



AOA  
AUSTRALIAN  
ORTHOPAEDIC  
ASSOCIATION

# Australian Orthopaedic Association National Joint Replacement Registry

Lay Summary

Hip, Knee & Shoulder Replacement



SUPPLEMENTARY  
REPORT  
**2019**

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Australian Orthopaedic Association  
National Joint Replacement Registry

**2019 Lay Summary**

# 20 YEARS OF THE AOANJRR

1999 Declared a Federal Quality Assurance Activity (FQAA)

1999 Hip & knee data collection commenced

1999 Partnership with University of Adelaide established

2000 First AOANJRR Annual Report

2002 Full national collection achieved

2007 First surgeon workshop held to review Annual Report

2007 Shoulder, wrist, ankle & spinal disc data collection commences nationally

2009 Federal funding legislated

2012 Secure online portals launched providing outcome data

2014 FQAA protection from subpoena upheld in court

2015 Over 1 million joint replacement procedures recorded

2015 Partnership established with the South Australian Health & Medical Research Institute and relocation to the Biomedical Precinct

2016 Annual individual Surgeon Outcome Reports released online

2018 Automated Industry Reporting System developed

2018 PROMs data collection commenced

2019 Registry Nested Clinical Trials commenced

2019 20th Annual Report produced

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# Highlights of 2018

## Reporting



**1,492,892**

Total number of joint replacement procedures recorded in the Registry at the end of 2018

Joint replacement procedures in 2018

**122,500**



**879**

Individual Surgeon Outcome Reports produced



**1388**

CPD Certificates released online via secure Surgeon Portal



Journal Articles Published

**22**



Podium Presentations

**65**



Conference Posters

**13**

**39**

Hospital Audit Reports produced



2018 Annual Report downloaded **31,883** times



Lay Summary downloaded **2,008** times



**228**

Ad Hoc Reports produced

Automated Industry Reporting System (AIRS) produced **802** reports in 2018

## Projects underway

### Grant Funded Projects

- **Stakeholder Access to Real-time PROMs Data** for Joint Replacement, Rapid Applied Research Translation (RART), MRFF Grant.
- **CRISTAL** - Comparing Two Standard Drug Protocols used for Preventing Venous Thromboembolism (VTE) Prophylaxis after Joint Replacement: A 10,000 Patient Registry Nested Clinical Trial (RNCT) MRFF Grant.
- Enhancing Joint Replacement Outcomes through **National Data Linkage**, NHMRC Grant.
- **Rehabilitation Outcomes** for Patients Receiving Joint Replacements: A Data Linkage Project, HCF Grant.
- Are Total Hip and Knee Replacements Associated with an **Increased Cancer Risk?** A Nationwide Cohort Study.



**PROMs** Patient Reported Outcomes Measures Pilot Study

**45** hospitals participating

**9,116** Pre-op PROMs recorded

**2,277** Post-op PROMs recorded

Knee Osteotomy Registry

**25** Hospitals now approved and another 21 hospitals with approval processes underway



ICT System built to deliver **Registry Nested Clinical Trials (RNCTs)**

## Introduction

This summary is an explanation of the major findings of the Australian Orthopaedic Association National Joint Replacement Registry 2019 Annual Report for Hip, Knee and Shoulder Arthroplasty (replacement). This is the major clinical report produced by the Registry each year.

The Lay Summary is provided to ensure that a clear, concise and easily understood explanation of the published findings is available to all those who may be interested.

The Australian Orthopaedic Association (AOA) believes this is especially important because of the high level of community interest in the Registry and the need to ensure that reports are accessible to all.

The full version of the 2019 Annual Report on Hip, Knee and Shoulder Arthroplasty is available in the 'Publications' section of the Registry website.

This year's report involved the analysis of 1,478,219 primary and revision procedures (643,567 hips, 782,600 knees and 52,052 shoulders). This is the total number of hip, knee and shoulder replacement operations recorded by the Registry with a procedure date up to and including 31 December 2018. This is 122,281 additional hip, knee and shoulder procedures compared to the 2018 Annual Report.

In addition to the Annual Report and this Lay Summary, there are a further 12 supplementary reports published by the Registry on the website:

<https://aoanjrr.sahmri.com/annual-reports-2019>

## A Brief History of the Registry Origins

The AOA commenced the National Joint Replacement Registry in 1999. It was initially for hip and knee replacement only. This was a complex system to set up and therefore it took almost 3 years to fully implement the Registry across Australia. The Registry receives information from over 300 hospitals. Since mid-2002, the Registry has received information on almost all hip and knee replacements undertaken in Australia.

In November 2007, the Registry commenced national data collection on a number of additional types of joint replacement. This included shoulder joint replacement procedures, the analysis of which is presented along with hip and knee replacement in the main report. The other additional types of joint replacement that the Registry collects information on include elbow, wrist, ankle and spinal disc replacement. The analysis of these procedures is presented in the supplementary reports available on the Registry website.

## The Purpose of the Registry

The AOA started the Registry to improve the results of joint replacement surgery in Australia. Generally, this type of surgery is very successful, but as with all areas of healthcare, there is always room for improvement. Since the Registry commenced data collection there has been improvement in the outcomes of this surgery.

One of the most serious consequences of a less than successful operation is the need to have a revision (redo) operation. The Registry provides information to assist surgeons keep the number of these operations to a minimum. It does this by identifying those things that work best and highlighting what can be improved.

Prior to establishing the Registry, Australian orthopaedic surgeons felt they had a lack of detailed information on the results of the many different procedures and types of joint replacement available. In particular, the surgeons required information to compare the impact of the many different factors known to influence the results for their patients.

Surgeons have a large choice of different types of artificial joints that they can use to replace damaged and painful joints. There are also different techniques, which can be used to put these artificial joints in place. Surgeons know that there is variation in the results depending on the patient, the nature of the patient's problem, which joint is being replaced, the way the operation is performed, and the type of artificial joint replacement used.

## Supplementary Reports

The Registry publishes data in addition to that included in the Annual Report, in the following Supplementary Reports:

1. **Partial Hip Arthroplasty**  
With the aim of streamlining the Annual Report detailed information on Partial Hip Replacement has been moved to this supplementary report.
2. **Partial Knee Arthroplasty**  
With the aim of streamlining the Annual Report detailed information on Partial Knee Replacement has been moved to this supplementary report.
3. **Demographics of Hip, Knee and Shoulder Arthroplasty**  
This report details the age and gender profile of people receiving hip, knee or shoulder replacement and includes information on the reasons for undergoing replacement surgery.
4. **Cement in Hip and Knee Arthroplasty**  
This report details the use of the different types of cement in hip and knee replacement surgery.
5. **Mortality of Hip and Knee Arthroplasty**  
This report details the risk of dying following the different types of hip and knee replacement surgery.
6. **Revision of Hip and Knee Arthroplasty**  
This report details the outcome of revisions of hip and knee replacements.
7. **Prosthesis Types No Longer Used**  
This report details the outcomes of classes of hip and knee replacement that are no longer used and therefore do not appear in the main report.

### 8. Metal on Metal Bearing Surface in Total Conventional Hip Arthroplasty

This report details the outcome of metal on metal bearings when used with large (larger than 32 mm) femoral heads.

### 9. Demographics and Outcomes of Elbow and Wrist Arthroplasty

This report details the age and gender profile of people receiving elbow and wrist surgery. It includes reasons for undergoing these different types of joint replacement as well as some early information on the outcome of these operations.

### 10. Demographics and Outcomes of Ankle Arthroplasty

This report details the age and gender profile of people receiving ankle joint replacement and reasons for undergoing ankle replacement as well as some early information on the outcome of this operation.

### 11. Demographics of Spinal Disc Arthroplasty

This report details the age and gender profile of people receiving spinal disc replacement and reasons for undergoing this operation.

### 12. Analysis of State and Territory Health Data – All Arthroplasty 1993/1994 – 2017/2018

#### INVESTIGATIONS OF PROSTHESES WITH HIGHER THAN ANTICIPATED RATES OF REVISION

Each year the Registry identifies prostheses that have a higher than anticipated rate of revision. This is a series of reports providing detailed information on each of the prostheses identified in the 2019 Annual Report.

