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Bone Cysts and Osteolysis in Ankle Replacement

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Abstract

Background: Total ankle replacements (TARs) have higher rates of osteolysis than hip or knee replacements. It is unclear whether this is a pathologic immunologic process in response to wear debris, or expansion of pre-existing osteoarthritic bone cysts. We aimed to determine the incidence of bone cysts in patients with end-stage ankle arthritis prior to surgery and review the literature on bone cysts and osteolysis in relation to TAR.

Methods: This is a descriptive/prevalence study in which all patients with end-stage ankle arthritis underwent plain radiographic imaging and computed tomographic (CT) scans prior to TAR surgery. Their imaging was assessed for the presence of cysts, measured on sagittal, axial, and coronal slices of the CT scan at the widest diameter. All cysts that would be removed as a result of the bone resection for the implant were excluded using digital analysis software. We assessed 120 consecutive patients with mean age of 63.4 years.

Results: Seventeen patients (14%) did not have any bone cysts based on CT images. Ten patients (8%) had cysts that would have been completely removed by surgery, leaving 93 patients for analysis (78%). In 60% of these cases, the cysts were not seen on the plain radiographs. In 39 patients (33%), the cysts were greater than 5 mm in size. The medial (36%) and lateral malleoli (33%) were the most common location for the cysts (mean diameter 4.6±2.0 and 4.2±2.3 mm, respectively).

Conclusion: Bone cysts outside of the resection margins for a TAR were present in 78% of patients with ankle arthritis prior to undergoing surgery. In 30% of cases, cysts were greater than 5 mm in size. In 60% of cases, the cysts were not seen on plain radiographs. Preoperative 3-dimensional imaging can provide a foundation to observe and quantify cyst presence, expansion, and time of onset in the postoperative setting.

Level of Evidence: Level IIc, diagnostic/prevalence study.

Keywords: Loosening, malalignment, revision, arthroplasty

Introduction

Bone cysts are part of the biochemical and mechanical process of osteoarthritis (OA) (Table 1).[6,18] Subchondral bone cysts occur because of excessive mechanical stress or synovial fluid intrusion into bone marrow spaces, creating a high turnover of bone.[7,14,28,29] Bone marrow edema is linked to the formation of subchondral cysts, and larger cysts may correlate with implant failure.[31,32] Three-dimensional imaging, such as computed tomography (CT) or magnetic resonance imaging (MRI), are useful modalities for finding cysts around the joint, especially as they are not always seen on plain radiographs.[13]

In contrast, osteolysis is defined as bone resorption due to a biological response to macrophage-activated osteoclastic action. In the context of joint replacement, this relates to polyethylene debris, which drives osteoclast activation that can compromise the bone stock around the implant and lead to loosening of the prosthesis.[34,36] An osteolytic cyst is

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Table 1. Differences Between Bone Cysts and Osteolysis.

Bone cysts	Osteolysis
Part of the normal biochemical process of OA	In the context of joint replacement, refers to a pathologic process
Subchondral cysts occur due to breach in chondral surfaces with synovial fluid intrusion into bone marrow spaces	Bone resorption due to biological response to debris, including osteoclast activation that can compromise the bone stock around the implant and can lead to loosening of the prosthesis
May be present preoperatively	Not present preoperatively

Abbreviation: OA, osteoarthritis.

defined as a hypodense zone greater than 5 mm in diameter with no inner bony trabeculae but with peripheral sclerosis that was not present preoperatively.[11]

Depending on the type of implant, the rates of osteolysis after total ankle replacement (TAR) can be as high as 76% at 9-year follow up,[11,17,19] which is much higher than that seen after hip and knee arthroplasty.[3,30] One factor implicated in the pathogenesis of osteolysis[1,3,30] is the possibility that these could be expansion of preoperative simple bone cysts.[9] We therefore aimed to assess the incidence of bone cysts in patients with end-stage ankle arthritis prior to TAR and review the literature on bone cysts and osteolysis in TAR.

