INTRODUCTION

In total knee arthroplasty, the accuracy of the location and orientation of the bone cuts is crucial to obtain proper joint kinematics and ligament balancing. One of the key issues in the procedure is the registration of the bones, because the accuracy of the entire system depends on it. This abstract is a report on the accuracy of the registration of the tibia by means of an intramedullary rod, a technique that is used in conventional total knee arthroplasty, and can be used in the robot-assisted procedure as well [1]. The novelty of this research is twofold: the accuracy of the registration itself was examined and not of the overall procedure (where also the play of the saw in the sawblade and the bowing of the saw is involved) and secondly, the accuracy was not only examined in the frontal plane but also in the sagittal plane and in 3D space.

Since this registration method is also used in conventional knee arthroplasty, this research is important for both the conventional and the robot-assisted procedure.

METHODS

In 18 formalin fixed cadaveric tibiae (10 right tibiae and 8 left tibiae) the deviation was examined between the intramedullary rod, inserted in two different ways, and three tibial axes. The RSA-technique allowed to measure this deviation in the three dimensional space, in the frontal plane and in the sagittal plane.

The three different axes are the anatomical axis and two mechanical axes, both frequently used by surgeons for planning. In the frontal plane, as well as in the sagittal plane, the first mechanical axis (further called mechanical axis 1) is defined as the line connecting the midpoint of the tibial plateau and the midpoint of the talus. The anatomical axis is defined as the line connecting the midpoint of the tibial plateau and the midpoint of the talus (like mechanical axis 1). In the sagittal plane, however, this axis connects the midpoint of the talus with the intersection point of the tibial plateau and a line running through the midpoints of the tibial shaft at distances of 10 cm and 20 cm of the tibial plateau. The anatomical axis is defined as the line connecting the midpoint of the tibial plateau and the midpoint of the tibial shaft at half of the tibial length, both in the frontal plane and in the sagittal plane.

The two methods of insertion of the intramedullary rod are the central approach and a newer technique to insert the rod a few millimetres medial to the tibial plateau. The anatomical axis and mechanical axis 2 in the sagittal plane correspond to varus or anterior slope respectively.

RESULTS

Three tibiae (one in group 1 and two in group 2) were excluded from further analysis because some of the inserted stainless steel markers moved.

Table 1 shows the mean of the standard deviation s of the angle in the frontal plane (F) and in the sagittal plane (S), and the angle in 3D space (3D) for group 1 (central insertion) and for group 2 (medialised insertion). Negative values in the frontal or the sagittal plane correspond to varus or anterior slope respectively.

Table 1: Mean (\(\bar{\alpha}\)) and standard deviation (s) of the angle between the intramedullary rod and the considered tibial axes, in the frontal plane (F) and in the sagittal plane (S), and the angle in 3D space (3D) for group 1 (central insertion) and for group 2 (medialised insertion). Negative values in the frontal or the sagittal plane correspond to varus or anterior slope respectively.

Student t-tests are performed on the results in table 1. No significant difference between the two approaches of insertion is detected (p>0.05). For the central insertion technique, the intramedullary rod is a significant better representation for the mechanical axis 1 than for the anatomical axis in 3D (p=0.014), and significant better for the mechanical axis 1 than for the mechanical axis 2 in the sagittal plane (p=0.03). For the medialised insertion technique the intramedullary rod is a significant better representation for the mechanical axes than for the anatomical axis in the frontal plane (p=0.05).

DISCUSSION

To determine the spatial relationship between the coordinate frames of the robot, the tibia and the pre-operative plan, a lot of robot-assisted surgical procedures use artificial fiducials placed on the anatomic object. These artificial fiducials are to be placed pre-operatively, in order to be visible on the pre-operative images. This has certain drawbacks: an extra operation is needed with the risk of infections, and in addition the patient often suffers from post-operative pains. Using an intramedullary rod offers the following advantages: pre-operative insertion of fiducials is not necessary, no CT-images, but only two X-ray-images are needed, and since this method is also used in conventional surgery, it needs no extra operation time. Both in the robot-assisted procedure and in the conventional technique, the precision of the pin placement is important because the accuracy of the position of the bone cuts depends on it. The accuracy of this registration method does not depend significantly on the approach of insertion. The averaged difference in inclination between the rod and the mechanical axis 1 is 0.21° in the frontal plane (s=1.12°) and 1.07° in the sagittal plane (s=1.28°) for the medialised approach.

REFERENCES