The Registry is able to compare all of these different factors simultaneously. In doing so, it provides information to assist surgeons to decide the best type of artificial joint replacement to use in any particular situation. The Registry is able to detail the results for different classes (or categories) of artificial joints and different individual types of artificial joints in each of the classes. It can also determine if patient age, gender, weight, general health and/or the reason a joint replacement is performed, affects the result.

It is important to emphasise that this is not the only information that is used to determine what the best approach should be. When providing advice to patients, surgeons will also rely on their training and experience as well as information from medical journals, other registries elsewhere in the world, conferences and courses they may attend, as well as learning from other surgeons.

**The Registry provides information to assist in deciding the best type of artificial joint replacement to use in any particular situation.**

When surgeons interpret information from the Registry, they use their knowledge and experience to put that information into context. The Registry does not decide or recommend the best joint replacement for a particular patient. This can only ever be decided by the surgeon in consultation with the patient. In this way, all factors can be carefully taken into consideration.

## HOW THE REGISTRY WORKS

The Registry collects a small amount of confidential information on each joint replacement operation undertaken in Australia, with the exception of those people who choose not to have their information collected by the Registry. The information collected includes details of the patient including age, gender, weight, height, general health the reason for the surgery, the joint that was replaced and whether it was on the right or left side. Information on the type of artificial joint replacement and the individual components used in the operation as well as techniques used to implant these devices are also collected.

**Currently, the Registry monitors and has information on approximately 1.5 million joint replacement operations.**

As previously mentioned, if a problem occurs following a joint replacement one of the possible outcomes is that the operation is redone. This is referred to as a revision procedure. The Registry is notified about the revision, records this information and links it to the first (or primary) operation. By doing this, it is able to determine how many initial primary procedures have been revised, the reason for the revision, how long after the original surgery, and which of the components (if any) were replaced is also recorded.

## WHO FUNDS THE REGISTRY

The Commonwealth Government, through the Department of Health, funds the Registry. The Government and the Department have been very supportive of the Registry. They provided the initial funding to establish the Registry and have maintained its core funding since the Registry commenced.

## THE FORMAT OF THE 2019 ANNUAL REPORT FOR HIP, KNEE AND SHOULDER ARTHROPLASTY

When the Registry prepares the Annual Report each year, it updates important information that it has previously reported. This is done in the routine chapters. In addition to the updates of information in these chapters, there is often new information presented. The reason that this new information is included is because it is an area of interest that has not previously been covered or because the Registry has sufficient new data to present. This year, new data that is being reported for the first time includes the early outcomes of hip replacement related to the operative approach. Operative approach refers to where the initial incision is made. This dictates what other tissues including which muscles are required to be separated or released prior to opening the hip capsule and removing and replacing the natural hip joint. The surgeon's view when undertaking the operation also differs depending on the operative approach. There are three main operative approaches. They include the posterior, lateral and anterior approaches. The posterior approach involves releasing muscles at the back of the hip joint. The lateral approach involves releasing and splitting muscles at the side of the hip joint. The anterior approach involves splitting and releasing muscles at the front of the hip joint. The anterior approach has been increasingly reused in more recent years, so there is a lot of interest to know if and when this works best.

The Annual Report also includes one or more new chapters that are on topics of importance that have not previously been reported in any detail. As this is a special 20<sup>th</sup> Anniversary report, the AOANJRR has taken the chance to look back over the last 20 years of hip and knee replacement to identify why outcomes have changed and the reasons for those changes.

The remainder of this year's Annual Report includes the routine chapters. They contain an additional year of information on the results that the Registry has previously reported, as well as some new information as previously mentioned. As the size of this report continues to increase, a decision was made to remove some of the information that has previously been available in this document. However, the information is not lost, it has been updated and is available as a separate supplementary report. The analysis that was moved to the supplementary report includes information on partial hip and partial knee replacement surgery. As with previous reports, there is a section on the outcome of those devices that have reached 10 and 15 year outcomes as well as sections on primary hip replacement, primary knee replacement, and primary shoulder replacement. As we have done for many years, the Registry provides a summary of prostheses that have been identified as having a *Higher than Anticipated Rates of Revision*. Detailed information on all of these devices is also available online along with this report, the main report and all the supplementary reports being provided.

## HOW THE REGISTRY PRESENTS THE RESULTS

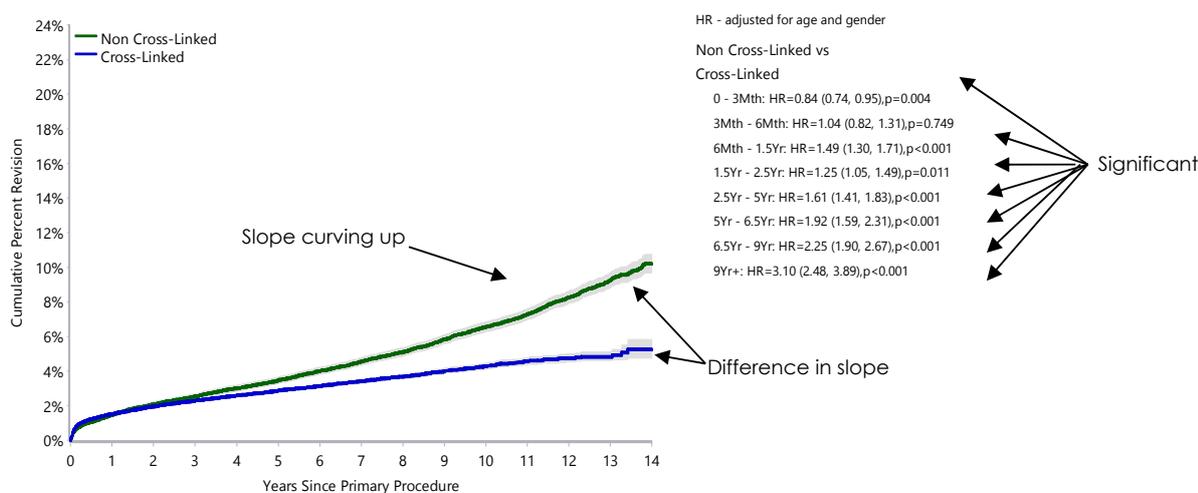
The fact that the Registry is a national database means it reports on the results of a very large number of operations, which improves the value of the information. Currently, the Registry monitors and has information on approximately 1.5 million joint replacement operations.

The Registry presents the results in many different ways. The simplest way is by using graphs and tables. The most important result that the Registry assesses is the number of redo operations (revisions). We know the number of redo operations and the time between the first operation and any redo's of that operation. This means that we can also determine the percent of procedures that have been revised at 1, 2 and 3 years after the original operation. This is known as the cumulative percent revision. This is an excellent way to measure the outcome of joint replacement surgery. There are many things that can affect this i.e. make it lower or higher. The aim is to identify what things make the cumulative percent revision lower. This is done by undertaking analysis that compares the cumulative percent revision when the surgery is undertaken in different groups of patients, using different types of prostheses and different techniques. We often refer to this as comparing one group to another or at times many others.

## GRAPHS

To assist in interpreting the results it is important to understand that the graphs are used to look at and compare the difference between different groups and we do this by plotting the cumulative percent revision against the time (years) since the original surgery for each of the groups being compared.

**Figure LS1 Example of a graph with Cumulative Percent Revision which compares the results of two different types of plastic commonly used in joint replacement surgery (cross-linked and non-cross-linked polyethylene).**



The lines on the graph represent the results for the factors being compared. The more the lines slope upwards the greater the number of revision (redo) operations that have been done. In general, the greater the difference in the slope of the lines the more important the difference. This graph shows that there are more revisions when non cross-linked polyethylene (non XLPE) (the green line) is used compared to cross-linked polyethylene (XLPE) (the blue line).