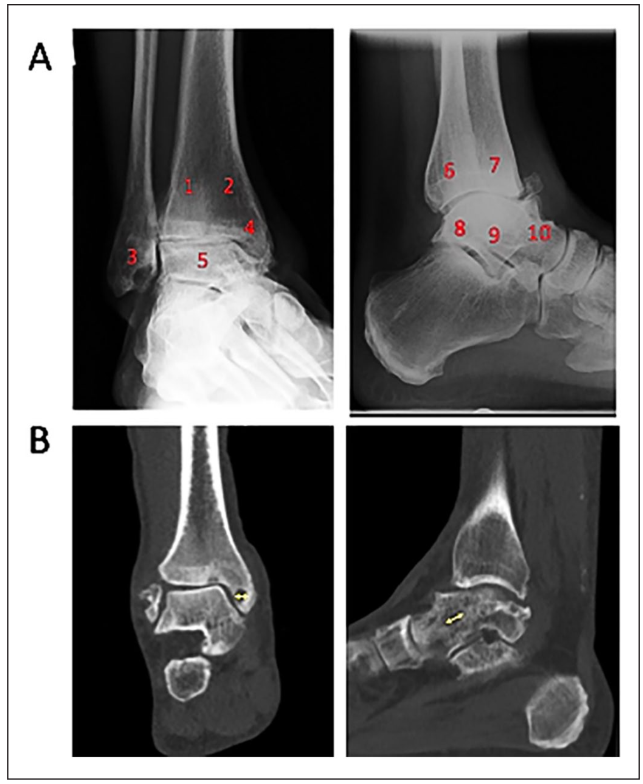

Figure 1. (A) The location of cysts were recorded according to a 10-zone protocol.[3] (B) Outline of coronal and sagittal views of the tibia and talus with demonstration of cysts at a section at its widest diameter. The cysts were measured using a measurement tool (indicated by arrows) (PACS, McKesson).

Methods

We analyzed the imaging of consecutive patients with end stage ankle osteoarthritis prior to TAR. Anonymized data were stored on the computer systems at the Royal National Orthopaedic Hospital, Stanmore, UK. Patient demographics, medical comorbidities, and previous fractures or trauma were recorded. All patients underwent preoperative plain radiographs and CT scans (Philips Ingenuity Core 128 Scanner) between October 2016 and September 2019 immediately prior to their TAR surgery. The plain radiographs were standardized standing lateral radiographs and long leg alignment views. The CT scans captured 1-mm slices at 0.5-mm increments from 10 cm above the ankle joint to the sole of the foot. Individual patient CT data were converted into 3-dimensional computer models.[15,23,25]

One hundred twenty patients were included. The mean age was 63.8 years (range 29-86 years). Sixty-seven of the patients were female, and 53 were male. Twenty patients (17%) had rheumatoid arthritis, juvenile idiopathic arthritis, or another form of inflammatory arthropathy. Forty-two patients (35%) had a previous fracture of the ankle, talus, or tibial plafond. Of these, 26 patients (22%) had previous operative fixation.

The plain radiographs were assessed for the presence or absence of bone cysts, and the location of the cysts were recorded. Independent of the plain radiographic assessment, cysts were also measured on the CT scans using the sagittal and coronal slices of the CT scan at the widest diameter (Figure 1) using a digital patient archive and communication system (PACS; McKesson, Coventry, UK). A single line was drawn along the largest diameter of the cyst in a single plane. The line was accurate to 0.1 mm. These were recorded in relation to a 10-zone protocol (Figure 1).[3] Only cysts greater than 3 mm were recorded.[1,21] If there were multiple cysts in the same zone, the sum of all cysts was taken. Cysts in the presence of bone resection zone for placement of the TAR were recorded in conjunction with the templates created by the digital analysis software (Figure 2). The size and location of cysts were also correlated to the digital analysis software.

All measurements were performed by A.N. and Y.G. Both authors were blinded to each other's measurements. To determine intra-observer (same tester) reliability, 50 CT scan measurements were repeated 1 week apart by A.N. To determine interobserver (different tester) reliability, 50 measurements were repeated by A.N. and Y.G. Reliability was assessed using intraclass correlation coefficient and Pearson correlation.

