Shoulder replacement is the definitive operation for the treatment of a painful arthritic shoulder joint. In this procedure, the worn out ends of the bone are replaced with metal and plastic, thus recreating a functional joint again. For the procedure to be possible, there needs to be good preservation of bone stock on the socket side and intact, functioning, rotator cuff tendons.

**Shoulder replacement**

Shoulder replacement can be performed in two ways:

1. **Total shoulder replacement** - in which both the ball and the socket parts of the joint are replaced or
2. **Hemi-arthroplasty (half a joint)** - where only the ball part is replaced and the socket is left in its natural state.

**Total shoulder replacement**

Most shoulder surgeons feel that, in ideal circumstances, total shoulder replacement is the procedure of choice for Osteo-arthritis of the shoulder. In this procedure, both the humeral head (the round ball at the top of the humerus or arm bone) and the glenoid (the socket, which sits in the scapula or ‘wing bone’) are replaced. The humeral head is replaced with a metal ball, and this sits on top of a metal stem which is placed in the hollow central canal of the humerus. When in place, this should look very much like the normal humerus. In order to achieve this, there is a variety of sizes available, and the hope is to be able to restore the height, the shape, and the offset of the ball, to how it was prior to the wear setting in.

The humeral component of the joint is modular. It comes in bits that have to be fitted together. The stem itself, which fits down the central canal in the humerus, is usually coated with a special ingrowth surface (porous metal, hydroxy-appetite, etc.) and, over a period of months, bone grows into this creating sound fixation. For most makes of replacement therefore, cement is not required for this part of the joint.
The ball that fits on the top of that stem (the head) can be changed or removed should revision surgery be required. This means (hopefully) that the stem, which is fully integrated into the bone, should never need removal.

The socket side of the shoulder (the glenoid) is also replaced when a total shoulder replacement is performed. The socket, in most shoulder replacements, is made entirely of polyethylene (special plastic), and it sits on top of the previously worn out bony socket. As it does not have a bony ingrowth surface, it has to be cemented into the bone using an acrylic cement. To help fixation the socket is made with pegs on its under-surface. These fit into specially prepared holes which are placed in the worn out bony socket.

**Metal Backed Glenoids**

There are also some designs available which use a metal backing for the plastic socket (a ‘metal backed glenoid’), a design similar to a knee or a hip replacement. The potential advantages of this are firstly, that cement does not have to be used, relying on a bone ingrowth surface instead, and secondly, that in some models the plastic can be replaced if worn out. For these reasons, many such designs have been tried. In some models, there have been problems with the locking mechanism between the metal backing and the plastic liner leading to premature separation and failure. A number of such models have been withdrawn from the market because of this, but a couple remain, albeit with improved locking mechanisms being tried.

The other problem of metal backed glenoid components is that of metal on metal wear that occurs when the plastic component of the socket has worn through (or separated and fallen out). The metal surfaces then rub on each other and, as they are not matching shapes, a large amount of metal debris can be deposited in the shoulder. This fine metallic debris is deposited onto the soft tissues of the shoulder where it can lead to systemic absorption of metal ions. Metals such as Chrome and Cobalt, both part of the standard metal alloy used for the humeral head bearing surface in this type of surgery, are both toxic when there are high circulating levels. Fortunately however, these levels are rarely reached before revision is undertaken.

In the last few years, a different type of metal backed component has been available. This does not have an exchangeable polyethylene component, but rather the polyethylene bearing surface is industrially bonded onto the metal base. This type of prosthesis, pioneered in the knee, is a bone ingrowth type, but initial screw fixation cannot be used because the polyethylene completely covers the metal. The metal used for this is Tantalum: a metal that is one of the least reactive metals to humans, and which has the best bone ingrowth potential of any of the metals currently available. It is manufactured such that it has...
small porosities within it which are very similar in size to those in bone. For this reason, it is often referred to as 'Trabecular Metal'. Our experience with this prosthesis has now made it the glenoid of choice for the majority of shoulder replacements performed. The exceptions being the very deformed sockets, sockets with substantial bony deficiency, and where there is sufficient osteoporosis such that the roughened surface of the metal back will not have adequate purchase on the bone to remain solid for the 6 weeks required for bony ingrowth.

Metal backed components that have screws for initial fixation, holding the socket steady until bony ingrowth occurs, are the prostheses of choice where there is some bone loss of the glenoid (socket). Firstly, these components have significant bulk which may be enough to avoid bone grafting the defects in the glenoid. Secondly, if bone grafting is necessary, then the bone can be placed under the prosthesis, and the composite unit stabilised by the screws.

With the same reasoning, a metal backed component is often a good choice in revision surgery, where a good deal of the socket may be missing or lost during extraction of the old prosthesis.

**Rotator cuff function**

The rotator cuff is a series of tendons and muscles that pass around the front, the top and the back of the shoulder joint to aid in function and movement. All of the rotator cuff tendons attach high on the humerus, just around the edges of the articular (joint) surface. The bigger and more powerful muscles of the shoulder such as the deltoid, pectoralis major and the latissimus dorsi, all attach further down the shaft of the humerus.