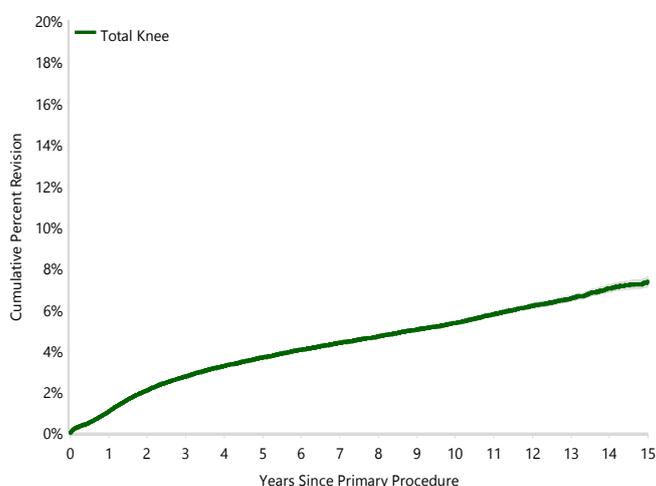
The information on the right-hand side of each of these graphs is important. This gives a measure of the amount of difference, how this is changing with time and how confident you can be that the difference is real. The most important information is the HR (hazard ratio) and the p (probability) value (see section on Hazard Ratios).

**TABLES**

The Registry also reports data in cumulative percent revision tables which accompanies these graphs. These tables give the number of revisions as a percentage of the number of operations at particular times (i.e. 1 year, 3 years etc). The numbers are simply the values on the graph at these specific time points and are listed to provide the actual number for each year so that the number does not need to be read from the graph.

**Figure LS3 Example of a table and corresponding graph**  
 (KT12 Cumulative Percent Revision of Primary Total Knee Replacement (Primary Diagnosis OA) from the 2017 Registry Annual Report)

Knee Class	N Revised	N Total	1 Yr	3 Yrs	5 Yrs	7 Yrs	10 Yrs	15 Yrs
Total Knee	17213	482373	1.0 (1.0, 1.1)	2.7 (2.7, 2.8)	3.6 (3.6, 3.7)	4.4 (4.3, 4.4)	5.3 (5.2, 5.4)	7.3 (7.1, 7.6)
<b>TOTAL</b>	<b>17213</b>	<b>482373</b>						



This table shows the values in the brackets, as the lower and upper limits of the cumulative percentage. So, at 10 years the cumulative percentage is 5.3%, and is the calculated mean from the upper limit of 5.4 and the lower limit of 5.2.

On occasion, the Registry provides only cumulative percent revision tables and does not provide the graphs. This is usually when the results of a large number of different replacements in one category are being presented. The reason the graphs are not provided for each of the different replacements is simply a space issue. It would make the report too large.

When examining the tables, it can be seen that there is variation in the outcome of the different prostheses that are listed. It is important to understand that just because a prosthesis combination has a higher cumulative percent revision than other prosthesis combinations, it does not necessarily mean that the combination is not as good. It is possible that this difference in the number of revisions between the prostheses has occurred by chance rather than being a true difference. In reality, most but not all prostheses have equally good results.

## HAZARD RATIOS

Hazard Ratios are used to compare two different factors such as non XLPE compared to XLPE. The HR is an indication of the difference in the risk of revision for non XLPE compared to XLPE. For example, if the HR=3, this means that there is a three times greater risk of being revised. If the HR=1, then this means that there is no difference. If the HR=0.5 then this means that that risk of revision is half.

The p value is a measure of the likelihood that a difference observed between groups being compared is real, rather than occurring by chance. In statistical terms, this is called significance. The difference is regarded as significant (in other words likely to be true) if a p value is smaller than 0.05. A p value of 0.05 means that there is a 1 in 20 chance that the difference is not true. A p value of 0.001 means that there is only a 1 in 1,000 chance that the difference is not true. In other words, it is more certain that the difference is real.

**Figure LS2 Example of a hazard ratio from a Registry graph**

HR adjusted for age and gender	
Non Cross-Linked vs Cross-Linked Polyethylene	
0-3Mth:	HR=0.84 (0.74, 0.95), p=0.004
3Mth-6Mth:	HR=1.04 (0.82, 1.31), p=0.749
6Mth-1.5Yr:	HR=1.49 (1.30, 1.71), p<0.001
1.5Yr-2.5Yr:	HR=1.25 (1.05, 1.49), p=0.011
2.5Yr - 5Yr:	HR=1.61 (1.41, 1.83), p<0.001
5Yr - 6.5Yr:	HR=1.92 (1.59, 2.31), p<0.001
6.5Yr - 9Yr:	HR=2.25 (1.90, 2.67), p<0.001
9Yr+:	HR=3.10 (2.48, 3.89), p<0.001

The hazard ratio (HR) could have a number for each of the listed time periods. The time period is the number that is on the left. The values in the brackets after the HR number are the possible lower and upper limits of the HR. The reason that these numbers are given is because the HR number is an estimate and the numbers in the brackets indicate that there is a 95% degree of certainty that the actual HR falls within this range. For instance, the first entry in Table LS2 above referring to the 0-3 month period has a lower limit of 0.74 and an upper limit of 0.95. The HR value of 0.84 is the arithmetic mean (average) value of the upper and lower limit but because this is an estimate there is a possibility that the actual HR is not this figure but that is a 95% likelihood that it falls within the range identified by the numbers in the brackets.

When the Registry compares two different factors, such as non-XLPE to XLPE, to see if there is a difference, it also tests whether that difference changes with time. That is why all the different time periods are listed. With this particular comparison it can be clearly seen that the difference between the two different polyethylenes is increasing as the time after the original operation increases.

The length of time after the initial operation when differences become evident is an important piece of information in helping to determine why there is a difference. Using Figure LS2 as an example, the HRs have been divided into eight time periods, the time from the joint replacement to three months after the surgery, then 3 months following the surgery to 6 months and so on. There are many reasons why some things may differ soon after surgery and these reasons often change as the time after surgery increases. What can also happen as is the case in the example provided is that the extent of difference can vary with time; sometimes the difference is greatest early, and other times the difference may increase as time progresses which is what has occurred with this example. In some graphs the difference does not change with time but is the same from start to finish. When this occurs then instead of having a list of different time periods then only one HR will be given, and it will state that the HR is over the entire period.

# Change in Practice and Outcome of Hip and Knee Replacement Surgery in Australia

## INTRODUCTION

This is the new chapter for 2019. This Annual Report is an important milestone for the AOANJRR as it is the 20<sup>th</sup> Report that the Registry has produced. We decided that it may be valuable to look back at what has happened since data collection commenced back in 1999. The results of joint replacement have improved. We felt it was important to better understand some of the reasons why this has occurred. We looked at both hip and knee replacement.

Many factors influence the result of joint replacement surgery. With this analysis, we looked at how some of these factors have changed over the last 20 years and how that has affected the number of redo operations (revisions). As mentioned earlier the number of redo operations is an important measure of the success of this surgery. The factors that we looked at included the class of prosthesis. Class is the term used by the Registry to describe groups of prostheses that broadly have similar features in design and are used in similar clinical situations. These similar clinical situations may overlap between classes, but some may occur more commonly in one class compared to another. Examples include things like partial hip replacement, which is most commonly used in the treatment of patients with a fractured hip, but it has been used on occasion when patients have arthritis. Total hip replacement is used most commonly to treat arthritis but in recent years it is also being increasingly used to treat patients with a fractured hip. In the knee group, there are also partial and total knee replacements. Partial knees are used most often to treat arthritis when the arthritis is limited to just part of the knee joint. Total knee replacement is also used to treat arthritis and is necessary when the arthritis involves most or all of the knee joint, but it can be also be used when the arthritis is limited to just part of the joint. Different classes are known to have different results. It is important to understand which classes perform best in different situations.

We also looked at whether patient factors have changed as these also affect the results. The things that were considered were gender, age, the reasons for having a joint replacement and also the health of patients at the time they had a joint replacement. All of these change the risk of having a redo operation in various ways.

The final group of factors was a more detailed study of the design features within the most commonly used classes of hip and knee replacements. Although a class is determined because of the similarity of design there are minor changes of design within each class which can have big effects on the number of redo operations performed.

To compare the effects of class, patient factors and differences in design within the main classes we looked at how these changed over the last 20 years. We compared the effect that these changes had on the results by looking at three different time periods. They were 1999-2005, 2006-2012 and 2012-2018.

