ORIGINAL PAPER

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Robotic-assisted versus standard unicompartmental knee arthroplasty—evaluation of manuscript conflict of interests, funding, scientific quality and bibliometrics

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Abstract

Purpose Robotic-assisted unicompartmental knee arthroplasty (UKA) has gained popularity over the last decade claiming enhanced surgical precision and better joint kinematics, with peer-reviewed publications about this new technology also increasing over the past few years. The purpose of our study was to compare manuscripts about robotic-assisted UKA to those about standard UKA in terms of industry funding, author conflict of interest, scientific quality, and bibliometrics.

Methods A systematic search using PRISMA guidelines on PubMed and Google Scholar from 2012 to 2016 resulted in 45 papers where robotic technology was performed for UKA and 167 papers that UKA were performed without the assistance of a robot. Between the two groups, we compared (1) rate of manuscripts with reported conflict of interest or industry funding, (2) journal impact factor, (3) level of evidence, and (4) relative citation ratio.

Results Fifty-one percent (23/45) of robotic UKA manuscripts were industry-funded or had authors with financial conflict of interest, compared to 29% ([49/167], $p < 0.01$) of non-robotic UKA papers. Significantly more robotic UKA papers (24% [11/45] vs 9% [16/167], $p < 0.01$) were published in journals that were not assigned an impact factor by the Journal Citations Report. There was no difference in regard to bibliometrics or level of evidence.

Conclusion Manuscripts in which UKA was performed with the assistance of a robot were more likely to be industry funded or be written by authors with financial conflicts of interest and published in less prestigious journals. There were no differences in scientific quality or influence between the two groups. Readers analyzing published data should be aware of the potential conflicts of interests in order to more accurately interpret manuscripts data and conclusions.

Introduction

Robotic technology in orthopedic surgery has greatly advanced over the last decade, promising several advantages compared to standard techniques [1]. Particularly among all robotic systems, robotic-assisted unicompartmental knee arthroplasty (UKA) has gained popularity with the recent introduction and propagation of semiautonomous robotic systems [2]. Currently, 15 to 20% of UKAs in the USA are performed with the assistance of a robot and this volume is estimated to increase to 37% in ten years [2]. In line with the rise in semiautonomous robotic UKA utilization, peer-review publications concerning robotic UKA have also increased over the last few years, most often giving background and support of this new technology. The vast majority of these studies endorse the benefits of robotic-assisted technology for UKA, including increased surgical accuracy, better component position, and substantial reduction of variability and outliers [3, 4].

Concerns continue to exist regarding the influence of financial conflict of interest and industry funding on such studies as well as scientific quality of the manuscripts [5]. Although the relationship between orthopaedic researchers and industry has provided unquestionable increase in published articles and

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expansion of medical knowledge, questions remain regarding the effects of industry funding and conflict of interests on the outcomes and quality of published orthopaedic research [6].

The purpose of this study was to investigate whether manuscripts that utilized robotic technology to assist UKA, as compared to manuscripts where UKAs were performed without the assistance of a robot, were more likely to be industry funded and written by authors with financial conflict of interest. We also elected to compare the scientific quality and bibliometrics of manuscripts that have robotic and non-robotic technology. In order to accomplish that aim, this study assessed all recent literature (last 5 years) regarding UKA and divided in manuscripts where robotic assistance was used to perform the surgeries and in manuscripts where UKA was performed under a standard technique. We compared these two groups in terms of industry funding and conflict of interest as well as the scientific quality by analyzing the level of evidence (LOE). We also evaluated the bibliometric values journal impact factor (JIF) and a new measure named relative citation ratio (RCR).

We hypothesized that manuscripts where robotic technology was used to assist UKA surgeries were (1) more likely to be funded by industry and have authors with financial conflict of interest, (2) have inferior scientific quality and rigor, (3) were published in less prestigious journals, and (4) have inferior scientific influence.

Methods

Search criteria

We conduct a systematic search using PRISMA guidelines [7] in the electronic databases PubMed and Google Scholar for studies pertaining to unicompartmental knee arthroplasty. The algorithms "(robot* AND knee arthroplasty OR replacement)" and "(knee arthroplasty OR replacement NOT total)" were used as search criterion. After removing duplicates and combining the search results, two authors (LMC and CSM) independently scanned all selected studies for eligibility by title and abstract. Selected studies were then scanned by full text on the inclusion and exclusion criteria. When disagreement occurred between the two authors, a third author (MJB) was consulted. Final consensus was reached with regard to inclusion and exclusion of all articles.

