COMPUTER-ASSISTED SPHERICAL OSTEOTOMY WITH A CURVED-BLADED TUKE SAW

Koyama, T; Sugano, N; Nishii, T; Miki, H; Sato, Y; Yoshikawa, H; Tamura, S
Osaka University Medical School, Suita, Osaka, Japan
koyama@cl-comp.med.osaka-u.ac.jp

Introduction: Techniques of spherical osteotomy are required for various orthopaedic surgeries such as rotational acetabular osteotomy (Fig. 1), Wagner’s spherical osteotomy of the acetabulum, or revision of well-fixed cementless acetabular sockets of total hip arthroplasty. Conventionally, curved chisels have been used for such spherical osteotomy, however, it is not easy to control the tip of the blade precisely even under fluoroscopic or navigation guidance. Moreover, chisels have a potential risk of damaging blood vessels or nerves. Therefore, to perform spherical osteotomy precisely, quickly and safely, we developed a computer-assisted surgical tool which consists of a navigation system and a curved blade vibrating bone saw (Fig. 2). This bone saw (Tuke Saw®) has a safety feature that prevents damage to soft tissues by limiting the diameter of its circular movement to only 1.5mm. The purpose of this study was to compare the accuracy and ease of use of this curved-bladed Tuke Saw with those of the conventional curved chisel in spherical osteotomy, both under CT-based navigation guidance.

Methods: To compare the accuracy and ease of use of the novel curved-bladed Tuke Saw with those of the conventional curved chisel in spherical osteotomy under CT-based navigation, two sets of experiments were conducted. First, to simply compare the design features of these surgical tools, a hemi-spherical osteotomy was performed on rectangular parallelepiped blocks of Sawbones either with one of the surgical tools. Next, as a preclinical study, rotational acetabular osteotomy on cadaveric pelves was performed with one of the surgical tools on one side of the hemipelvis and with the other tool on the other side. To evaluate accuracy, the distance error of the actual osteotomy surface from the planned sphere was measured. For the usability test, procedure time was measured. All the osteotomy experiments were conducted under a CT-based navigation system utilizing an optical 3D positionmetry sensor (OPTOTRAK® 3020). Statistical analyses were performed using the t-test with a significance level of 0.05.

1. Hemi-spherical osteotomy on Sawbones blocks: Sawbones® rectangular parallelepiped blocks were used as a model of cancellous bone. The planning of hemi-spherical osteotomy was made with the center placed on the surface of the block and a radius of 50mm (Fig. 3). Three hip specialist surgeons performed a hemi-spherical osteotomy with one of the surgical tools with a 50-mm radius blade. After the osteotomy, CT images of the cut blocks were obtained and distance error of the actual osteotomy surface was evaluated at the depth of an angle θ from the block surface (Fig. 3). The distance error was defined to be positive if the position was outside the sphere of the plan. The trials of hemi-spherical osteotomy were repeated 15 times for each surgical tool. The results of the experiment of Sawbone blocks are shown in Fig. 4. The procedure time with the Tuke Saw was significantly shorter than that of the chisel (P < 0.05).

2. Rotational acetabular osteotomy on cadaveric pelves: Eight normal cadaveric pelves were used and their preoperative CT images were obtained. Preoperative planning of rotational acetabular osteotomy was made for each hemipelvis with an adequate radius and position. For each pelvis, the hip specialist surgeons performed rotational acetabular osteotomy with one of the surgical tools on one side of the hemipelvis and with the other tool on the other side of the hemipelvis. In all the hemipelvess, a curved blade with a 50-mm radius was selected and used. After osteotomy, CT images of the cut pelves were obtained and the postoperative 3D models were superposed on the preoperative 3D models with the registration method using the ICP algorithm. After registration, the root mean square (RMS) of the distance error of the osteotomy surface from the planned sphere was calculated.

Results: 1. Hemi-spherical osteotomy on Sawbones blocks (Fig. 4): At positions greater than 50 degrees from the surface of the block, the distance error of the Tuke Saw was significantly smaller than that of the chisel (P < 0.05). The procedure time with the Tuke Saw was significantly shorter than that of the chisel (P < 0.05).

Conclusions: Both the accuracy and ease of use of the novel curved-bladed Tuke Saw is higher than or equal to those of the conventional curved chisel. In addition, the nature of the Tuke Saw motion is safer for the surrounding soft tissues than that of the chisel. Clinical use of this surgical tool for spherical osteotomy is considered to be quite easy and encouraging.