## HIP REPLACEMENT

There have been major changes in the use of different classes of hip replacement over the last 20 years. This has had quite large effects on the likelihood of having a redo operation. The best results overall occurred in the most recent period (2013-2018). Operations done between 2006-2012 have had a higher chance of having a redo operation compared to the other two time periods. A major reason for this is that during this time there was more use of some classes of hip replacement that are now known to have higher redo rates. In particular, one class, commonly called large head metal on metal hip replacements had the most effect. This class started being used during 1999-2005 and its use increased so that it peaked in use in 2007. It was about that time that the AOANJRR started identifying that there was a problem with this new class of hip replacement. So much so that it is now no longer used. There were other classes of device that were also being used in this period that were causing issues. These included what is referred to as exchangeable neck devices. Normally with a femoral stem the device is

one piece. With exchangeable necks, the device is in two pieces that are put together at the time of surgery. The two pieces include that part of the stem that is inside the femur and provides the anchor to bone and a separate piece that then joins to that part of the femoral stem, protrudes out of the bone and allows the attachment of the ball of the hip joint. When a femoral stem is in two pieces rather than one, the chance of having a redo is higher. The use of exchangeable neck devices has decreased but there can still be reasons why a surgeon may need or wish to use this type of device. However, its use is much less common now than it was during 2006-2012.

Resurfacing hip replacement was also quite commonly used during this period. It was identified that this class of hip did not work as well in older patients, females and small patients. Resurfacing when used in younger male patients has similar rates of redo operations to a routine total hip replacement. The use of resurfacing hip replacement has decreased and is now largely limited to this group of younger male patients. The reduced use of this class and its more specific use in younger males have reduced the number of redo operations.

As was mentioned, the Registry also looked at patient factors. We only looked at this for the main class of hip replacement. This class is what the Registry refers to as conventional total hip replacement and is what is routinely used for most patients. Apart from increasing use of conventional total hip replacement for the treatment of broken hips, not much else has changed over the last 20 years. The proportion of men and women having this class of hip replacement each year is about the same. The age has changed very little and the health of patients at the time of surgery does not appear to have changed at all. As there has been no or little change in patient factors, then changes in the results of conventional hip replacement over time have not occurred because of patient factors but because of other reasons.

The main reason has been the use of conventional hip replacements with design features which are known to be beneficial. In the past, the main reason hip replacements needed to be redone was because of wearing of the moving surface of the joint. This has been reduced dramatically by the use of new materials that wear much less. When a hip replacement wears there are small fragments of material that are produced, and this can cause inflammation. Inflammation can result in bone resorbing which can lead to the hip replacement becoming loose and/or painful. There are a number of main reasons why a hip replacement might need to be redone. In addition to wear there is also dislocation, fracture and infection.

The need to redo a hip replacement for dislocation which usually has occurred more than once has been known to be closely related to the femoral head size (i.e. the size of the ball). Larger sizes of femoral head reduce the risk of dislocation. However, the downside is that they increase the risk of wear. One of the big advantages of using materials that reduce the risk of wear is that it has also meant that larger head sizes can also be used. The use of these more wear-resistant materials in combination with larger head sizes has decreased the number of redo operations for both wear and dislocation.

Fracture when it occurs is usually a fracture of the femur. It may occur at the time or soon after the surgery or also at a much later time. Early femoral fractures are known to be associated with the use of cementless femoral stems rather than the alternative cemented femoral stems. It is more likely to occur if the femoral bone is weaker than normal. There has been increased use of cementless femoral stems and as a result the number of redo operations for early fracture has increased. The number is small but is important that everyone is aware of this trend. This, however, needs to be balanced by a number of other observations. There can be good reasons for using cementless stems particularly in younger patients and patients with good quality bone. Cementless stems once they become fixed in the bone do very well. It is also important to note that the use of cementless stems in Australia has not increased in older patients receiving hip replacements which, because of bone quality issues, is the group that is most at risk of femoral fracture.

The other reason for a redo, that the Registry has identified as increasing, is early infection in the hip joint. However, the numbers remain small. The reason for this is unknown at this stage. The Registry is currently undertaking more detailed analysis of the results and working with other experts in Australia and overseas to better understand why this is occurring and how best to reverse this trend.

## KNEE REPLACEMENT

A very similar analysis was undertaken for knee replacement surgery. The results of knee replacement have continuously improved over the last 20 years. There have been a number of reasons for this. One important change has been the reduced use of partial knee replacement and in particular one type of partial knee usually referred to as unicompartmental knee. When the Registry first started collecting data, this class of knee replacement was used in about 15% of knee operations. This has now reduced to around 5%. Unicompartmental knee is known to have about twice the risk of revision compared to total knee replacement. Its reduced use has resulted in a decrease in the overall risk of redo surgery. There is always a balance in selecting the class of knee replacement that should be used and the possibility of being revised is only one of the things that patients and surgeons consider. It is for these reasons that unicompartmental knee is still a choice that may be suitable for some patients.

There are a number of different classes of total knee replacement. The two main classes that have been used over the last 20 years are minimally stabilised and posterior stabilised. As the names suggest, each of these designs differ in the degree of knee stability that each provides. The stability of the natural knee is very much dependent on knee ligaments. There are two ligaments inside the knee, and these may be damaged by knee arthritis and/or removed as a result of the surgery. They are the anterior and posterior cruciate ligaments. The anterior cruciate is almost always removed as part of a total knee replacement. It is also the cruciate ligament that is most likely to be damaged as a result of arthritis. If this is done, adequate knee replacement stability can be obtained using a minimally stabilised knee replacement. If the posterior cruciate is not working properly or is removed, then a posterior stabilised total knee replacement may be used. It is not always clear when it is better to use a posterior stabilised total knee. Over recent years, the use of posterior stabilised knee replacements has decreased. This has been associated with a reduction in the overall risk of redo surgery. However, there will always be situations where a posterior stabilised knee replacement may be the better option for a patient.

As with hip replacement, patient factors have not changed very much if at all in the last 20 years when a total knee replacement is undertaken. The reducing rate of revision that has been observed for total knee replacement and particularly for minimally stabilised knee replacements, which is the most commonly used class of total knee, is occurring for other reasons. The most important of these have been the increased use of patella (kneecap) resurfacing and the increased use of cement fixation.

It is not always necessary to resurface the patella when doing a minimally stabilised total knee replacement. Resurfacing the patella is when the natural joint surface of the patella is removed and replaced by an artificial surface. Excellent results can be obtained without resurfacing the patella. The rate of resurfacing has been gradually increasing and this appears to be associated with a reduced risk of having a redo operation, particularly for knee pain in the first few years after surgery.

Cement fixation in total knee replacement, particularly cement fixation on the tibial side, is known to have a reduced risk of revision. The increased use of cement fixation has decreased the risk of a redo. There are newer designs of cementless fixation that are becoming available. The Registry will continue to monitor and assess both the short and long-term outcomes of these newer designs.

The trend of increasing early revision within the first few months of surgery because of infection that was seen with hip replacement is also occurring in knee replacement. As previously mentioned, the Registry is looking closely at this not only to confirm that this initial finding is correct but if so, why it is occurring. It is important to emphasise again that the risk of early revision for infection even though it appears to be getting a little higher is still very small.

## Ten and Fifteen Year Prosthesis Outcomes

This chapter provides information on hip and knee prostheses that have the longest follow-up in the Registry. This year, the Registry is reporting on the outcome of 93 different hip prostheses (combinations of femoral and acetabular prostheses with at least 10 years of follow-up). Prostheses with 10 years of follow-up data account for 67.7% of all primary total conventional hip procedures being undertaken in Australia. The percentage of hip procedures that have 10 years of follow-up data and have been revised varies from 1.7% to 46.2%. Two groups of devices have been identified. Those with what is referred to as a 'superior benchmark' and those with a 'non-inferior benchmark'. All of these devices have proven low revision rates at 10 years with the superior benchmark devices having a slightly lower revision rate than the non-inferior benchmark devices. Both of these groups of devices have what is regarded as low revision rates at 10 years. The Registry identified 16 hips with a superior benchmark and an additional 11 with a non-inferior benchmark. In other words, of the 93 different hip prosthesis combinations 27 (29.0%) are identified as having low revision rates at 10 years. This is regarded as an excellent result for these 27 different hip replacements.

