Arthroplasty Today 3 (2017) 137–140

Contents lists available at ScienceDirect

Arthroplasty Today

journal homepage: http://www.arthroplastytoday.org/

Original research from AJRR

Infection burden in total hip and knee arthroplasties: an international registry-based perspective

Bryan D. Springer, MD [a,b], September Cahue, MPH [b], Caryn D. Etkin, PhD, MPH [b], David G. Lewallen, MD [b,c], Brian J. McGrory, MD, MS [d,e,*]

[a] OrthoCarolina Hip and Knee Center, Charlotte, NC, USA
[b] American Joint Replacement Registry, Rosemont, IL, USA
[c] Department of Orthopaedic Surgery, Mayo Clinic, Rochester, MN, USA
[d] Maine Joint Replacement Institute, Portland, ME, USA
[e] Tufts University School of Medicine, Boston, MA, USA

ARTICLE INFO

Article history:
Received 7 May 2017
Accepted 7 May 2017
Available online xxx

Keywords:
Revision burden
Infection burden
Joint replacement registry
Total joint arthroplasty
Revision

ABSTRACT

Background: Infection remains a leading cause of failure of hip and knee replacements. Infection burden is the ratio of implants revised for infection to the total number of arthroplasties in a specific period, measuring the steady state of infection in a registry. We hypothesized infection burden would be similar among arthroplasty registries.

Methods: We evaluated publicly reported data from 6 arthroplasty registries (Australian Orthopaedic Association National Joint Replacement Registry [AOANJRR], New Zealand Joint Registry, Swedish Hip Arthroplasty Register, Swedish Knee Arthroplasty Register, National Joint Registry of England, Wales, Northern Ireland, and the Isle of Man, and the American Joint Replacement Registry) for revisions performed with an infection diagnosis over the last 6 years.

Results: The 2015 hip infection burden varied between registries from 0.76% (AOANJRR) to 1.24% (Swedish Hip Arthroplasty Register), and the unweighted overall average for hip infection burden was 0.97%. In 2012, 2013, and 2014, average hip infection burden held steady at 0.87%, 0.93%, and 0.94%, respectively, higher than the preceding 2 years. The 2015 knee infection burden varied from 0.88% (AOANJRR) to 1.28% (Swedish Knee Arthroplasty Register), and the unweighted average was 1.03%. In 2012, 2013, and 2014, knee infection burden was 1.04%, 1.11%, and 1.02%, respectively. These numbers were also higher than the preceding 2 years.

Conclusions: Infection burden may be one measure of the overall success in registry populations as well as monitoring the steady state of infection worldwide. Despite global efforts to reduce postoperative infection, infection burden has actually increased in the selected registries over time.

Introduction

Total hip and knee arthroplasties (THA and TKA) are among the most successful procedures in all of medicine with high survivorship and low morbidity and mortality [1,2]. They are associated with dramatic improvement in patient pain, function, and quality of life [3]. As such, the volume for both THA and TKA is currently increasing, and is expected to grow by 174% for THA and 673% for TKA [4]. One of the major endpoints to measure the success of THA and TKA is revision surgery. The etiology of revision surgery has been well documented and includes instability, aseptic loosening, periprosthetic wear, fracture, and infection [5,6].

Revision burden has been defined as the ratio of implant revisions to the total number of arthroplasties performed in a given period within a specific population. First introduced by Malchau et al. [7], revision burden was envisioned as a means for comparing different national total joint registries. It has been used for results reporting, economic analyses, and procedural volume estimates

One or more of the authors of this paper have disclosed potential or pertinent conflicts of interest, which may include receipt of payment, either direct or indirect, institutional support, or association with an entity in the biomedical field which may be perceived to have potential conflict of interest with this work. For full disclosure statements refer to http://dx.doi.org/10.1016/j.artd.2017.05.003.

* Corresponding author. 5 Bucknam Road, Suite 1D, Falmouth, ME 04105, USA. Tel.: +1 207 781 1551.

