In patients with a Scandinavian total ankle replacement (STAR), how will performing a 3D MPR rotational radiography influence the diagnostic accuracy in regards to the presence and the extent of cysts as compared to conventional radiographs?

Poster No.: C-0266  
Congress: ECR 2013  
Type: Scientific Exhibit  
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Keywords: Musculoskeletal bone, Musculoskeletal joint, Fluoroscopy, Conventional radiography, Technology assessment, Cysts, Prostheses  
DOI: 10.1594/ecr2013/C-0266

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Purpose

Severe idiopathic, post-traumatic and inflammatory osteoarthritis in the ankle joint may in end stages lead to severe pain, malalignment and subluxation, with surgical options limited primarily to arthrodesis or restoring anatomical alignment by performing a Total Ankle Replacement (TAR), maintaining range of motion. A TAR is however not without possible complications, studies showing, that periprosthetic bone cysts are a frequent occurrence in these patients. (1, 2, 3) The presence, extent and etiology of periprosthetic cysts are a topic of varying disagreement in the literature, as is the choice of best postoperative imaging modality. An early and accurate quantification of these periprosthetic cysts is however of utmost importance allowing for earlier intervention in cases of complications, potentially increasing the survival rate of the TAR, being of both medical and economical benefit.

Standardized weight bearing Anterior Posterior (AP) and Lateral conventional radiographs are in most cases the choice of imaging method when evaluating patients with a TAR. (3, 4) The sensitivity of conventional radiographs (CR), when diagnosing the presence and extent of periprosthetic cysts in TAR patients, is a topic of varying disagreement, and it has been shown, that a Computed Tomography (CT) scan, in spite of the metal artifacts introduced by the prosthesis and the fact that it cannot be performed fully upright and weightbearing, is more accurate when detecting and quantifying periprosthetic bone cysts in TAR patients. (5)

With the multi-purpose Philips Medical System, Multi diagnostic Eleva a new option has become available, a system that, in addition to performing conventional and fluoroscopic images, also through a single 180-degree rotation scan is able to collect a series of fluoroscopic images that are post-processed into multi-planar reconstruction (MPR) slice images similar to CT images. The post-processing software allows for dynamic choice of axis and image slices as thin as 0,1mm. Fully upright and weight bearing imaging is possible with this three-dimensional (3D) MPR modality.

The primary purpose of this prospective study was to evaluate the diagnostic accuracy of conventional radiographs as compared to fluoroscopic (MPR) imaging when diagnosing periprosthetic bone cysts in patients with a TAR.

Methods and Materials

Ethics
This is an independent study, approved by the regional board of ethics, "Den videnskabsetiske komite, Region Syddanmark". All participants gave written informed consent prior to enrollment.

**Patients**

A total of 42 consecutive patients with pre-scheduled follow-ups at the orthopedic outpatient department, were enrolled in this prospective study during a nine-month period. Patients who visited the orthopedic outpatient department for not pre-scheduled visits, i.e. extra visits due to pain, complications etc. were not invited to enroll in this study. The cohort consisted of 17 men and 25 women with a mean age of 61.6 years (range 40 to 79) and a mean age of implant of 36 months (range 3 to 72). Their preoperative diagnoses are osteoarthritis (29), post-traumatic osteoarthritis (11) and rheumatoid osteoarthritis (2).

Each patient undergo 3D MPR and CR imaging in the same session with both sets of images acquired by the same radiographer.

**Implant**

The implant used in this study is the non-cemented Scandinavian Total Ankle Replacement® (STAR). The implant consists of a metal tibia component with two cylindrical fixation bars that anchor the implant to the bone of the tibia and a talus component that has a ridge in the upper surface providing a sliding core for the mobile bearing. Both the talar and the tibial components are made of Cobalt Chromium alloy that are coated with pure titanium at all bone interfaces. In between the two metal components a polyethylene mobile bearing with a metal liner inside is inserted allowing movement of the artificial joint.