A similar analysis was undertaken for primary total knee replacement. The Registry identified 66 total knee replacement combinations with data for 10 years or more. This group accounts for 87.3% of all the total knees reported to the Registry. The percentage of knee procedures that have 10 years of follow-up data and have been revised varies from 2.9% to 13.2%. The Registry identified 8 knees with a superior benchmark and an additional 23 with a non-inferior benchmark. In other words, of the 66 different knee prostheses combinations, 31 (47.0%) are regarded as having an excellent result.

The Registry also has a number of prostheses (56 hip and 42 knee) that have information that extends out to 15 years. Many of the devices have performed well. The percentage of hip procedures that have 15 years of follow-up data and have been revised varies between 2.7% and 20.6%. Seventeen of the hip prostheses have a 15 year revision rate that is less than 6.5%, and 6 less than 5%. For knee replacements the percentage of procedures that have 15 years of data and have been revised varies between 4.3% to 15.5%. Seven of the knee prostheses have a percent revision of less than 6.5% and 2 with less than 5%.

## Hip Replacement

The Registry considers three different categories of hip replacement. These are primary partial, primary total and revision hip replacement. Each of these categories is divided into a number of different classes. These are described in the Annual Report at the start of the section on hip replacement.

There were 49,764 hip replacements reported to the Registry in 2018. This is an increase of 1.7 % compared to the number undertaken in 2017.

Primary partial hips account for 14.9% of all hip replacements reported to the Registry since it commenced data collection. Primary total hips account for 74.2% and revision hips 11.0%.

Due to the staged introduction of the Registry, the first year that the Registry recorded complete national data was 2003. Since that time, the number of hip replacements reported to the Registry has increased each year. The number of hip replacements undertaken in 2018 was 83.4% more than undertaken in 2003.

However, there are differences in the rate of increase depending on the category of hip replacement. The number of primary partial hip replacements, which are almost always done for fractured neck of femur (broken hip), has increased by 30.2% since 2003. The number of primary total hips, which are most often done due to severe arthritis, has increased by 108.1% during the same time. The increase in revision hip replacement was the lowest of all categories and comparing 2003 to 2018 the number of revision hip procedures increased by 19.5%.

The proportion of hip procedures that are undertaken each year that are revision operations is called the revision burden. The aim of any intervention to improve the outcome of joint replacement is to reduce the revision burden. The revision burden has declined since 2003 with the exception of 2011. In that year, the Registry reported an increase in the revision burden. This was largely due to the high revision rate of large head metal on metal hip replacements and in particular the ASR XL prostheses. In 2012, the revision burden again declined and has continued to decrease since that time. In 2011, the revision burden was 12.6%, in 2012 it was 11.9%, in 2013 it was 10.7%, and in 2018 it had decreased to 8.4%. This is the lowest revision burden for hip replacement ever reported by the Registry.

The Registry data continues to show that in general Australian surgeons have increasingly used approaches to hip replacement and hip replacement prostheses that the Registry has identified as being associated with an improved result. This is particularly evident in recent years with increased use of prostheses known to have excellent outcomes over a long period and decreased use of those that are known to have a less satisfactory result. It is anticipated that the effect of these changes will have a progressively beneficial impact on the revision burden in coming years.

### PRIMARY PARTIAL HIP REPLACEMENT

Most partial hip replacements are used to treat broken hips. In particular, elderly patients with a broken hip involving a complete fracture at the base of the femoral head (ball of the hip joint) which is significantly displaced (moved out of position). This is commonly referred to as a sub capital fractured neck of femur.

The Registry has previously reported that the risk of further revision surgery following the treatment of broken hips with primary partial hip replacement is dependent on a number of factors. These include the age at the time of surgery, class of partial hip replacement, method of fixation and the type of prosthesis used.

There are three main classes of partial hip replacement: unipolar monoblock prostheses, unipolar modular prostheses and bipolar prostheses. Each has their place in the management of broken hips.

When the Registry first started collecting data, unipolar monoblock prostheses were the most common type of partial hip prostheses used. Of the three types of partial hip replacement, this has the highest

rate of revision. The use of these devices, however, has continuously declined over the years and it is now rarely used.

Unipolar modular and bipolar replacement have a lower risk of revision in the 'younger' elderly population (below 85 years of age). Bipolar prostheses are revised less frequently than unipolar modular prostheses when individuals are less than 75 years of age.

The use of cement fixation reduces the risk of revision by approximately half, regardless of the class of partial hip replacement. Consequently, in recent years there has been a dramatic increase in the use of cement fixation when partial hips are used. However, the vast majority of partial hip replacements will do well, whether they are cemented or not. The information on the use of fixation is available in the supplementary report on partial hips.

## PRIMARY TOTAL HIP REPLACEMENT

There are two main classes of primary total hip replacement. The first and most common is total conventional hip replacement, which involves replacing the femoral head (ball of the hip joint) as well as the acetabulum (socket of the hip joint). The second is a total resurfacing hip replacement. Although the socket is replaced in a similar way to a conventional hip, it differs in that only the surface of the femoral head is replaced rather than the whole head.

Overall, resurfacing hip replacement has a higher rate of revision compared to primary total conventional hip replacement. In recent years, the use of total resurfacing hip replacement has continued to decline. In 2018, it was used in only 0.08% of all hip replacements performed.

Factors that affect the outcome of primary total resurfacing hip replacement include the type of prostheses used, as well as the gender, age and size of the patient. Women have a significantly higher rate of revision. This difference has resulted in this procedure now being done almost exclusively in males. Men have an age-related rate of revision. Males over the age of 65 years have a much higher rate of revision in the first 6 months after surgery and consequently this surgery is almost never done in patients above this age.

It appears that there are a number of reasons for the difference in outcomes related to gender. The first relates to the size of the patient. Smaller femoral head sizes do not do as well in a resurfacing procedure and women on average have smaller femoral head sizes. It also appears that women still have a higher rate of revision following a resurfacing hip replacement when a larger head size is used, but the reason for this is not clear. Males with a smaller femoral head size also have an increased risk of revision compared to males with larger femoral head sizes.

The Registry has identified many factors that affect the outcome of primary conventional hip replacement. These can be divided into patient and prosthesis factors.

Patients with osteoarthritis have better outcomes compared to patients having a total hip replacement for a different reason. Generally, it can be said that women have a slightly lower rate of revision compared to men. In the long term, the rate of revision decreases as the age at the time of the initial surgery increases. This is more apparent in women than men.

The Registry is again reporting on the impact of ASA score and BMI for all patients. The impact of ASA score and BMI is only seen in the first few years after surgery as the Registry only commenced collection of ASA data in 2012 and BMI data in 2015. The ASA score is a measure of general health. The score increases with the number of health problems. The higher the ASA score the higher the risk of revision and this is due in part to an increased risk of revision for infection. There are six categories of BMI which include underweight, normal, pre-obese and then obese 1, 2, and 3. The revision rate is increased in patients with a BMI that is categorised as obese 1, 2, or 3. The most common reason for the increased revision rate is infection.

As mentioned in the introduction, for the first time this year the Registry is reporting on the effect of surgical approach. The Registry only commenced collecting data on approach in 2015 so this analysis is

only relevant to early outcomes. Overall, there is no difference in the risk of a revision when the anterior, lateral and posterior approaches are compared. However, there are differences in the reasons why a revision is undertaken. The anterior approach has a higher rate of revision for fracture in the first 3 months and loosening but a lower rate of revision for dislocation and infection. It is also apparent that when the anterior approach is used that the patients tend to be younger, healthier and less overweight. When these things are also taken into account the anterior approach currently has a higher rate of early revision.

As has been done in previous years, a number of important prosthesis characteristics that influence outcome have been highlighted again in this year's report. These include the method of fixation, the use of an exchangeable femoral neck, and the bearing surface of the hip prosthesis.

Primary total conventional hip replacements vary in the method used to fix the prosthesis to bone. There are three main types of fixation, cemented, cementless and hybrid fixation.