Inclusion and exclusion criteria

Inclusion criteria included studies regarding UKA written in the English language and published between January 2012 and December 2016. Clinical and basic science studies, reviews, technical notes, case reports and editorials were included. Exclusion criteria included articles where full texts were not available, including journal proceedings or manuscripts where the surgical technique for performing the UKA was not described. Surveys, letters to the editor, and correspondences were excluded. The manuscripts were further divided into "robotic UKA" if surgeries were performed with the assistance of a robot or if a review article was about robotic UKA technology and "Standard technique UKA" if no robotic assistance was used, including navigation and patient-specific instrumentation.

Quality assessment and bibliometrics

All manuscripts were analyzed in the full-text format and searched for any sort of industry funding, financial disclosures from the authors, or if any of the author were employees of a company with compelling financial interests in the subject of the work. While some journals only reported whether conflict of interest existed of not, others provided specific information regarding the type and nature of financial disclosures by the authors. Other journals simply did not mention anything regarding conflict of interest or funding at all.

For LOE, we used the most recent grading system recommended by the Journal of Bone and Joint Surgery [8]. For the statistical analysis, LOE was sorted into three groups: high LOE (I and II), intermediate LOE (III), and low LOE (IV and V). Non-systematic reviews were considered as low level of evidence while opinions and editorials were considered level V.

Journal impact factor was accessed via InCites Journal Citations Report (JCR) website, available at https://jcr.incites.thomsonreuters.com, and RCR was accessed via NIH iCite website available at https://icite.od.nih.gov.

Statistical analysis

The Student t test was used for analyzing the continuous variables JIF and RCR. The chi-square test was used for analyzing the categorical variables conflict of interest, industry funding, and for comparing LOE for manuscripts published in journals not ranked by JCR. Processing and data analysis were performed using GraphPad Prism 7 (La Jolla, CA). Significance was set as $p < 0.05$.

Results

After removing duplicates and reviewing title, abstract and full text of the manuscripts, 212 articled were included. One hundred sixty-seven articles (79%) were classified as robotic UKA and 45 articles (21%) were classified as "Standard technique UKA".

Conflict of interest

Manuscripts using robotic-assisted technology were more likely to have conflict of interest or be funded by industry (Fig. 1). Twenty-three of 45 of robotic UKA articles (51%) stated that a conflict of interest or industry funding was present, while in 10/45(22%), this was negative. Any mention regarding conflict of interest or funding occurred in 12/45 (27%) of the robotic UKA manuscripts. This proportion was significantly different from the Standard technique UKA papers ($p < 0.01$), where only 48/167 (29%) reported conflict of interest, 86/167 (52%) reported no conflict of interest, and in 32/167 articles (19%), conflict of interest or industry funding was not mentioned in the text.

Level of evidence

Robotic UKA manuscripts demonstrated, on average, lower level of evidence comparing to Standard Technique manuscripts, although not statistically significant ($p = 0.13$) (Fig. 2). Among the 45 manuscripts from the robotic UKA group, only 1/45(2%) had high level of evidence, while 9/45(20%) had intermediate level of evidence and 26/45(58%) had low level of evidence. Nine articles (20%) were classified to either basic science or to a modality of research that a level of evidence could not be assigned. Manuscripts regarding Standard Technique UKA demonstrated 15/167 articles (13%) with high level of evidence, 47/167(28%) with intermediate level of evidence, and 80/167(46%) with low

level of evidence, while 29/167(17%) of the articles were not possible to be rated.

Journal impact factor

Robotic-assisted UKA manuscripts were more likely to be published in less prestigious journals comparing to standard technique UKA manuscripts (Fig. 3). Only 34/45(76%) of robotic UKA articles were published in journals ranked by JCR. This proportion is significantly lower ($p < 0.05$) than 151/167 (90%) of standard technique UKA articles. Among manuscripts published in journals ranked by JCR, there was no difference between the robotic UKA and standard technique groups (2.07 ± 1.01 vs 2.21 ± 0.80, $p = 0.44$).