**Imaging**

Weight-bearing conventional ankle radiographs with lateral and AP views are acquired at 66Kv and automatic exposure. The mobile bearing must be shown with the metal liner within it fully visualized in both planes by angling the tube. The two cylindrical fixation bars on the tibia component must be shown as perfect circles in the AP plane and in their full length in the lateral plane. Refer to figure 1 and 2. All images are anonymised in the Picture Archiving Communication System (PACS) and evaluated in a blinded fashion by one senior musculoskeletal radiologist in regards to the presence and extend of periprosthetic bone cysts. Cysts were measured in three planes whenever possible.

Weight-bearing 3D MPR images are acquired in the same session as the conventional radiographs with the patient in the same position as for the AP radiographs and in the exact iso-center. Acquisition parameters are 66Kv and automatic exposure. All 3D MPR
images are post processed dictating a 1mm slice thickness and the reconstruction axis parallel to the ankle joint (axial plane) and along the axis of the tibial bone (sagital and coronal plane). All images are anonymised in the PACS and evaluated randomly in regards to size and location of cysts by two musculoskeletal radiologists whom are blinded to the results of the plain radiographs.

**Data collection**

The radiologists are asked to make definite diagnosis regarding the presence (value of 1) or the absence (value of 0) of a cyst. To allow direct comparison of individual cysts in between 3D MPR and CR, the location of each cyst is recorded using a zonal system, dividing the tibia and the talus into each three zones in the lateral plane, into each five zones in the AP plane and the fibula one zone.

Whenever possible a cyst must be measured in three planes using the greatest diameter in each plane, the longest height and the longest width perpendicular to the height and the longest depth.

**Images for this section:**
Fig. 1: AP image of a STAR ankle with metal liner fully visualized and the two cylindrical fixation bars shown as perfect circles.
**Fig. 2:** Lateral image of a STAR ankle with the metal liner fully visualized and the fixation bars shown in their full length.
Results

Number of cysts

Significantly more cysts are detected on 3D MPR, (74 vs. 55), P=0.03 (McNemars test). A total of 103 observations (100 cysts) are provided in 42 patients as depicted in the 2x2 contingency table below. Table 1.

<table>
<thead>
<tr>
<th>Cyst CR</th>
<th>Cyst 3D No cyst</th>
<th>Cyst 3D One Cyst</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No cyst</td>
<td>3</td>
<td>45</td>
<td>48</td>
</tr>
<tr>
<td>% Cyst CR</td>
<td>6.2%</td>
<td>93.8%</td>
<td>100.0%</td>
</tr>
<tr>
<td>% Cyst 3D</td>
<td>10.3%</td>
<td>60.8%</td>
<td>46.6%</td>
</tr>
<tr>
<td>One Cyst</td>
<td>26</td>
<td>29</td>
<td>55</td>
</tr>
<tr>
<td>% Cyst CR</td>
<td>47.3%</td>
<td>52.7%</td>
<td>100.0%</td>
</tr>
<tr>
<td>% Cyst 3D</td>
<td>89.7%</td>
<td>39.2%</td>
<td>53.4%</td>
</tr>
<tr>
<td>Total</td>
<td>29</td>
<td>74</td>
<td>103</td>
</tr>
<tr>
<td>% Cyst CR</td>
<td>28.2%</td>
<td>71.8%</td>
<td>100.0%</td>
</tr>
<tr>
<td>% Cyst 3D</td>
<td>100.0%</td>
<td>100.0%</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

Table 1. Number of cysts in total

Images

Figure 3, 4 and 5 are 3D MPR images of a patient with a STAR showing two large cysts adjacent to the talus component and in the medial malleolus. The corresponding CR images of the same patient (figure 6 and 7) are suspicious of a small cyst in the medial malleolus and in the anterior part of the talus. The CR images underestimate the extent of the cysts as well as the presence of the cyst in the posterior part of the talus not visible in the CR images.

Size of cysts

The cysts diagnosed using 3D MPR are significantly larger than those diagnosed using CR in this cohort of STAR patients P<0.0001(Wilcoxon signed rank test). In total, 100 cysts are diagnosed and measured; in cases with only two measurable dimensions, the
third dimension is estimated at 1mm. This estimation is performed five times in the 3D MPR group and 41 times in the CR group.