Cemented fixation is when the femoral and acetabular prostheses are fixed to bone using a hard setting plastic called methyl methacrylate (bone cement). Cementless fixation is when the femoral and acetabular prostheses are fixed to bone using macro fixation initially, which is followed by bone ingrowth into the surface of the prostheses which gives a biological fixation. Macro fixation is achieved by shaping the bone and placing a slightly oversized prosthesis into the cavity produced by that shaping. Prostheses are designed to be specifically used with cemented or cementless fixation. The other main approach to fixation is hybrid fixation. This involves cementing the femoral component and using an acetabular component that is cementless. There is also an approach used which is termed 'reverse hybrid' where the acetabular component is cemented, and the femoral component is cementless. This method of fixation is rarely used in Australia.

For a number of years, the Registry has identified that there is an age-related effect associated with the method of fixation. In general, older patients do better with hybrid or cement fixation and younger patients do better with hybrid or cementless fixation.

This year, the Registry is again highlighting the increased rate of revision associated with the use of an exchangeable femoral neck. The Registry has previously identified this class of prosthesis as having a higher rate of revision compared to other conventional hip replacements. The neck is the part of the femoral component that protrudes outside of the femur. It is usual that the stem and neck are all one piece, i.e. the neck is fixed to the femoral stem. An exchangeable neck consists of the stem and neck as separate pieces, which are put together after the femoral stem is placed in position inside the femur. As the femoral head connects to the femoral component by the neck, the supposed advantage of an exchangeable neck is that it enables the surgeon to slightly vary the position of the head after the stem has been placed in position. This is not possible if the neck and stem are in one piece.

As the Registry has previously reported, our analysis shows that the use of an exchangeable neck is associated with twice the rate of revision. As in previous years, the Registry is also reporting that the rate of revision was higher regardless of the type of bearing surface used, and if the metals in the stem and the neck did not match. There is a much higher rate of revision if the stem and neck combination is titanium and cobalt chrome, compared to a titanium and titanium combination. All prostheses with exchangeable necks, on which the Registry has more than 5 years follow-up, show an increased rate of revision. Those with a metal mismatch have a higher rate of revision.

The Registry also reports the results of a number of different types of hip replacements that have special features. These included mini femoral stems, as well as constrained and dual mobility acetabular components. The Registry has reported the results of these devices again this year.

Mini stems are very short cementless femoral stems, where fixation to the bone is over a smaller area entirely in the top of the femur. This contrasts with the standard femoral stem that usually extends almost halfway down the length of the femur. Currently, mini femoral stems remain a relatively new technology and are not commonly used. They represent only 1.2% of all total conventional hip procedures. This analysis does not identify any difference in the overall revision rate compared to standard femoral stems. There is a difference in the reasons for revision, with the mini stems requiring revision because they

have become loose at 10 years just over twice as often as the standard stem. The rate of revision also varies depending on the type of mini stem used.

As mentioned last year, a constrained acetabular prosthesis is a special prosthesis. Unlike normal acetabular prostheses, it has a mechanism to lock the femoral head inside the acetabular socket so that there is a reduced chance of dislocation. It is not surprising to find they are used in different types of clinical situations to usual acetabular prostheses. In particular, they have been used more commonly in situations known to have a higher risk of dislocation. They do seem to have some beneficial effect because there is no difference in the rate of revision when a constrained acetabular prosthesis is used, when it would be expected that the risk of revision would be increased in the patient that it has been used in. However, younger patients (aged 70 years or less) do not do as well compared to older patients when a constrained cup is used. They have over three times the rate of revision. When total hip replacement is used to manage a broken hip (fractured neck of femur), a constrained acetabular prosthesis is associated with a lower risk of revision.

Another type of special acetabular prosthesis is the dual mobility acetabular prosthesis. The reason it is called dual mobility is because the femoral head articulates with a polyethylene liner, but unlike the common situation where the polyethylene liner is fixed to the acetabular shell, in the dual mobility the liner is designed to move or articulate with the metal shell (i.e. there is dual mobility). The purpose of the dual mobility design is similar to the constrained acetabular prosthesis, in that it is designed to reduce the risk of dislocation. Similar to constrained acetabular prostheses the proportion of dual mobility acetabular prostheses used for unusual reasons is high compared to standard acetabular prostheses. At 5 years, there is no difference in the revision rate of dual mobility acetabular prostheses compared to standard acetabular prostheses when the patient is being treated for either osteoarthritis or fractured neck of femur.

This year, the Registry has again undertaken an extensive analysis on outcomes related to the use of different bearing surfaces used in primary total conventional hip replacement. The bearing surface is the articulating surface, and this varies depending on the material used to make the articulating surface on both the acetabular and femoral sides.

The acetabular articulating surface may be metal, ceramic or polyethylene. The polyethylene may be non cross-linked (non XLPE) or cross-linked (XLPE). XLPE means that an additional manufacturing process has been used that increases the bonding of the molecules within the polyethylene. It has been shown in laboratory testing that increasing the cross-linking, increases the resistance to wear when this material is used in hip replacement.

The femoral articulating surface may be metal, ceramic, or a third option called ceramicised metal, which is available mainly from one company. Consequently, there are a number of possible combinations that make up the different bearing surfaces. These include metal on polyethylene (non XLPE and XLPE) ceramic on polyethylene (non XLPE and XLPE), ceramic on ceramic, and metal on metal. Ceramicised metal femoral heads have only been used in sufficient numbers to assess when combined with XLPE. There are a small number of procedures where the bearing surface is ceramic on metal. The data on these are not included in the main report as they are no longer used.

As the Registry has reported since 2008, large head metal on metal bearings continue to have a much higher rate of revision compared to other bearings. This is because they produce metal particles at a higher rate compared to other bearing surfaces. These particles cause an inflammatory reaction which can damage the bone and muscles around the joint replacement. They have not been used for many years.

Although ceramicised metal on XLPE has the lowest reported cumulative percent revision at 10 years, the Registry has explained that this result should be interpreted with caution. This is for a number of reasons; the Registry is not confident that this result is due to the bearing. While there is no doubt that it is a perfectly satisfactory bearing, there is not enough evidence in the current data to suggest that it is the best. A complicating factor is that this bearing has only been used with a small number of different femoral stems and acetabular cups and shells from the same company. Many of these are well

performing stems and acetabular components that are likely to be contributing in a major way to the lower revision rates seen with this bearing when compared to other bearings. In recent years, there has been increasing use of XLPE. The use of this material has been associated with a significant reduction in the rate of revision in primary total conventional hip replacement for dislocation, loosening and lysis. The reduced rate of revision for dislocation is due to an increased use of larger head sizes (32mm or greater) in XLPE procedures.

These larger head sizes can be used because there is a lower rate of wear with this polyethylene. As mentioned earlier, when a larger head size is used, the hip replacement is more stable and so there is a lower rate of revision for dislocation. The reduced rate of revision for loosening and lysis is thought to be due to the lower wear rate. Loosening and lysis is most often due to an inflammatory reaction, that occurs following the production of small wear particles. Theoretically, a reduced wear rate means less particles and therefore less inflammation. The reduction in loosening is supportive of a lower wear rate for XLPE.

XLPE has a lower rate of revision compared to non XLPE, regardless of whether a metal, ceramic or ceramicised metal femoral head is used. In addition to the overall analysis of all prostheses, the Registry has also undertaken analyses on 6 different acetabular prostheses, each have been used in large numbers with both XLPE and non XLPE. Five of the 6 prostheses have a lower rate of revision when XLPE is used. The remaining prosthesis does not show any difference. This is further evidence supporting a reduced revision rate when XLPE is used, but it does raise the question of whether this is true for all types of XLPE.

The Registry has undertaken a detailed analysis of ceramic on ceramic bearings. Although the Registry has information on three different ceramics, only one of these ceramics (mixed ceramic) is in current use. It is the best of the three ceramics. The revision rate of mixed ceramic varies with femoral head size. When the femoral head size is 28mm or smaller then there is a higher risk of revision in the first 3 months compared to 32mm head sizes. Increasing the femoral head size larger than 32mm does not make much difference although for head sizes that are 40mm or larger there is a small reduction in revision risk compared to 32mm femoral head size.

## Knee Replacement

As with hips, the Registry considers three different categories of knee replacement: primary partial, primary total, and revision knee replacement. Each of these categories is further divided into a number of different classes. These are described in the Annual Report at the start of the section on knee replacement.