Relative citation ratio

Regarding RCR, there was no difference between robotic-assisted and standard technique manuscripts. While robotic-assisted articles demonstrated a higher mean (1.81 ± 1.32 vs 1.49 ± 1.55), this was not statistically significant ($p = 0.28$).

Discussion

With the recent rise in utilization of robotic technology in orthopaedics, it is not a surprise of the substantial influence of industry towards manuscripts encompassing robotic-assisted UKA. Even accepting that conflicts of interests and

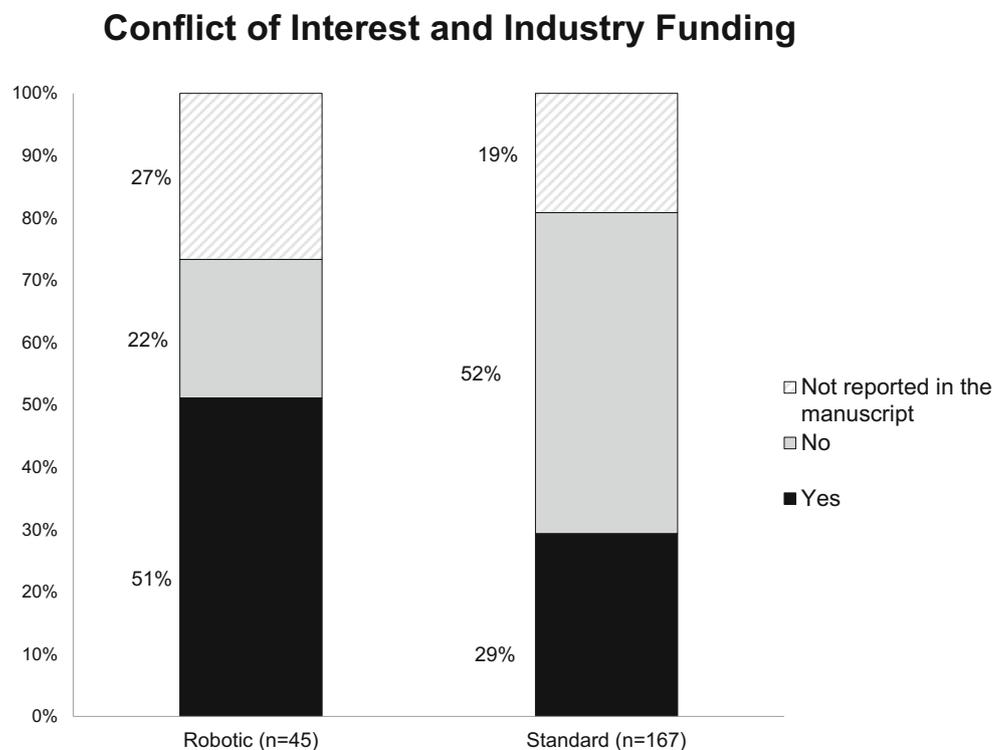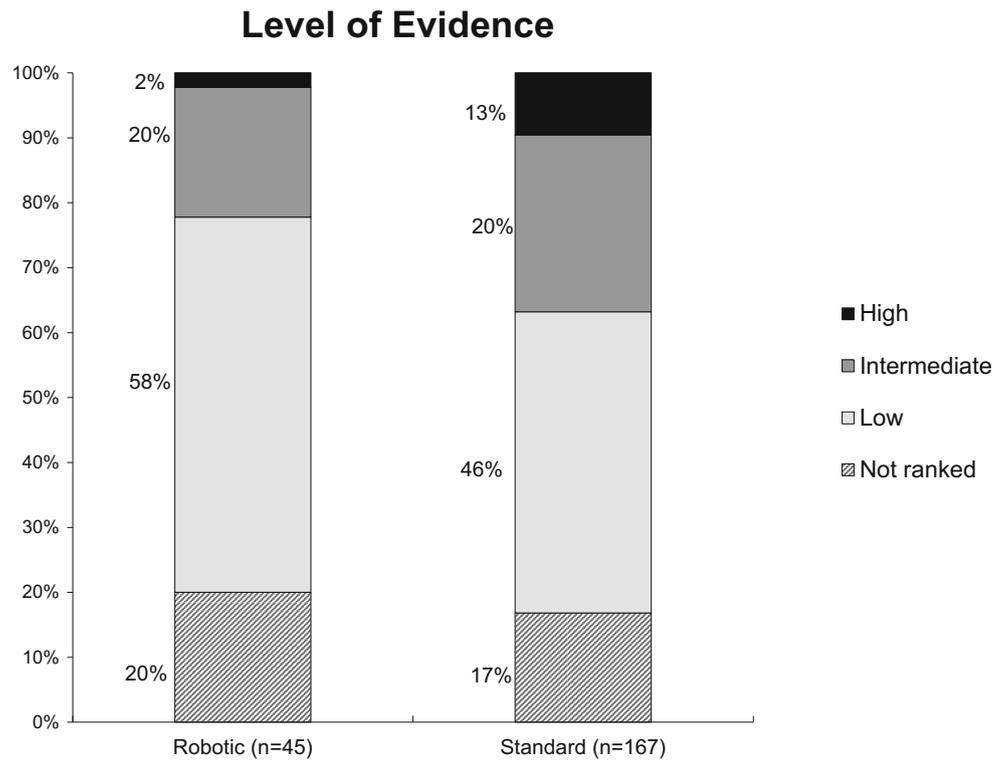**Fig. 1** Conflict of interest and industry funding for manuscripts regarding robotic and standard technique UKAs