The average size of a cyst diagnosed on 3D MPR is more than six times larger than that diagnosed on CR, 1545 mm$^3$ (SD±1679) vs. 253 mm$^3$ (SD±820) and the total sum size of all cysts on 3D MPR is more than eight times larger than that on CR 114330 vs. 13935.

**Cyst in patient yes/no**

Of the 42 ankles included, 39 are diagnosed with one or more cysts on CR and/or 3D MPR. In total 86% of the patients are diagnosed with at least one cyst on 3D MPR with the corresponding number being 74% on CR. Despite the tendency that 3D MPR diagnose more patients with cysts this difference is not significant P=0.23 (McNemars test).

**Inter- and intra-rater reliability**

The level of agreement between and within the two observers when deciding between cyst/no cyst, is measured using #, Cohen's Kappa. The results are presented in table 2.

<table>
<thead>
<tr>
<th>Observer</th>
<th>Inter-rater reliability</th>
<th>Intrarater reliability</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>TT and AKH</td>
<td>#=-.244 (p=0.1)</td>
<td>#=-0.164 p=0.3)</td>
<td>95% CI (-0.07936,0.40864)</td>
</tr>
<tr>
<td>AKH; 3D MPR</td>
<td>#=-0.164 p=0.3)</td>
<td># =0.195 (p=0.3)</td>
<td>95% CI (-0.48152, 0.15352)</td>
</tr>
<tr>
<td>TT; 3D MPR</td>
<td># =0.0*</td>
<td># = 0.0*</td>
<td>95% CI (-0.23032, 0.62032)</td>
</tr>
<tr>
<td>TT; CR</td>
<td># =0.0*</td>
<td># = 0.0*</td>
<td>95% CI (-0.23032, 0.62032)</td>
</tr>
</tbody>
</table>

Table 2. Inter- and intra-rater reliability

None of the Kappa scores reach significance; the highest kappa score is achieved by the senior observer TT, on the 3D MPR readings #=-0.195, CI (-0.23032, 0.62032) supporting the statement by Bonin et al, who highlight the value of experience when reading STAR images (1)
Fig. 3: 3D MPR of a patient with a STAR showing two large cysts adjacent to the talus component and one cyst in the medial malleolus.
Fig. 4: 3D MPR of a patient with a STAR showing two large cysts in the talus.
**Fig. 5:** 3D MPR of a patient with a STAR showing a large cysts anteriorly adjacent to the talus component.

**Fig. 6:** CR image of the same patient (figure 3-5) are suspicious of a small cyst in the medial malleolus.
Fig. 7: CR images of the same patient (figure 3-5) are suspicious of a small cyst in the anterior part of the talus.
Conclusion

The data in this study suggest that performing a fluoroscopic 3D MPR will allow for better detection and more accurate quantification of periprosthetic bone cysts in patients with a STAR; however none of the Kappa scores reaching a significant level calls for caution when adding value to the findings.

It must also be kept in mind, that this study is the first of its kind and although the data implies that fluoroscopic 3D MPR is superior to CR on this potentially important subject, the diagnostic accuracy of the Multi diagnostic Eleva 3D MPR will need to be assessed in further studies before any definite conclusions may be drawn.

3D MPR does depict more cysts than CR but 26% of all cysts are diagnosed only on CR and not on 3D MPR, where 45% of all cysts are diagnosed on 3D MPR only thus a combination of the two modalities may turn out be the optimal solution for the patient in the future.

Figure 8-11 are an example of a STAR patient suspicious of cysts in the AP view on CR. The presence and the size of two large cysts are confirmed in the 3D MPR images.

Images for this section:
Fig. 8: 3D MPR of the same patient as figure 10-11 with two large cysts confirmed in the distal tibia.
**Fig. 9:** 3D MPR of the same patient as figure 10-11 with a large cyst confirmed in the distal tibia.
**Fig. 10:** Same patient as figure 8-9. A STAR patient suspicious of two cysts in the distal tibia in the AP view on CR.

**Fig. 11:** Same patient as figure 8-9. A STAR patient not suspicious of cysts in the Lateral view on CR.
References


Personal Information