E-mail address: mcgrob1@mmc.org

http://dx.doi.org/10.1016/j.artd.2017.05.003
2352-3441/

[4,7,8]. A recent study by McGrory et al. [9] evaluated the concept of revision burden for THA and TKA across total joint registries worldwide. They found that the revision burden for THA had decreased over a 4-year period, but had remained relatively constant for TKA.

Although there has been a decline in revision surgeries for loosening and wear over time, periprosthetic joint infection (PJI) rates have not improved, resulting in PJI becoming one of the most common modes of failure in THA and TKA [5,6]. Studies project that revision for PJI will dramatically increase over the next two decades compared with other modes of failure, with some anticipating over 60% of all revisions eventually due to infection [10]. As such, there have been numerous studies published over the past decade discussing infection prevention and techniques to reduce the incidence of PJI [11,12]. However, there have been few if any reports that demonstrate that the global rate of PJI is decreasing. The primary purpose of this study was to determine the infection-related revision burden and delineate if the infection burden was similar across 6 nationwide total joint registries : The Australian Orthopaedic Association National Joint Replacement Registry [AOANJRR], New Zealand Joint Registry, Swedish Hip Arthroplasty Register [SHAR], Swedish Knee Arthroplasty Register [SKAR], National Joint Registry of England, Wales, Northern Ireland, and the Isle of Man, and the American Joint Replacement Registry [AJRR]. The secondary purpose of this study was to determine if the burden of revision for infection has changed over time. We hypothesized that the infection burden would be similar across these registries and that the burden of infection would be decreasing over time compared with historical controls.

Material and methods

Infection burden was defined as the ratio of the total number of revisions due to infection to the total number of arthroplasties (primaries and revisions) performed in 1 year. Infection burden was calculated for the last 6 years or since registry inception. Designation as an infection-related revision or removal of components was based on the specific criteria and definitions of revision used by each individual registry. We sought to count a revision or removal of components for infection only once for a given infection episode when multiple subsequent procedures were carried out on the same joint. That is, if a component exchange and debridement failed, or if a patient underwent a 2-stage procedure, these procedures were combined and counted as a single revision/removal of components for infection. We developed the following parameters for acceptable definitions for each variable analyzed.

Hip

- **Primary hip arthroplasty** was defined as a total hip procedure that replaces both the femoral and acetabular sides of the joint, but we excluded hip resurfacing and hemiarthroplasty.
- **Hip component revision** included all procedures, where one or more of the prosthetic components were exchanged or removed as part of either a 1-stage or 2-stage process.
- **Hip revision due to infection** was defined as any repeat or revision surgery on an existing device, where one of the diagnoses for the revision procedure included infection (per the reporting registry criteria).

Knee

- **Primary knee arthroplasty** was defined as a total knee procedure that replaces the femorotibial articulation, and excluded unicompartmental procedures (unicondylar and patella-femoral procedures).
- **Knee component revision** included all procedures, where one or more of the prosthetic components were exchanged or removed as part of either a 1-stage or 2-stage process.
- **Knee revision due to infection** was defined as any repeat or revision surgery on an existing device, where one of the diagnoses for the revision procedure included infection (per the reporting registry criteria).

Table 1
Results of contemporary hip and knee infection burden, in percent

Results of contemporary hip infection burden, in percent						
Registry	2010	2011	2012	2013	2014	2015
AOANJRR	0.80	0.78	0.85	NA[a]	0.82[a]	0.76[a]
NZJR	0.64	0.59	0.56	0.75	0.70	1.00
SHAR	0.88	1.12	1.14	1.18	1.3	1.24
NJR	0.84	0.86	0.91	0.85	0.91	0.94
AJRR	NA	NA	NA	NA	0.99	0.91
Unweighted average	0.79	0.84	0.87	0.93	0.94	0.97
Results of contemporary knee infection burden, in percent						
Registry	2010	2011	2012	2013	2014	2015
AOANJRR	0.87	0.80	0.89	1.08	0.98	0.88
NZJR	0.64	0.71	1.05	1.07	1.10	1.20
SKAR	1.11	1.22	1.27	1.35	1.11	1.28
NJR	0.91	0.94	0.96	0.94	0.97	0.94
AJRR	NA	NA	NA	NA	0.95	0.85
Unweighted average	0.88	0.92	1.04	1.11	1.02	1.03