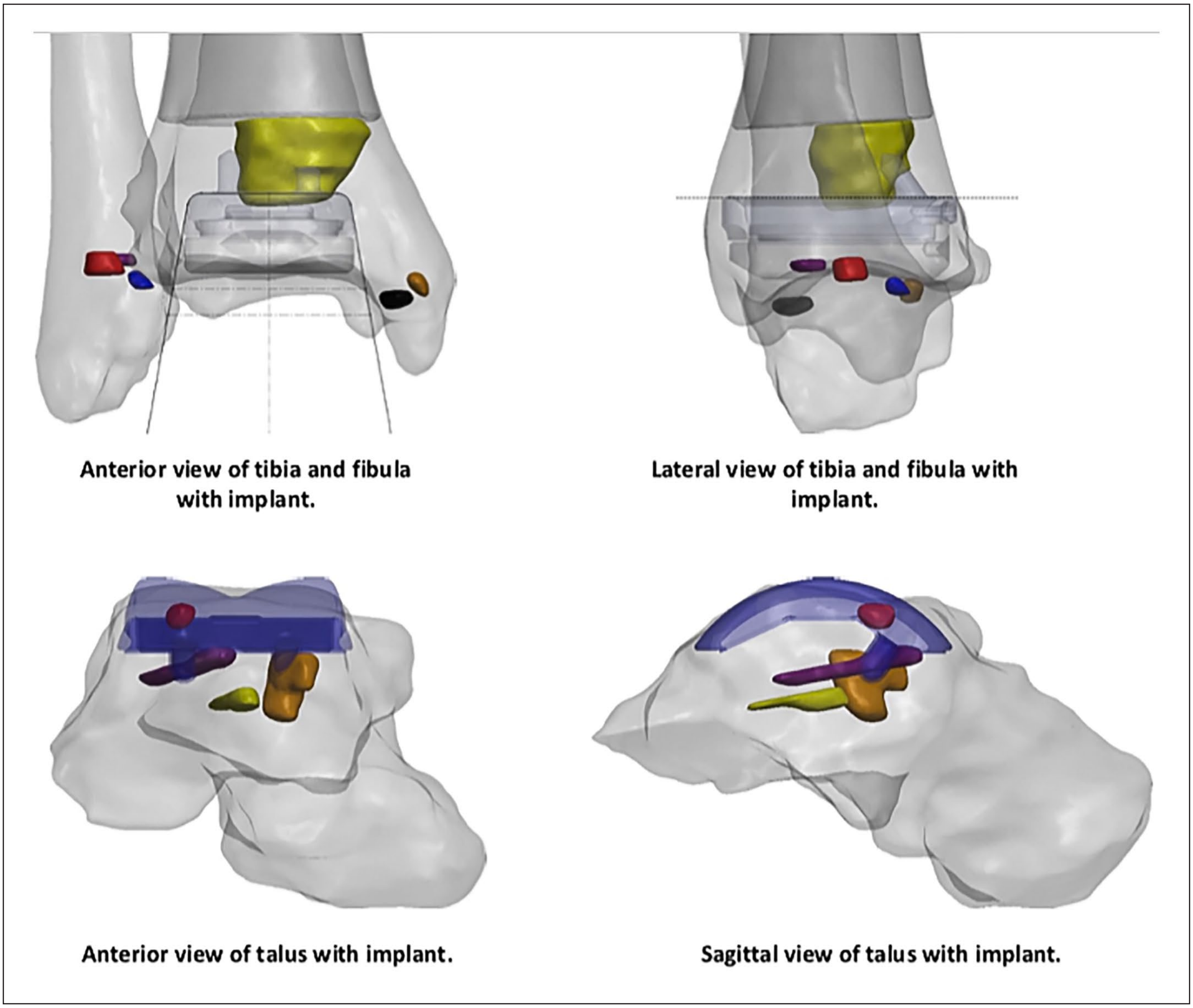

Figure 2. Outline of coronal and sagittal views of the tibia and talus with demonstration of cysts. Aside from the smaller cysts, there is a large cyst in zone 2 and zone 7 of the tibia, outside of the zone of resection. The outline of the INFINITY implant (Wright Medial Technology [WMT], Memphis, TN) shows which cysts will be removed with bony resection for placement of implants. Images taken from PROPHECY templates, courtesy of WMT, Memphis, TN, USA.

