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Original Research

Routine Histopathologic Examination of Bone Obtained During Elective Primary Total Knee Arthroplasty May Not Be Necessary

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ABSTRACT

Background: Many institutions require the routine collection of pathology samples from every primary total knee arthroplasty (TKA) performed. These policies are controversial, and their cost-effectiveness is difficult to define. We sought to judge the cost-effectiveness of one such policy according to World Health Organization recommendations.

Methods: We analyzed 3200 consecutive primary TKAs, comparing our presumed preoperative diagnoses against the diagnoses made by the pathologist. Diagnoses were categorized as concordant (matching), discrepant (not matching but without impact to patient management), or discordant (not matching and resulting in a direct change to patient management). An incremental cost-utility ratio analysis was performed to determine the cost-effectiveness of our institution's policy to routinely collect pathology samples from every primary TKA performed. Cost-effectiveness was defined by World Health Organization guidelines as a cost of less than $228,090 per quality-adjusted life year gained.

Results: Twelve pathology samples were lost before reaching a pathologist. From the remaining 3188 samples, we identified 3158 concordant cases, 29 discrepant diagnoses, and 1 discordant diagnosis. It cost an estimated $10,522.60 to identify each discrepant diagnosis and an estimated $305,155.36 to diagnose one discordant case in our cohort. Our incremental cost-utility ratio analysis revealed that we spent $305,155.36 to gain 0 quality-adjusted life years for our patients.

Conclusions: Routine histopathologic analysis of TKA samples was cost-ineffective in our patient cohort and may not be necessary during routine TKA.

Introduction

Total knee arthroplasty (TKA) is one of the most commonly performed procedures in the United States each year [1]. Although pathologic examination of removed bone is commonplace during total hip arthroplasty (THA), it is an inconsistent practice for routine TKA [2]. The most common diagnosis for TKA is osteoarthritis, and the value of pathologic exam in these patients has been studied previously using total cost and reimbursement calculations and determining whether the results led to a change in patient management [3]. In total, over 675,000 TKAs are performed each year in the United States [4], and this number is expected to increase significantly over the coming years as the "baby boomer" generation matures [1,5,6]. Examining the cost-effectiveness and utility of pathologic examination in primary elective TKA at a single, high-volume, tertiary care, private hospital can add to the scarce literature on this topic and determine if there are other diagnoses that might necessitate the practice.

Multiple studies have looked at whether the routine collection of histopathologic samples from primary THA could be justified. Many found that the elimination of these policies would produce significant cost savings to society [3,7,8]. However, this conclusion is controversial, as there have been patients identified who received life-saving interventions as a result of such policies [9,10]. Although it would be difficult to tell such a patient that the test that resulted in his or her life-saving intervention was not justified, the World Health Organization (WHO) has provided recommendations to assess the cost-effectiveness of screening tests [11].

The literature regarding the cost-effectiveness of pathology collection from primary THA is quite robust [10]. However, there is

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a paucity of literature analyzing similar policies in TKA. Most prior studies were not published recently, do not implement WHO-recommended criteria, and do not specify the frequency at which specimens were collected [12,13]. Our institution has required the routine collection of histopathologic samples from every primary TKA performed for many years to screen for patients with undiagnosed pathologies for whom life preserving or life prolonging interventions may be indicated. As a tertiary center in a large medical center, we perform over 1000 primary TKAs per year. The aim of this study was to evaluate whether routine pathologic examination of TKA bone from primary procedures is clinically indicated and/or cost-effective, judged according to WHO recommendations for cost-effectiveness. We hypothesized that routine histopathologic sample collection during primary TKA would be cost-ineffective because malignancies are much less common at the knee than at the hip [14,15].

Material and methods

Our institutional review board approved this retrospective analysis of our institution's joint replacement registry. We identified and analyzed 3200 consecutive TKAs performed between 5/23/2016 and 6/3/2019.

