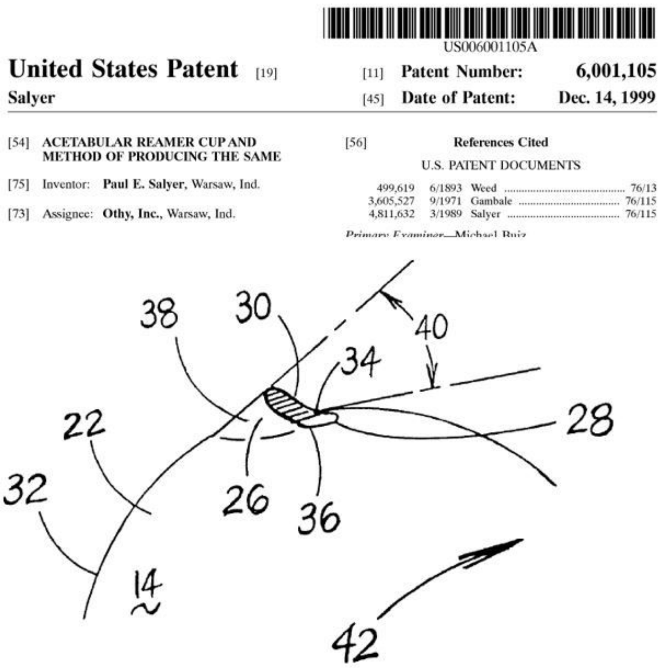

Figure 7: Distortion of the holes to obtain the cutting edges.

2-3 Types of acetabular reamer available.

Most of the acetabular reamers currently on offer to the orthopaedic surgeon are of the Mueller rasp type. There are different sorts available, depending on the number of holes, the hemispherical or cylinder–spherical shape, or notches to adjust them for minimally invasive surgery (Fig. 8).

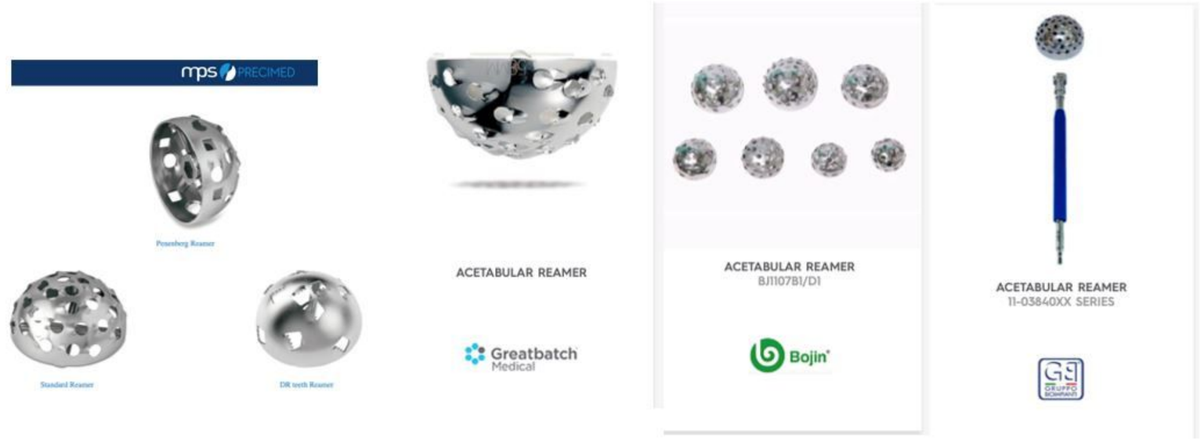

Figure 8: Different types of acetabular reamer.

2-4 The precision and reproducibility of the reaming must take into account:

Manufacturing dimensions of the reamers.

Tolerance between the size that has purportedly been reamed and the actual size reamed.

Quality of the abraded surface (spherical shape, roughness).

Wear of the cutting instrument.

Heat produced by the cutting instrument.