Approvals

The institutional review board deemed that this was a review of patient imaging and because all data were captured as part of routine care and was anonymized, it was considered service evaluation and did not require ethical approval.

Results

Preoperative radiographs were reviewed in all 120 patients. Of these, 89 patients (74%) had no cysts visible on radiographs. Seventeen (14%) of these patients had no cysts seen on CT scan either. Therefore in 72 patients (60%), cysts were missed on the radiographs and were only detectable on the CT scans (Figure 3). In 31 patients who had cysts visible on plain radiograph, only 7 patients had a true representation of the cysts when reviewing their CT scans. In the 23 others, there were cysts missed in the tibia (9 patients), talus (7 patients), or both (talus and tibia) (8 patients).

On the CT scans, 17 patients (14%) did not have any cysts in the distal tibia or talus. Ten patients (8%) only had cysts that would have been completely removed by the resection margins. This left 93 patients with bone cysts that would be present after the surgical implants are placed (78%). The location and presence of cysts is shown in Figure 4, and the

Figure 3. An example of a patient in whom a medial talus cyst is visible on computed tomography, but is not visible on the plain radiograph. (A) A plain anteroposterior (AP) and lateral radiograph of this patient. (B) The sagittal and axial view of the talus cyst, which measured 6 mm in diameter at its widest.

mean sizes of the cysts in the locations are shown in Figure 5. In 36% of patients, there were cysts in the medial malleolus (zone 4) (mean diameter 4.6±2.0 mm). Lateral malleolus cysts (zone 3) were present in 33% (mean diameter 4.2±2.3 mm). Body of talus cysts (zone 9) were present in 32% of patients (mean diameter 4.0±1.5 mm).

Thirty-nine patients (33%) had cysts greater than 5 mm, with the largest cyst measuring 18 mm. The larger cysts were present in zone 2 in the coronal plane and zone 7 in the sagittal plane (Figure 5); the mean diameter was 6.1 ± 3.8 mm and 6.8 ± 3.7 mm, respectively. The smallest cysts were found in the neck of talus (3.9±1.3 mm) and in the body of the talus in zone 9 (4.0±1.5 mm).

In those with previous open reduction and internal fixation, the distribution of cysts was similar, with the most common being zones 3, 4, and 9 (35%, 48%, and 26%, respectively). There was no significant difference between the size of cysts in different zones between those who had previous fracture surgery and those who did not.

Measurements were performed twice in separate sessions, indicating excellent intra- and interobserver reliability (intraclass correlation coefficient 0.80 and 0.78, respectively; Pearson correlation 0.80 and 0.88, respectively; $P < .001$).

Discussion

We have demonstrated the presence of bone cysts in 78% of patients with end-stage ankle arthritis prior to undergoing TAR which would not be removed by the bone resection of their surgery. One-third of these patients had bone cysts greater than 5 mm in size. In 60% of patients, the presence of preoperative cysts would have been missed on plain radiographs.

The majority of bone cysts were in the medial and lateral malleoli, and the body and neck of the talus. The largest cysts were found in the anteromedial tibia, with some being greater than 1 cm in size. Talar cysts are more commonly located under the weightbearing portion of the talus and would be obscured by an implant with a side wall.

Osteolysis in relation to TAR has been described as 2 types: mechanical osteolysis, a stress shielding phenomena, characteristic of small nonprogressive cysts with an early onset; and the second type reported as ballooning or expansile osteolysis due to wear particles.[19] The use of the word *osteolysis* to describe the first "mechanical" type of lucency is probably incorrect, as this most likely refers to the presence of pre-existing cysts that had not been seen, or progression of pre-existing cysts due to stress shielding.