Histopathologic analysis from TKA samples

In accordance with our institution's policy to collect histopathologic samples from every primary TKA performed during this time interval, 3188 pathology samples were successfully analyzed by our institution's pathologists. There were 8 cases (0.25%) in which histopathologic samples were not successfully sent to the lab from the operating room and 4 cases (0.125%) in which a sample was sent from the operating room but subsequently lost in transit before reaching a pathologist. We elected not to exclude these 12 cases (0.375%) because they provide a real-world representation of what may be expected to occur under such policies.

Patient demographics for the 3188 TKA samples (99.625%) are summarized in Table 1. From each of these cases, both tibial and femoral resection samples were analyzed systematically in accordance with College of American Pathology standards. A standard combination of gross and histologic examination was used to diagnose the underlying pathology. Confirmatory tests such as immunohistochemistry analyses and/or flow cytometry were performed based on the preliminary diagnosis.

Table 1
Demographics and preoperative diagnosis.

Variable	N = 3188
Gender	
Male	1399 (43.9%)
Female	1789 (56.1%)
Mean (IQR) age in years	66.9 (61.1-73.0)
Race	
American Indian	14 (0.4%)
Asian	64 (2.0%)
Black or African American	407 (12.8%)
Native Hawaiian or other Pacific Islander	0 (0%)
White	2482 (77.9%)
Two or more categories	96 (3.0%)
Not reported	125 (3.9%)
Preoperative diagnosis	
Osteoarthritis	3156 (99.0%)
Rheumatoid arthritis	6 (0.19%)
Septic arthritis	1 (0.03%)
Posttraumatic arthritis	20 (0.63%)
AVN/osteonecrosis	5 (0.16%)

Postoperative pathologic diagnoses were categorized into 3 categories based on their relation to the presumed preoperative diagnosis: concordant (meaning that the postoperative diagnosis matched the presumed preoperative diagnosis), discrepant (the postoperative diagnosis differed from the presumed preoperative diagnosis but did not change patient management), and discordant (the postoperative diagnosis differed from the presumed preoperative diagnosis and this resulted in a direct alteration to the patient's subsequent management). For patients with discordant diagnoses, further chart review was performed to determine clinical outcomes of the new diagnosis.

Cost-effectiveness analysis

The total cost of a histopathologic analysis of TKA samples was obtained using Medicare reimbursement rates for Current Procedural Terminology codes 88305 and 88311 in 2022-adjusted dollars. This resulted in a total cost of $95.72 per histopathologic examination. Costs of additional workup that resulted from the histopathologic analysis, including both confirmatory pathology tests (such as immunohistochemistry analyses and/or flow cytometry) and additional clinical workup (such as additional laboratory tests and/or samples forwarded to microbiology for culture) were excluded from this analysis. Therefore, the costs we report to identify a discrepant or discordant case were calculated based on the number of cases identified in each of these categories divided by the total number of pathologic examinations performed. This decision was made in accordance with the standard set in the THA literature, so direct comparisons could be made [10].

The incremental cost-utility ratio (ICUR) was used to perform our cost-effectiveness analysis [16,17]. ICUR is calculated as the cost of histopathologic screening divided by the gain in quality-adjusted life years (QALYs) gained by the patients who underwent such screening. The QALY is a common outcome measure used to determine the value of health-care expenditures that quantifies the quantity and quality of life years gained as a result of an intervention [18]. The WHO has set a standard for determining if an intervention is cost-effective. This is set as an ICUR equal to 3 times a country's gross domestic product per capita. Interventions below this cutoff are considered cost-effective [11]. According to the International Monetary Fund [19], the gross domestic product per capita for the United States is $76,030, meaning that interventions that cost less than $228,090 per QALY gained can be considered cost-effective.

Results

Of the 3188 TKA samples that were analyzed by a pathologist, 3158 (99.1%) were concordant with the preoperative diagnosis. There were 29 discrepant diagnoses (0.9%) identified in our analysis. This included 13 new pseudogout diagnoses (0.4%), 9 new inflammatory arthritis diagnoses (0.3%), 4 new gout diagnoses (0.1%), and 3 new tenosynovial giant cell tumor (TGCT) diagnoses (0.1%). The inflammatory arthritis diagnoses led to referrals to rheumatology and no further orthopaedic intervention. The TGCT diagnoses required no further local treatment out to 2 years of follow-up. The results from our study are summarized in Figure 1.