Together, these bigger muscles act in consort with the rotator cuff such that, the bigger muscles provide the force to elevate the arm, and the rotator cuff acts to help lever the arm out by pulling the humeral head in. The counter force thus provided by the rotator cuff is such that, when the bigger muscles are being used, the joint reaction force is always through the socket. Hence, this prevents dislocation of the shoulder during use.

If the rotator cuff tendons become badly enough torn, the remaining deltoid muscle may not be strong enough to lift the arm out from the side of the body. Hence, rotator cuff function is critical to the normal function of the shoulder and, because replacement only provides new surfaces for the joint and does not replace muscles and tendons, an unrepairable rotator cuff tear will remain as a permanent deficit, even after the joint surfaces have been replaced. For that reason,
long term protection of the rotator cuff becomes important and, frequently, sub-acromial decompression to remove damaging spurs from above the rotator cuff, is performed (and, if possible, any rotator cuff tears are repaired) well prior to any consideration of replacement. Often, by doing this, the shoulder pain is substantially reduced even though the arthritis itself has not been treated. In a number of cases therefore, this actually delays replacement, which is something that is considered to be beneficial. Needless to say however, this is not always the case, and sometimes, despite removing impingement type pain, and despite repairing the rotator cuff tendons, the arthritis continues to give trouble until replacement is performed.

At the current time, if the rotator cuff tendons are considered unrepairable, and pain or loss of function is significant, then a reverse replacement may be indicated. Although there are some muscle transfers that are regarded as possible (albeit last resort) to try and improve function in younger patients with unrepairable rotator cuff tears, these are of no value where the joint is arthritic and requires replacement. It can thus be seen that protecting rotator cuff function, and ensuring that those muscles and tendons work, is imperative in the lead up to any replacement surgery.

**Hemi-arthroplasty**

This is a procedure, where the socket part of the joint is not replaced but, instead, only the humeral head is replaced. In this instance the humeral head (ball part of the joint) is replaced by metal in the same fashion as for total shoulder replacement but the socket remains the original bony socket.

**Reasons for considering a hemi-arthroplasty might be:**

1. Inadequate bone stock in which to seat the socket (including those dysplasias of the socket which represent a malformation of that part of the joint), or
2. Inadequate tendons (rotator cuff tendons) to make the joint function or
3. A damaged or destroyed humeral head associated with a totally normal (unworn) socket

Whilst these have been regarded as indications for this procedure in the past, the results of hemi-arthroplasty have been less than pleasing. In controlled trials of these versus total replacements, there has been a marked difference in both pain and function in favour of the total replacement.

The potential problem of premature wear of the polyethylene glenoid in the younger individual, which might then lead to multiple revisions being required during a lifetime, makes the option of not using a resurfaced glenoid seem attractive. Unfortunately however, the results of doing this have rarely been as good as one would desire, and hence, even in this age group, the tendency nowadays is to do a total replacement.

**Humeral Head Resurfacing**

This is a procedure that was designed with the aim of obtaining a better result from only performing the humeral replacement than a traditional hemi-arthroplasty. The hope was that, by just putting a cap on the humeral head, the size and position of the ball could be made much more anatomical than can be achieved by removing the head and putting a ball on top of a stem. Results from Copeleand’s group in Reading have shown great promise, with long term satisfaction being high. Unfortunately however, despite good 15 - 20 year results from that group, most surgeons in the rest of the world have been unable to replicate that success. Indeed, the revision rate of humeral head resurfacing, as documented in the Australian Joint Registry, is identical to that of the conventional hemi-arthroplasty. Accordingly, whilst there is some argument for resurfacing humeral components, most think that they should only be performed with a glenoid replacement as well. This combination however, is technically demanding, and few centres use this as a
Custom Glenoid Components

Where there is significant deficiency of the glenoid, and particularly when it faces very posteriorly, it can be almost impossible to install a satisfactory glenoid component: one that faces the correct way, is solidly fixed, and has enough bone graft to form a more normal bony socket underneath the component. And, even if that can be done, the bone graft may not unite, and the component may just lever out. In other words, component failure that may prove unfixable.

To get around this, there are now custom implants available which are designed specifically to deal with the pathology of the native glenoid (see pictures on next page). These are made to order based on 3D reconstructions of CT scans performed on the shoulder. Instead of using bone graft, they come with Trabecular...
Reverse Shoulder Arthroplasty

If the rotator cuff tendons are damaged beyond repair, then instead of the humeral head being held centrally

Reverse Shoulder Replacement

Note that the ball is on the glenoid side

Cuff-Tear Arthropathy

The humerus is abutting the acromion

Custom Glenoid Component

Note the trabecular metal behind the tray which is used to fill the defect in the glenoid bone

Custom Glenoid in-situ

Note how well it fits the defect

Humerus pushed down by the glenosphere, overcoming rotator cuff deficiency

Needless to say, this technology is expensive. It is done overseas, meaning that it takes 6 or so weeks between getting the CT scan organised and receiving the prosthesis but, when the situation demands it, such prostheses can be arranged. Usually the health funds will help with the cost of this if no other alternatives are available. It is however, not for everyone.
Replacement of the shoulder has been carried out since the early 1960's and the method of insertion of the joint has been largely standardised in that time. In general, it takes about an hour and a half to do a shoulder replacement but this may be extended out to two and a half hours depending on the degree of difficulty. The most technically demanding part of shoulder replacement is the insertion of the glenoid component (the socket). This can be very difficult, particularly when the shoulder joint is very tight beforehand and where there has been an extremely limited range of motion for some time. In addition, if there is a large amount of bone loss, or the bone has been eroded more at the back of the socket than the front, then it may take some time to either build the bone up at the back (bone graft), or to cut the bone down at the front to make it face in a more normal direction.