In fact there is no consistency in nomenclature, with terms such as "cysts," "ballooning lysis," "large osteolytic cavity," "osteolysis greater than 2 mm," "cavity," "cavitation," "subchondral cysts," "cystic-like osteolytic lesion," "well-circumscribed peri-prosthetic area of lucency," "radio-lucent area greater than 2 mm," and "demarcated hypodense zone" all being used in publications; there is a need for a clear distinction between bone cysts present prior to the surgery and the pathologic process of osteolysis that takes place after TAR.[1] This study has shown that in the absence of 3-dimensional imaging prior to surgery it is difficult to determine whether an area of lucency noticed postoperatively is worsening of a missed pre-existing bone cyst or the development of a new cyst as a result of osteolysis.

Yoon et al suggested that half of the late-onset lesions showed continuous progression against only 9.5% in the early onset group,[35] which would support the argument that the early onset, non-progressive cysts may be related to bone cysts present preoperatively, whereas the later-onset lesions reflect the pathologic process of osteolysis. Bonnin et al also supported this argument when they reported 19% patients with STAR TAR demonstrating cysts greater than 5 mm on review.[5] Besse et al. stated that preoperative CT

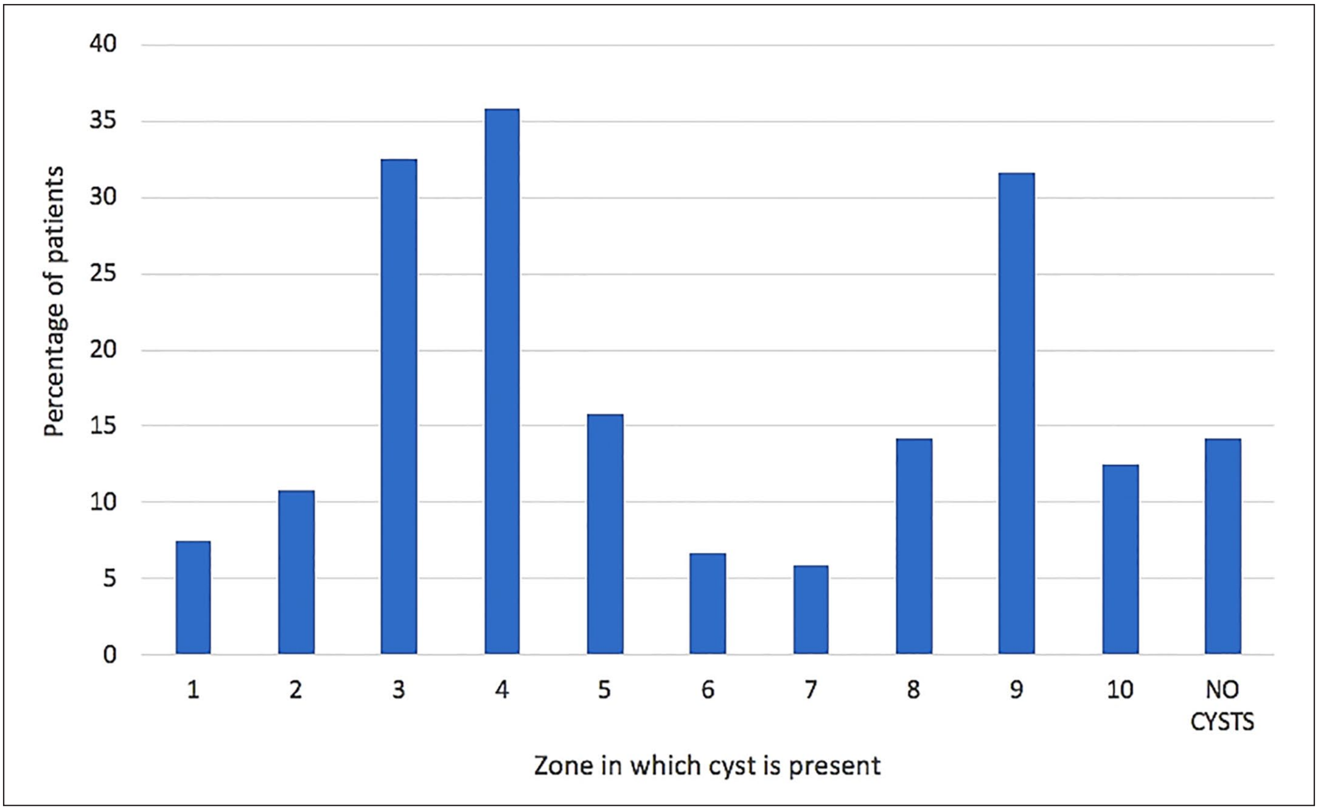

Figure 4. A bar chart demonstrating the percentage of patients in whom there were cysts present, within the zones described by Besse et al.[3]