There were 65,266 knee replacements undertaken and reported to the Registry in 2018. This is an increase of 5.0% compared to the number reported in 2017.

Primary partial knee replacement accounts for 7.8% of all knee replacements reported to the Registry since it commenced data collection. Primary total knees account for 84.2% and revision knees 8.0%.

Since 2003 (which as previously mentioned was the first year that the Registry collected full national data), the number of knee replacements undertaken each year has increased. In 2018, there was a 128.1% increase in the number of knee replacements compared to 2003. However, the rate of change differs depending on the category of knee replacement. Primary total knee replacement has increased by 156.2% since 2003 and revision knees by 108.2%. However, primary partial knees have decreased by 4.0%. Almost all primary knee replacements, whether they are partial or total, are undertaken for osteoarthritis.

The proportion of knee procedures that are revision procedures, has been decreasing since the Registry was implemented. The percentage of knee replacements that are revisions decreased from 8.8% in 2004 to 7.5% in 2018.

### PRIMARY PARTIAL KNEE REPLACEMENT

A partial knee replacement replaces only part of the knee joint. The Registry identifies five classes of primary partial knee replacement. Most are used in small numbers and two are no longer used in Australia. The main report provides information on unicompartmental knee replacements, and other partial knee replacements still being used are reported in the *Partial Knee Arthroplasty Supplementary Report*. The results of the two classes of partial knee replacement that are no longer used are available in the supplementary report on the AOANJRR website called *Prosthesis Types No Longer Used*.

The most used partial knee replacement is the unicompartmental knee. This replaces the femoral and tibial joint surfaces on either the inner or outer side of the knee (most commonly the inner side of the knee). Its use accounts for 92.8% of all primary partial knees. Other types of partial knee replacement are partial resurfacing and patella/trochlear knee replacements.

Partial resurfacing involves the use of special buttons to replace damaged areas of the knee joint surface. They account for 0.4% of all partial knee replacements. The Hemicap is the only partial resurfacing prosthesis currently available. Over the last few years, the Registry has reported that this prosthesis has a higher rate of revision compared to other partial knee replacements. These findings have been confirmed again this year.

Patella/trochlear prostheses replace the joint surfaces of the kneecap, both on the underside of the kneecap and on the top of the femur in the groove where the kneecap runs. This area of the femur is referred to as the trochlear. This is the second most used partial knee replacement and accounts for 6.4% of all partial knees. There are a range of different patella/trochlear prostheses available for use. Patella/trochlear replacement is used in relatively small numbers and generally in very special circumstances. Overall, almost half of these procedures have been revised at 16 years. Age is a risk factor for revision. The rate of revision in patients younger than 65 years of age is significantly higher than patients aged 65 years or older. Men have a slightly higher rate of revision compared to women. There is variation in the outcome depending on the type of patella/trochlear prosthesis used.

Primary unicompartmental knee replacement has a higher rate of revision than primary total knee replacement. Age is a major factor affecting the outcome of unicompartmental knee replacement.

The younger the patient, the more likely it is that the procedure will be revised early. At 18 years following a unicompartmental knee replacement, 27.3% have been revised. Almost 40.6% of patients less than 55 years of age at the time of their surgery have been revised within 18 years.

Unicompartmental knee replacement may be undertaken on the medial (inner), or lateral (outer) side of the knee. Medial unicompartmental knee replacement is much more common and accounts for 90.0% of all unicompartmental knee replacements. There is no difference in the revision rate when medial and lateral unicompartmental knee replacements are compared. The revision rate of unicompartmental knee replacement varies depending on the type of prosthesis used.

## PRIMARY TOTAL KNEE REPLACEMENT

A primary total knee involves the removal and replacement of the joint surface of the femur and the tibia on both the medial (inner) and lateral (outer) sides. A single femoral prosthesis and a single tibial prosthesis are used. The tibial prosthesis may be one component, but it is more commonly two that are put together at the time of surgery. Usually, a metal tray fits over the cut surface of the tibia with a plastic insert that fits inside the tray to make the tibial prosthesis. This then articulates with the single femoral replacement. A primary total knee replacement may or may not have the under-surface of the patella replaced.

Primary total knee replacement has the lowest rate of revision compared to all other types of primary knee replacement. Men have a slightly higher rate of revision compared to women. The most important patient factor identified by the Registry that influences the rate of revision, is age at the time of surgery; the younger the patient the higher the subsequent rate of revision. Patients less than 55 years of age at the time of surgery, have a 17.8% chance of being revised at 18 years. The rate of revision declines as patients get older and in patients aged over 75 years, for only those that live another 18 years, 3.6% end up being revised.

There is only a small variation in the outcome of knee replacement related to the type of fixation used to hold the tibial and femoral components tightly to bone. Hybrid fixation has the lowest rate of revision, but the difference is not major. Cemented fixation has a lower rate of revision compared to cementless fixation but this varies depending on whether the total knee replacement is minimally or posterior stabilised. Minimally stabilised knees do best, if at the very least the tibial component is cemented. Posterior stabilised knees do best when both the tibial and femoral components are cemented to the bone.

An important difference between hip and knee replacement is what keeps the artificial joint surfaces from moving out of position. This is referred to as the stability of the joint. An unstable joint has additional unnatural movements between the joint articulating surfaces. The very extreme example of this is when the articulating surfaces come apart. This is referred to as dislocation. There can also be lesser degrees of unnatural movement that can cause problems with the function of an artificial joint without the joint actually dislocating. In general, the stability of the joint is dependent on the shape of the joint as well as the soft tissues (muscles and ligaments) around the joint. If everything is working correctly, the combination of these factors allows normal movement and prevents unnatural movements between the joint surfaces. As the hip is a ball inside a socket joint, there is a lot of stability simply because of the shape. This is not the case with knee replacement, where two relatively flat surfaces articulate with each other. The stability of the knee joint is much more dependent on surrounding soft tissues and in particular ligaments that hold these joint surfaces in place and in the correct alignment. Quite often in patients receiving a knee replacement, one or more of these ligaments may already be damaged. In order to address this issue, primary total knee replacement can vary depending on the additional built-in stability that may be required. In certain circumstances, it is necessary to use a replacement that is designed to substitute for one or more of the damaged ligaments.

Most knee replacements used do not require any additional stabilising, other than substituting for the anterior cruciate ligament. These are referred to as minimally stabilised knee replacements. The next most common group is posterior stabilised. These have additional stability built into the knee replacement, so that the prosthesis substitutes for the posterior cruciate ligament as well. The vast majority of knee replacements used are either minimally or posterior stabilised prostheses. Minimally

stabilised prostheses have a slightly better outcome than posterior stabilised prostheses. However, there is some difficulty in being too definite about this, as posterior stabilised prostheses may be used more often in difficult cases. If a case is more difficult, it has more potential to be revised.

Other important ligaments around the knee are the medial and lateral collateral ligaments. These can also be substituted by what is often referred to as constrained knee replacements. These are not often required in primary operations. There is one final group of knee replacement when considering stability and these are hinged knees. These are used mostly when there is absolutely no ligament stability left in the knee. Their use is very rare for primary knee replacement.

Another general difference in the design of primary total knee replacement, is the way the tibial insert is designed to move on the surface of the tibial tray. It may either be fixed to the tray (fixed insert) or designed to move slightly in one or more specific directions (mobile insert). Mobile inserts either rotate, slide, or do both. For a number of years, the Registry has reported that in general, fixed inserts have a lower rate of revision.

In previous reports, we provided information on the use of cross-linked polyethylene (XLPE) in total knee replacement. This year we have repeated and extended that analysis. Comparing the outcome of XLPE to non XLPE across all knee replacements, there appears to be a benefit when XLPE is used. There is a lot of variation between the type of prostheses and the type of polyethylene used. As a consequence, any difference seen when comparing the overall result of XLPE to non XLPE may be in part due to the type of prosthesis, rather than the type of polyethylene. To try and overcome this problem, the Registry has undertaken analyses of specific designs of total knee replacement that have used both XLPE and non XLPE. Only prostheses that had a minimum of 500 procedures, in at least one of the polyethylene groups, and a follow-up time of 5 or more years, were used in this analysis. There were 18 different primary total knee prostheses that met this requirement.