NJR, National Joint Registry of England, Wales, Northern Ireland, and the Isle of Man; NZJR, New Zealand Joint Registry.
[a] AOANJRR analysis excluded data for metal-on-metal THA with a head greater than 32 mm for 2013, 2014, and 2015, confounding calculation for 2013.

Infection burden for both hip and knee arthroplasties was calculated from publicly reported data (ie, annual reports or other reporting methods) from national hip and knee arthroplasty registries. The comparative review included 6 national registries: AOANJR, New Zealand Joint Registry, SHAR, SKAR, National Joint Registry of England, Wales, Northern Ireland, and the Isle of Man, and AJRR.

Results

The overall results for infection burden for THA and TKA for the 6 surveyed registries are summarized in Table 1.

The 2015 infection burden for THA varied from 0.76% in AOANJRR to 1.24% in the SHAR, and the unweighted average was 0.97%. In 2012, 2013, and 2014, the THA infection burden (unweighted average) held steady at 0.87%, 0.93%, and 0.94%, respectively. This is higher than the preceding 2 years (0.79% and 0.84%). Each registry with 6-year data showed an increase in infection burden for THA over the period of the survey. AOANJRR analysis excluded data for metal-on-metal THA with a head greater than 32 mm for 2013, 2014, and 2015, confounding calculation for 2013.

The 2015 infection burden for TKA varied from 0.88% in AOANJRR to 1.28% in the SKAR. The unweighted average was 1.03%. In 2012, 2013, and 2014, the knee infection burden (unweighted average) was 1.04%, 1.11%, and 1.02%, respectively. These numbers were higher than the preceding 2 years (0.88% and 0.92%). Each of the 5 registries with 6-year data demonstrated an increase in the infection burden reported for TKA over the period of the study.

Discussion

PJI remains a leading cause of failure in THA and TKA [5,6]. The treatment of PJI is associated with substantial morbidity and

Table 2
Components of infection burden calculation.

Component of infection burden equation	Factors affecting component of equation
Numerator = deep infection in joint replacement in a given period	• Population with prior primary joint surgery • Population with prior revision joint surgery • Criteria for surgery for infection • Availability (surgeons and/or hospital) to offer revision joint surgery for infection • Population life expectancy and mortality • Definition of deep infection of joint replacement
Denominator = revision and primary joint replacements in the same period	• Numerator • Criteria used for primary and revision joint surgeries (definition of surgical arthritis and failed total joint within a health system) • Population with surgical arthritis and failed total joint replacement • Availability (surgeons and/or hospital) to offer primary and revision joint surgeries

mortality [13-15]. In addition, the treatment of PJI remains one of the most resource intensive and financially costly entities to treat in all of orthopaedic surgery [16]. Kurtz et al. [10] has projected that rate of PJI will continue to rise over the next 15 years and may account for up to 60% of all revisions.

Much of the focus and clinical research related to infected arthroplasty over the last decade has looked at ways to identify those patients at risk for the development of PJI and at ways to reduce the incidence by altering modifiable risk factors, improving the intraoperative environment, and defining appropriate use of prophylactic antibiotics in the perioperative period [11,12]. Despite these efforts, it is difficult to document a reduced incidence and burden of arthroplasty-related infection.

Our present study surveyed 6 international registries to determine the contemporary burden of revision performed for a diagnosis of infection. The infection burden was defined as the number of revisions performed for a diagnosis of PJI over all primary and revision total joint performed in a given year for each of the specific registries surveyed and for the overall combined total. The defined infection burden would include both early (less than 1 year) and late (beyond 1 year) infections performed on implants inserted in preceding years.