Fig. 2 Level of evidence for manuscripts regarding robotic and standard technique UKAs

Level of Evidence

funding by industry are unavoidable in orthopaedic research, the fact that nearly half of the robotic UKA articles stated funding by industry or financial disclosure by any author is still a very significant number. This proportion could even be a low estimate, considering that 27% of manuscripts did not mention any information (either positive or negative) as of conflict of interests or industry funding. Manuscripts in which UKAs were done with a standard technique,

Fig. 3 Publication of manuscripts regarding robotic and standard technique UKAs in journals ranked and not ranked by the journal of citations report (JCR)

Journal Impact Factor
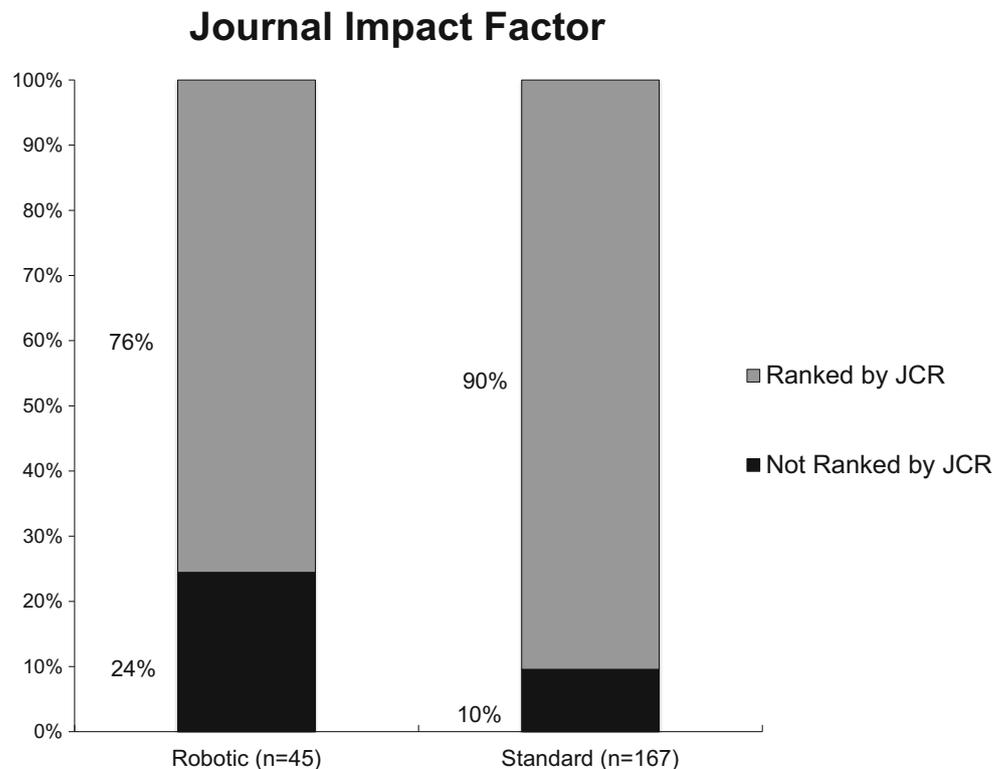
conflict of interests, or industry funding were present in only 29%, a significant lower incidence.