There was one discordant diagnosis (0.03%) identified in our cohort after histopathologic analysis. A "likely abscess" was identified on histopathologic review of one TKA sample. This patient received a short course of intravenous antibiotics while additional workup was performed, including additional analysis of this sample by the microbiology lab and the collection of patient blood samples for additional laboratory tests. This discordant diagnosis was determined to be a false-positive, and the short course of

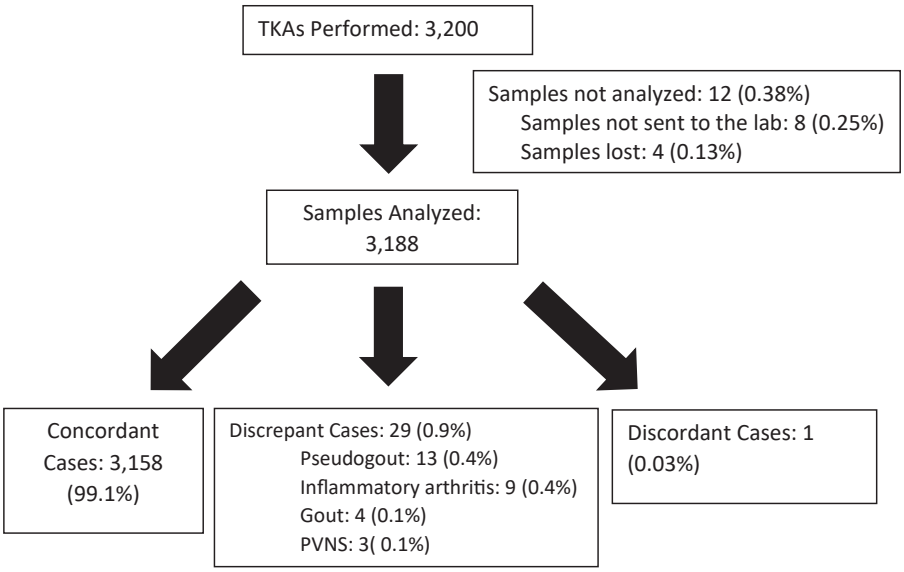

Figure 1. A summary of the consistency of diagnoses by histopathology with preoperative diagnoses.

intravenous antibiotics was discontinued. An extensive chart review was performed for this patient. He has remained off antibiotics since his last dose on the third postoperative day, and he has remained infection-free through his recent 4-year postoperative follow-up.

Cost-effectiveness analysis

Of the 3188 TKA samples that were sent for histopathologic examination, only one discordant diagnosis was reached, which proved to be a false-positive diagnosis. No resultant QALYs were gained by that patient. We spent $305,155.36 to make one discordant diagnosis from which no QALYs were gained; our ICUR = $305,155.36 / 0 QALYs.

Discussion

Policies to routinely send samples from common surgeries for histopathologic analysis, such as those following total joint arthroplasty, are well intentioned and provide an opportunity to screen patients for potentially life-altering disease processes. Unfortunately, value considerations must also factor into the health-care decisions physicians make.

It has been estimated that approximately 1 in 770 femoral head samples sent from routine THAs reveal an undiagnosed malignancy [20]. No matter the cost, policies that demand such screening can certainly be considered justified for these individual patients. Determining the justification for society, considering the scarcity of health-care resources and in efforts to distribute them as equitably as possible, is a more difficult analysis to perform.

The cost-effectiveness of routine histopathologic analysis of femoral head samples is a controversial topic. Liow et al. found that it cost $4390 to diagnose each discrepant case and $122,933 to diagnose each discordant case [10]. Based on Medicare reimbursement rates of $95.72 in 2022-adjusted dollars to perform histopathologic analysis of samples from each TKA performed, it cost $10,522.60 to reach each discrepant diagnosis and $305,155.36 to diagnose one discordant case in our cohort. The incidence of pathologic findings about the knee is known to be less common than about the hip [14,15]; therefore, it makes sense that our costs to diagnose discrepant and discordant cases in our TKA cohort are higher than those reported in the THA literature. However, higher cost does not necessarily equate with an intervention being less cost-effective, as it could provide more utility to patients than a less expensive intervention does.