Several studies have looked at the overall incidence of PJI as a mode of failure in total joint arthroplasty [17-20]. However, very few studies have looked at burden of infection in total joint arthroplasty. Kamath et al., using the US National Impatient Sample (NIS) from 2005-2010, demonstrated that PJI was the most common reason for revision TKA (25%) and third most common reason for revision THA (15.4%) [21]. They used the term "burden", however, as the strain placed on the surgeon, patients, and healthcare system rather than a mathematical formula. The "burden" of infection occurred in patients with the highest severity of illness was associated with the longest hospital stay, and was the costliest to the hospital system. Bozic et al. [22], using the same NIS data set as Kamath, more precisely defined a revision burden for THA and TKA as the number of revisions over the total number of primaries and revisions. From this, we were able to calculate the infection burden because all reasons for revisions were listed. The infection burden from the data presented over the 5-year span of the study (2005-2010) was 2.3% for THA and 2.4% for TKA.

We are not certain why this calculation is higher than the AJRR result from 2014 and 2015 (2014 hip—0.99, 2015 hip—0.91; 2014 knee—0.95, 2015 knee—0.85), but hypothesize that the NIS data set may include all revisions for infection, rather than only one revision per deep infection episode. If the NIS data set reports each operative procedure for the same infection episode, it would tend to explain the disparity between these two data sets because in the United States, 2-stage treatment remains common for deep PJI.

There are several limitations to reporting combined data from multiple national registries, particularly with regard to attempted comparisons between registries. There can be varying definitions of infection and related factors among the different registries (Table 2). There is a strong potential for reporting bias between registries. AJRR, using a convenience sample and with data capture from less than 50% of annual procedures nationally, has relatively few "linked revisions" in its database. A linked revision refers to a revision surgery with details of the original primary surgery also available and reported to the registry. Although the number of linked revisions reported to the AJRR has grown, it remains a fraction of all revisions recorded and thus our ability to report longitudinal data regarding the entire course of care for infected patients is limited. International registries, where reporting of data is in many cases mandatory, and greater than 90% of all arthroplasty procedures are captured, will give a much more accurate picture of the overall course of treatment. In addition, we used any revision surgery that was submitted with an International Classification of Diseases, Ninth Revision diagnosis code of infection as a presumed true infection. Although we assumed that the inclusion of an infection code would take precedence over any other diagnosis code, this could lead to relative over or under reporting of the diagnosis of PJI from some centers because of variations in coding practices. We also had no way to apply a standardized definition of PJI (from either the Musculoskeletal Infection Society or Centers for Disease Control and Prevention) to these cases so it is possible that many cases coded as PJI could have been "false positives" and thus over-reported or alternatively were not called infection when in fact they met criteria, as sometimes seen with patients referred with negative cultures, on antibiotics but with draining sinuses. Despite these limitations, we believe the concordance of data on relative rates of the infection burden across registries validate the benefits of this information for longitudinal tracking over time within a specific registry as well as between registries.

Conclusions

The infection burden is defined as the number of joint replacement revisions performed for a diagnosis of infection divided by all revision and primary total joint arthroplasties in a given period (1 year in our analysis). For both revision THA and revision TKA, the burden of infection has increased over a 6-year period. Despite efforts to optimize patients and improve preventative measures, we have not seen a decline in the infection burden across 6 international registries and periprosthetic infection remains one of the most frequent modes of failure in total joint arthroplasty worldwide.

References

[1] Ranawat CS, Flynn Jr WF, Saddler S, Hansraj KK, Maynard MJ. Long-term results of the total condylar knee arthroplasty: a 15-year survivorship study. Clin Orthop Relat Res 1993;286:94.
[2] Berry DJ, Harmsen WS, Cabanela ME, Morrey BF. Twenty-five-year survivorship of two thousand consecutive primary Charnley total hip replacements. J Bone Joint Surg Am 2002;84(2):171.
[3] Verra W, Kernkamp W, van Hilten J, et al. Patient satisfaction and quality of life at least 10 years after total hip or knee arthroplasty. Int J Orthop 2016;2(2):05.