Comparing with available literature, conflict of interest in robotic UKA manuscripts have also been among the highest. Okike et al. [9] reported that 47% of Adult Knee Reconstruction podium presentations of the 2001 and 2002 Annual meeting of the American Academy of Orthopedic Surgeons reported some type of conflict of interest. Friedman et al. [10] reported that 22% of the original studies published at the New England Journal of Medicine and 16% of the original studies published at the Journal of the American Medical Association in the year of 2001 had conflict of interests according to criterion established by the International Council of Medical Journal Editors (ICMJE). More recently, Foughty et al. [6] reported that 18% of the articles published at the Journal of Shoulder and Elbow Surgery for the year of 2014 reported financial of conflict of interest.

In an era of increasing transparency and a clear direction towards full disclosures, the proportion of manuscripts in this study that did not mention any information about conflict of interest or industry funding was noted to be very high (27% for robotic UKA and 19% for standard technique UKA papers). In 2012, the editors from 20 major orthopaedic journals [11] met and agreed to adopt the ICJME disclosure form, a more comprehensive and uniform form of disclosure. However, several journals analyzed in this study seem to be going in the opposite direction by not readily revealing any disclosures and not giving the importance that this matter deserves. Certainly, more transparency would help readers better interpret the effects that the various sources of conflict of interests have on orthopaedic research.

For comparing the scientific quality of the manuscripts, our study analyzed the LOE grading system. LOE is a hierarchical classification developed by the Centre for Evidence-Based Medicine in Oxford, UK, used to classify study designs and is widely accepted to grade clinical evidence. In 2003, the Journal of Bone and Joint Surgery converted the original hierarchy into an orthopaedic-specific format [12], last revised and updated in January 2015 [8]. Considering LOE, a factor that can be used to summarize the quality of study design, and a proxy for study quality [13], our data showed that robotic UKA articles had, on average, less quality and scientific rigor than standard UKA articles, albeit this difference did not reach statistical significance ($p = 0.13$). Among all manuscripts that used robotic technology for UKA from 2012 to 2016, only a single article (2%) had high level of evidence, while 49% demonstrated low level of evidence. For the standard UKA manuscripts, 13% presented high LOE and 46% presented low LOE.

Other authors have also analyzed the LOE from other orthopaedic specialties. Scheschuk et al.. [13] rated LOE from orthopaedic trauma manuscripts published in three major orthopaedic journals and found that for the year of 2013, 18% of the studies were classified as having high LOE, while 40% demonstrated low LOE. Similarly, Grant et al.. [14] examined the Sports Medicine literature in two major journals for the year of 2010 and found that 24% of the articles demonstrated high LOE and 53% low LOE. For the foot and ankle subspecialty, Zaidi et al [14] searched manuscripts from four major orthopaedic journals and found that for the year of 2010, 10% of the studies were rated as having high LOE and 76% as low LOE. These studies, however, excluded all manuscripts that could not be classified by the LOE guidelines, including basic science, biomechanical, and studies in cadavers, highlighting that the LOE grading system currently used is by no means comprehensive. Other limitation in this system is that a considerable variation of quality can still exist within each level of evidence. Moreover, a study classified as low in the hierarchy can still cause substantial impact to the scientific community and influence clinical decisions.