The results of this analysis showed that for all prostheses tested there was no disadvantage to using XLPE, but for a number of specific types of prosthesis there was a clear benefit. However, this was only for a small number of the prostheses (5 out of 18).

We have also done a follow-up analysis on the outcome of computer navigation in primary total knee replacement. Computer navigation is computer-assisted surgery, which was first used over 15 years ago. It involves the use of intraoperative computer monitoring in an attempt to more accurately place the knee prosthesis. It is known that accurate positioning of the prosthesis is a very important factor in determining the result of the operation. The current information from the Registry suggests that there may be a small advantage, particularly in younger patients, as there is a small reduction in the rate of revision for loosening in this group.

There is another technique, which surgeons are using in an attempt to improve the positioning of knee prostheses. This is known as Image Derived Instrumentation (IDI). This technique involves obtaining accurate images of the knee joint preoperatively, so that the instruments used to achieve the alignment can be specifically made for that patient. The Registry has looked at the 11 different total knee prostheses where either the standard approach or IDI was used to determine the correct position of the knee prosthesis. For 9 of these prostheses there was no difference in the subsequent revision rates when these two techniques were compared. For 2 of the prostheses, the revision rate was increased when IDI was used.

## Shoulder Replacement

Shoulder replacement is also grouped into three different categories: primary partial, primary total and revision shoulder replacement. Each of these categories is divided into a number of different classes. These are described in the Annual Report at the start of the section on shoulder replacement.

There were 7,251 shoulder replacements reported to the Registry in 2018. This is an increase of 8.1% compared to the number undertaken in 2017.

Primary total shoulders account for 77.1% of all shoulder replacements reported to the Registry since it commenced data collection. Primary partial shoulders account for 13.0% and revision shoulders 9.9%.

Due to the staged introduction of the Registry, the first year that the Registry recorded complete national shoulder data was 2007. Since that time, the number of shoulder replacements reported to the Registry has increased each year. The number of shoulder replacements undertaken in 2018 was 167.6% more than undertaken in 2008.

However, there are differences in the rate of increase depending on the category of shoulder replacement. The number of primary partial shoulder replacements has decreased by 68.1% since 2008. The number of primary total shoulders has increased by 306.3% and revision shoulder replacement has increased by 136.3% during the same time.

The proportion of shoulder procedures that are undertaken each year that are revision operations is called the revision burden. The aim of any intervention to improve the outcome of joint replacement is to reduce the revision burden. In 2008, the revision burden was 9.8%. This increased and peaked at 10.9% in 2012 and 2015. In 2018, the revision burden has declined and is lowest at 8.7%.

### PRIMARY PARTIAL SHOULDERS

The Registry subcategorises primary partial shoulder replacement into four main classes. These are defined by the type of prostheses used. The main report provides information on the two main classes of partial shoulder replacement.

The most used shoulder knee replacement is hemi stemmed. This replaces the humeral head and humeral stem prosthesis. Hemi stemmed accounts for 73.1% of all primary partial shoulder replacements.

The second most used partial shoulder replacement is hemi resurfacing that uses a humeral prosthesis to replace the humeral articular surface only, without replacing the humeral head. Hemi resurfacing accounts for 23.4% of all primary partial shoulder replacements.

Partial resurfacing involves the use of one or more button prostheses to replace part of the natural articulating surface on one or both sides of the shoulder joint. Partial resurfacing accounts for 2.7% of all primary partial procedures. Hemi mid head is the least used type of primary partial shoulder replacement, accounting for 0.8%. It involves the resection of the humeral head and replacement with a humeral head and a humeral stem prosthesis. A humeral stem prosthesis may have metaphyseal or diaphyseal fixation.

## PRIMARY TOTAL SHOULDERS

There are four types of primary total shoulder replacement: total reverse, total stemmed, total mid head and total resurfacing.

Total reverse accounts for 61.9% of all primary total shoulder replacements. It involves glenoid replacement with a glenosphere prosthesis combined with resection of the humeral head and replacement with humeral cup and humeral stem prostheses. A humeral stem prosthesis may have metaphyseal or diaphyseal fixation.

After 3 months, total reverse shoulder replacement has a lower rate of revision compared to total stemmed shoulder replacement.

Total stemmed is the second most used type of primary total shoulder replacement, accounting for 33.5%. This procedure involves glenoid replacement combined with resection of the humeral head and replacement with humeral head and humeral stem prostheses. A humeral stem prosthesis may have metaphyseal or diaphyseal fixation. Cement fixation of the glenoid component in total stemmed shoulder replacement has a lower rate of revision.

Total mid head is less frequently used accounting for 4.0% of all primary total shoulder replacements. This procedure involves glenoid replacement combined with resection of part of the humeral head and replacement with a humeral head and an epiphyseal fixation prosthesis.

Total resurfacing shoulder replacement is the least used type of primary total shoulder replacement accounting for 0.6%. This procedure involves glenoid replacement and the use of a humeral prosthesis that replaces the humeral articular surface without resecting the head.

## Hip, Knee and Shoulder Prostheses with a Higher than Anticipated Rate of Revision

The Registry reports on the results of individual prostheses in the different classes. There is variation in the revision rates for different types of prostheses in each class. Many of these differences are not statistically significant.

The Registry, however, does identify individual prostheses that have a statistically significant higher rate of revision. The threshold for that identification is that the revision rate is more than twice that of all other prostheses in the same class and the difference is statistically significant. In other words, the revision rate of these devices lies outside the expected norm. They are often referred to as outliers. These outliers are identified in the final chapter of the 2019 Annual Report.

This information highlights to surgeons, orthopaedic companies and regulatory bodies worldwide, that something unexpected is happening with respect to the outcome of these prostheses. It enables consideration to be given as to the possible reasons for this difference and whether it is worthwhile or appropriate to continue to use these prostheses.

It is important to emphasise that there may be many reasons why the revision rate is twice that of other prostheses. Some of these may not necessarily be related or specific to the identified prostheses. The data related to each of these prostheses have been carefully considered by an expert group of orthopaedic surgeons who have recommended these prostheses be identified and therefore be considered further as to whether or not they should continue to be used. When they undertake that consideration, all available data is reviewed and any subsequent investigation that they may request is undertaken and provided. The consequence of this process is that not all outliers are recommended for identification. One of the main reasons that an outlier is not identified is because it is a non-standard prosthesis that is used in unusual or complex clinical situations associated with a higher risk of revision. In this situation it is not fair to compare the results of these special devices to that of standard prostheses used in standard clinical situations.

This year, the Registry has identified 143 prostheses, or prosthesis combinations (83 hip, 53 knee and 7 shoulder).

The identified prostheses are listed in one of three groups. There are those that have a higher rate of revision that are being identified for the first time and are still in use in Australia. The second group includes prostheses that are being re-identified but are also still used. This list identifies that the prosthesis continues to have a higher than anticipated rate of revision and it provides updated information on its continued use. Most prostheses that are identified for the first time or re-identified prostheses decline in use with time. This is usually evident only after the first year because almost a full year of use has occurred prior to the identification in a previous Annual Report.

The third group are prostheses that are identified but are no longer used in Australia. Most of these have been previously identified. However, occasionally there is a prosthesis in this group that is identified for the first time. These are prostheses that are no longer available for use in Australia, and that as time progresses the Registry is able to identify that this device has a revision rate that is subsequently identified to be higher than anticipated.

The Registry identification of prostheses with a higher than anticipated rate of revision has resulted in many of these prostheses being withdrawn from national and international markets. Only summary information is provided in the Annual Report. However, the full detailed analysis for each of these prostheses is available from the Registry website (*Investigations of Prostheses with Higher than Anticipated Rates of Revision*).

## Conclusion

The purpose of the AOANJRR is to provide high quality independent data on the results of joint replacement in Australia.

The Registry provides this information to surgeons, and all other stakeholders to assist them to make informed judgments on the best approach to joint replacement surgery.

It is hoped that the information presented in this report is useful to people who are seeking additional information on joint replacement surgery, particularly those that are considering or have already undergone the operation. Registry information can be very complicated, as many factors interact to influence the outcome of the surgery. The intention of making this information available to everybody is to assist in promoting informed discussion about the outcome of joint replacement surgery, particularly between patients and their treating surgeons.