[4] Kurtz S, Ong K, Lau E, Mowat F, Halpern M. Projections of primary and revision hip and knee arthroplasty in the United States from 2005 to 2030. J Bone Joint Surg Am 2007;89(4):780.
[5] Bozic KJ, Kurtz SM, Lau E, et al. The epidemiology of revision total knee arthroplasty in the United States. Clin Orthop Relat Res 2010;468:45.
[6] Bozic KJ, Kurtz SM, Lau E, et al. The epidemiology of revision total hip arthroplasty in the United States. J Bone Joint Surg Am 2009;91(1):128.
[7] Malchau H, Herberts P, Eisler T, Garellick G, Söderman P. The Swedish total hip replacement register. J Bone Joint Surg Am 2002;84(Suppl 2):S2.
[8] Bhandari M, Smith J, Miller LE, Block JE. Clinical and economic burden of revision knee arthroplasty. Clin Med Insights Arthritis Musculoskelet Disord 2012;5:89.
[9] McGrory BJ, Etkin CD, Lewallen DG. Comparing contemporary revision burden among hip and knee joint replacement registries. Arthroplasty Today 2016;2(2):83.
[10] Kurtz SM, Lau E, Schmier J, et al. Infection burden for hip and knee arthroplasty in the United States. J Arthroplasty 2008;23(7):984.
[11] Perry KI, Hanssen AD. Orthopaedic infection: prevention and diagnosis. J Am Acad Orthop Surg 2017;25:S4.
[12] Levy DM, Wetters NG, Levine BR. Prevention of periprosthetic joint infections of the hip and knee. Am J Orthop 2016;45(5):E299.
[13] Bozic KJ, Lau E, Kurtz S, Ong K, Berry DJ. Patient-related risk factors for postoperative mortality and periprosthetic joint infection in Medicare patients undergoing TKA. Clin Orthop Relat Res 2012;470(1):130.
[14] Berend KR, Lombardi AV, Morris MJ, et al. Two-stage treatment of hip periprosthetic joint infection is associated with a high rate of infection control but high mortality. Clin Orthop Relat Res 2013;471(2):510.
[15] Zmistowski B, Karam JA, Durinka JB, Casper DS, Parvizi J. Periprosthetic joint infection increases the risk of one-year mortality. J Bone Joint Surg Am 2013;95(24):2177.
[16] Kurtz SM, Ong KL, Schmier J, et al. Future clinical and economic impact of revision total hip and knee arthroplasty. J Bone Joint Surg Am 2007;89(Suppl 3):144.
[17] Kurtz SM, Ong KL, Lau E, et al. Prosthetic joint infection risk after TKA in the Medicare population. Clin Orthop Relat Res 2010;468(1):52.
[18] Dalury DF, Pomeroy DL, Gorab RS, Adams MJ. Why are total knee arthroplasties being revised? J Arthroplasty 2013;28(8):120.
[19] Gioe TJ, Killeen KK, Grimm K, Mehle S, Scheltema K. Why are total knee replacements revised?: analysis of early revision in a community knee implant registry. Clin Orthop Relat Res 2004;428:100.
[20] Ulrich SD, Seyler TM, Bennett D, et al. Total hip arthroplasties: what are the reasons for revision? Int Orthop 2008;32(5):597.
[21] Kamath AF, Ong KL, Lau E, et al. Quantifying the burden of revision total joint arthroplasty for periprosthetic infection. J Arthroplasty 2015;30(9):1492.
[22] Bozic KJ, Kamath AF, Ong K, et al. Comparative epidemiology of revision arthroplasty: failed THA poses greater clinical and economic burdens than failed TKA. Clin Orthop Relat Res 2015;473(6):2131.