Concerning bibliometrics, our study compared JIF and a RCR from robotic and standard UKA manuscripts. Our data showed that robotic UKA manuscripts were more likely to be published in less prestigious journals comparing to standard UKA manuscripts, considering the percentage of articles published in journals ranked by JCR and had an impact factor assigned. While 90% (151/167) of the manuscripts pertaining UKA using the standard technique were ranked by JCR, this number was only 76%(34/45) for the articles involving robotic-assisted UKA. This difference may suggest that researchers involved in robotic-assisted arthroplasty may perhaps pursue faster and more facile routes to provide data and evidence in support of robotic technology. On the other hand, among manuscripts ranked by JCR, there were no significant differences between the two groups, meaning that articles from both groups are equally cited once they are published in more prestigious journals. The JIF measure, however, has some intrinsic weakness that limits its utility and hide large differences in the influence of individual papers. One reason is because JIF only takes into consideration citations in the first two years after publication while citations usually follow a log-normal distribution, being progressively more cited over the years [15]. Another reason is the limited use in multidisciplinary science-of-science analysis, as researchers in disparate fields have differential access to high-profile publication venues [16]. Notwithstanding, JIF is still the most widely used bibliometric tool to characterize and grade scientific journals [17].

Given the limitations of the JIF system, many alternative methods for quantifying scientific accomplishments have been proposed. RCR is a new bibliometric measure introduced by PLoS Biology Journal on September 2016 [16] that was developed to quantify the impact and influence of a research article both within the context of its research field and benchmarked against publications resulting from NIH R01 awards. It is a field-normalized metric that

shows the scientific influence of an article relative to the average NIH-funded paper, and it is considered the most current and rigorous bibliometric measure available. According to our data, both groups showed similar RCR scores, meaning that manuscripts in regard to robotic technology and standard technique achieved, on average, equivalent scientific influence. Considering the small number of robotic UKA manuscripts, subsequent newer studies regarding the same topic have the tendency to cite the very same articles, increasing their own citation rate and bibliometric scores.

Some other important considerations should be made regarding this study. While this paper specifically highlights the findings of robotic UKA research quality and conflicts of interest, it may also deliver, in a broader perspective, evidence of all new technology or technique recently introduced in any surgical or medical field. Thus, although it was beyond the scope of this study to look at research quality and conflicts of interest of any other new technology (i.e., bicruciate retaining total knee arthroplasty [18], patellofemoral arthroplasty [19], robotic-assisted revision total knee arthroplasty[20]1) or any other new technique (i.e., direct anterior approach to the hip [21]), it is possible that the same findings would be repeated should they be analyzed. When a new technology is introduced to the market, early adopters, not infrequently the very designers, try to spread their knowledge and experience to the masses. It is even possible that early adopters, who initially did not have any bond with industry, may eventually become recruited by industry once they wax their utilization on the product or technology and, as a result, finish as establishing a conflict of interest. Since development of new technology in medicine needs not only good basic science research but also innovators and early adopters, a common path to successful innovative process is funding surgeons and leaders on the field to evaluate the concepts and document their findings.

Under these circumstances, first papers are usually of lower quality, published in less impactful journals, or have significant conflict of interest. Often, neither the methodology nor the finding of industry-funded, pilot research meet the level of evidence required by the more prestigious journals. It is not until such new technology or technique becomes more accepted, if this ever happen, that those neutral-party, high-quality papers emerge. Perhaps this early transition through less scientific rigorous research is the natural progression of advances in medicine and orthopaedics.

It should also be made clear that this paper does not have an anti-robot agenda nor has prejudice towards robotic technology. Rather, this study simply analyzed research quality and conflicts of interest vis-à-vis robotic UKA using the best scientific tools available. As discussed, the same findings could possibly be found in any new technology or technique. This study does not conclude, by any means, that robotic technology is "no good" or should not be used.

We believe that transparency and readily availability of disclosures (on both author conflict of interest and funding) should be adopted by all scientific journals, leaving interpretation of this information to the discretion of the reader. We believe that investigations with funding by industry or written by authors with conflicts of interest should be done and even encouraged, as this may be the natural path of all emerging new technology.

Our study has some potential limitations. Firstly, we were unable to separate industry funding from conflict of interest, as most articles just did not make this distinction. Additionally, all data regarding disclosures and conflict of interests were analyzed as they were reported in the manuscripts, and thus, this study relied on the integrity and honesty of all authors and journals.

Conclusions

We showed that manuscripts concerning UKA assisted by robotic technology had, on average, more authors with a financial conflict of interest or were funded by industry and were published in less prestigious journals. There was no difference in the scientific influence achieved by manuscripts in which UKA utilized robotic technology.

Compliance with ethical standards

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