Slotkin et al. [27] tested two types of new or used acetabular reamer. The size reamed is significantly smaller than the nominal size of the acetabular reamer, whatever reamer is used. New reamers are significantly more efficient than used ones. Used reamers can degrade the quality of the hollowed-out surface and produce heat that is damaging to the vitality of bone cells.

2-5 Regulatory constraints: decontamination and traceability.

Medical devices are defined in directive 93/42/CEE [28] and are subject to CE marking under article L. 5211-1 of the Public Health Code [29].

The new European regulations will apply to this medical device from 2020. Acetabular reamers are classed as critical reusable medical devices and are subject to a prescribed decontamination and sterilization procedure, laid out in the guidelines for good disinfection practice [30]. The maker or manufacturer who provides acetabular reamers is required to establish the maximum number of times the device can be used, as well as its lifespan.

3- SURGICAL ROUTINES

3-1 SFHG survey, 2019.

We carried out a survey into current practices among the members of the SFHG in January 2019. We obtained 102 responses from 135 invitations (response rate 75.5%). Some 88% of the surgeons questioned use a cementless and screwless acetabular implant placed using press-fit in 51.6% of cases; 53% use a posterior approach; 74.5% carry out sequential reaming with rasps of increasing size; 77.1% have total confidence in the company providing the acetabular reamers in terms of size, reaming quality and type of reamer.

3-2 Comments:

The survey provides a snapshot of current acetabular reaming practices among a targeted population of orthopaedic surgeons who perform an average of 100 THRs per year.

Bonnin [14] and Meermans [15] demonstrated that sequential reaming may be responsible for medialization of the centre of the prosthetic hip. Clearly, the majority of French surgeons ream the acetabular cavity with rasps of increasing size.

They have total confidence in the manufacturers as far as the reaming tool is concerned. To our knowledge, very few details are provided by these companies on the device's features, tolerance between the size of the reamer and the size of the cavity reamed, consistency between the exact size of the definitive acetabular cup (nominal diameter + coating and the coating's macrostructure), verification procedures for instrument sets, or the lifespan of the reamers or other instruments.

4- ADDED VALUE OF A SINGLE-USE REAMER

The production (conception, manufacture and marketing) of single-use instrument sets has been defined as the primary objective of the Lépine group's business strategy. The decision is justified as the advantages are experienced by patient, surgeon and treatment centre, as well as the company, which gains a confirmed and sustainable development policy.

Patient and surgeon benefit from a precise, high-performance reaming tool that improves placement and fixation of the acetabular implant.

The treatment centre saves money on the long and costly procedures required to decontaminate, wash and sterilize multiple trays of instrument sets. Traceability is ideal and interruptions to supply are minimized. The storage space freed up by conventional instrument sets may be used for storing blister packs of single-use instrument sets. Limiting sterilization procedures and transportation lowers the carbon footprint.

The Lépine's group's business decision to manufacture single-use instrument sets for acetabular reaming has been supported by clinical and financial validation from two private treatment centres (Clinique du Parc-Lyon- Dr A Ferreira, Clinique des Cèdres- Echirolles- Dr JL Prudhon).

Following this reasoning, the only element in the reaming kit that remains traditionally reusable is the reamer holder (Fig. 9).

Figure 9: Single-use instrument set for acetabular preparation (LepineTM group, Genay, France)

5- IDEAL REAMING IN 5 POINTS

1- For us, careful 2D planning with frontal and side views, or 3D planning, is an indispensable preliminary to any prosthetic hip surgery. The fossa does not form part of the articular area of the hip.

2- Perioperative measurement of the femoral head is an ideal tool for deciding which acetabular reamer to choose, and for avoiding over-reaming of the acetabulum and oversizing of the cup. Beyond a difference of 6 mm, over-reaming constitutes a major risk.

3- Acetabular reaming must be performed peripherally or 'anatomically', ideally using one or even two single-use reamers. Sequential reaming is not recommended.

4- Initial placement of the reamer must correspond to the desired position of the final implant (45° tilt, 15° anteversion).

5- The quadrilateral lamina must be preserved to minimize the risk of protrusion.

N.B. The cutting quality of single-use reamers must be taken into consideration during the learning period.

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