Liow et al. performed an ICUR analysis on their cohort and determined that they spent $49,569.74 per QALY gained. They concluded that policies demanding routine histopathologic screening of THA samples could be justified by WHO cost-effectiveness standards. We elected to assess the justification of our institution's TKA screening policy according to the same WHO guidelines. We maintain that our one discordant diagnosis was a false-positive that provided no QALYs for this patient, yet $305,155.36 was spent sending routine TKA samples for histopathologic analysis. Therefore, we conclude that routine histopathologic analysis of TKA samples was cost-ineffective in our patient cohort.

Our conclusion must be assessed with regard to several limitations of our study. A limitation could be perceived in our definitions of TGCT and inflammatory arthritis as discrepant and not discordant diagnoses. TGCT is an aggressive, tumor-like condition, but it is also a benign condition for which arthroplasty with concurrent synovectomy is considered a definitive treatment [2,21]. Similarly, end-stage single-joint inflammatory arthritides are treated with arthroplasty, typically without the addition of disease-modifying antirheumatic drugs due to concerns with infection risk [2,22]. For both of these disease processes, adequate surveillance is provided by the routine radiographic monitoring that is performed in clinic following a TKA [2].

Additional limitations stem from the assumptions and calculations used to determine our ICUR. First and foremost, the ICUR of our institution's policy could not be defined. The denominator of the ICUR equation is the QALYs gained, and after reviewing the patient records from 3200 TKAs, not a single QALY was gained in our cohort. It is possible that a review of a larger cohort might have revealed a patient for whom multiple QALYs would have been saved by this policy, defining the ICUR as a lower number than the $305,155.36 that was spent to save 0 QALYs in our analysis. However, given that well over the WHO standard cutoff in cost/QALY was spent in our cohort and we were unable to demonstrate benefit to our patients, we concluded that our screening policy is not cost-effective. Also, although our study analyzed a 3-year period from

2016 to 2019, due to temporal fluctuations in histopathology costs, we adjusted all charges to 2022 levels to add consistency and simplify our calculations. We did not include the costs of secondary or tertiary tests incurred by patients after the primary histopathology testing. These costs would have been exceedingly difficult to gather, and had they been included in this analysis, our cost estimates and our calculated ICUR would have been much higher, only strengthening our overall conclusion that routine histopathologic analysis of TKA samples was cost-ineffective in our patient cohort.

A final limitation could exist in the generalizability of the conclusions drawn from our single-institution dataset. Specifically, 77.9% of our patients identified as white, and 99.0% of our patients had an osteoarthritis diagnosis, whereas white Americans accounted for 57.8% of the population on the 2020 Census [23] and osteoarthritis is the reported diagnosis for about 94% of patients undergoing TKA [24]. Unfortunately, health-care disparities exist, and nonwhite patients are less likely to undergo TKA than white patients [25]. Additionally, with improvements in biologic therapies for inflammatory arthritis, the relative percentage of patients undergoing TKA for osteoarthritis is believed to be increasing [26]. Therefore, the demographic variables of our patient cohort are likely not dissimilar to those expected in a standard cohort of TKA patients.

Our study was not powered to identify clear and reasonable guidelines for the submission of pathologic samples during routine elective TKA. Future studies may evaluate patient-specific risk factors that would justify TKA histopathologic analysis, such as those that could be correlated with possible underlying pathologic or infectious processes. These endeavors may incorporate the role of predictive analytics in deciding whether to order histopathologic analysis and the role of artificial intelligence in interpreting histopathologic specimens in a more efficient and cost-effective manner.

Conclusions

Our institution mandates histopathologic analysis of samples from all primary TKAs. This practice was cost-ineffective in our patient cohort. Such policies may not be necessary for routine TKA, and given the results of this study, we have taken steps to change this practice at our institution.

Conflicts of interest

The authors declare there are no conflicts of interest.

For full disclosure statements refer to https://doi.org/10.1016/j.artd.2023.101200.

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