scans did not reveal bone cysts in their cohort of patients who underwent AES TAR.[2,3] However, their methodology to rule out pre-existing cysts is unclear. Subsequently, more than 20% of patients had severe osteolysis at 45 months' follow-up.

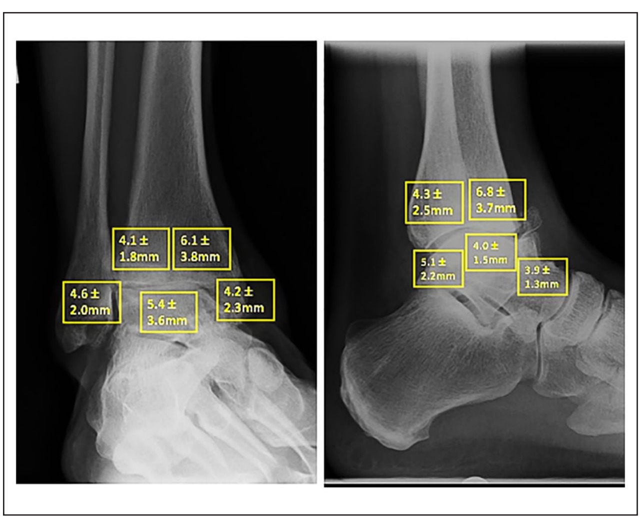

Figure 5. An anteroposterior (AP) and lateral radiograph of an ankle with end stage osteoarthritis. The zones described by Besse et al[3] have been replaced with the mean diameter of the cysts ± standard deviations.

The causes of osteolysis following TAR are multiple, ranging from an inflammatory cytokine-cascade response to wear debris,[16,20] mechanical factors such as high joint fluid pressure, implant micro-motion and stress shielding,[1,8,9] and material properties of the implants themselves.[1,22,27] Malpositioning of implants in TAR surgery leads to higher contact pressures and greater shear stress, and can lead to higher rates of osteolysis.[3,10,21,26,30] A full discussion on this subject is beyond the scope of this article but we would like to reinforce the argument that the existence of preoperative cysts is an important variable that needs to be considered in the analysis of postoperative cysts.

Bone grafting is believed to be safe and may improve the survivorship of the implant. Published series looking at grafting of osteolysis in TAR have reported variable outcomes with high rates of cyst progression after grafting.[24] Trincat et al[33] reported 21 cases of painful cysts treated by autograft, although there was a 19% failure rate. Gross et al[12] also reported good results with curettage and cyst filling with a success rate of 90.9% at 24 months and 60.6% at

48 months in a group of patients with osteolysis after primary TAR. Yoon et al[35] reported no evidence of progression of osteolytic lesions after 8 revisions with bone graft treatment. However, Besse et al[4] analyzed a series of 50 TARs for which 20 revision procedures with bone cyst curettage and grafting were performed. At a mean follow-up of 32 months, 79% functional and 92% radiologic failure rate was reported and 28% were converted to arthrodesis.

There have been no reports as to the management of cysts intraoperatively for primary TAR. It has become the author's standard practice to graft larger and accessible cysts at the time of the primary TAR. Further work is needed to assess the longer-term clinical and radiologic response. Although ours is a small series, we believe it to be the biggest documented analysis of preoperative bone cysts in end-stage ankle arthritis to date.

Conclusion

Bone cysts that would not be removed by implant resection were present in 78% of patients with end-stage ankle arthritis prior to undergoing a TAR, of which 30% of cases were larger than 5 mm. In 60% of cases the cysts were not picked up by plain radiography. Preoperative 3-dimensional imaging can provide a foundation to observe and quantify cyst presence, expansion, and time of onset in the postoperative setting.

Declaration of Conflicting Interests

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