The procedure is done through a wound at the front of the shoulder which goes from the bottom of the collar bone down the front of the deltoid (approximately one third of the way down the upper arm itself). It requires a general anaesthetic to perform and it requires the help of assistants. It is somewhat harder to perform than a hip replacement or a knee replacement. Despite this however, it tends to be less sore than either of those procedures, often allowing discharge from hospital within 3 - 4 days.

Shoulder replacement - after surgery

Traditionally, the glenoid component is cemented into place, and hence, is fixed from the outset. The humeral component is uncemented, however, it is a tight press fit into the humeral shaft, and hence is usually considered very stable. What limits or slows down recovery is neither of these factors, but rather the sub-scapularis muscle and its re-attachment to the humerus.

The sub-scapularis is a large muscle which forms the part of the rotator cuff that sits at the front of the shoulder, underneath the pectoral muscles and the deltoid. It causes the arm to rotate inwards for activities like putting the arm behind the back. In order to get to the shoulder joint proper, this muscle has to be moved out of the way. Traditionally, its tendon, which directly overlies the shoulder joint, is divided, being re-attached at the end of the procedure. This repair takes a couple of months to heal strongly enough to allow this tendon to be used with any force, and hence, needs a lot of protection. In recent times however, the trend has been to take
this tendon off intact, but with a small piece of bone from the humerus still attached. The advantage of this is that the tendon can be re-attached by suturing that piece of bone around the stem of the prosthesis. This gives a much more stable construct, and it will allow much earlier movement of the arm than the older style direct tendon repair. Accordingly, this is now regarded as the standard method of doing this procedure.

The bit of bone that is re-attached needs some protection, but usually, most patients can start removing their sling between 2 and 4 weeks to allow for increased range of motion exercises. As this is a bone to bone repair (rather than a tendon to tendon repair), it will be reasonably strongly healed by 6 weeks. The other limiting factor for complete removal of the sling however, is the biceps tendon. At the time of surgery, this is normally taken from its insertion at the top of the socket and re-attached to the upper humerus (tenodesis). Generally, it is just sutured to other soft tissues as part of the repair, so this will need some protection from both stretch and overuse. This will mean not lifting anything too heavy, even whilst in the sling. It also means not twisting the hand up to face the ceiling (supination) with any force, this being one of the main functions of the biceps.

The range of motion obtained whilst in hospital is usually within the 90˚ range, although occasionally better motion can be achieved. Initially the motion is quite hard to regain but, over a period of some months, this gradually returns. Ultimate shoulder function is somewhat dependent on pre-operative function, meaning that those joints that are extremely tight and have very limited motion pre-operatively, are unlikely to ever get full range. As a rough guide, most patients get about halfway between where they start and the full range. Hence, the more range present pre-operatively, the better the likelihood of a good end result.

Independent of the amount of motion that is or isn’t achieved in hospital, the range of motion will continue to improve throughout the recovery period, and indeed, improvements may be seen out to about one year following surgery.

As this is an upper limb joint, patients can generally walk around the ward within a day or two of surgery. Within a three or four days, most are sufficiently mobile to be able to cope at home.

**Physiotherapy**

Whilst in hospital there will be ongoing physiotherapy to help with recovery, and most patients are seen at least twice a day. Once leaving hospital, a home programme will be organised. This will include a variety of exercises aiming to regain motion of the shoulder. It is important to realise that these are designed to take the shoulder through a range of motion and are not intended to help regain either strength or fitness. Too much activity can harm the repair, even with the newer methods and the newer high strength sutures that are used.

Following discharge, physiotherapy outside the hospital can be organised. However, in general, most patients are able to do all their exercises at home very adequately, and the benefit of getting more intensive therapy may be lost given the difficulties and the problems associated with travelling. Accordingly, in most instances, immediate follow up physiotherapy will not be organised and generally is not considered necessary. Either way, this will be assessed during the hospital stay and arrangements can be made if necessary. Similarly, further assessment will be made during the follow up period.

**Home help etcetera**

If not noted at the pre-operative clinic, then certainly whilst in hospital, we can assess as to whether or not home help will be required. If this looks necessary, then either the clinic or the Ward Staff can have an Occupational Therapist visit to discuss the situation with you and your family. The Occupational Therapists have considerable experience with joint replacement patients, and will be able to offer advice on home aids as well as support. If it is clear from the outset that some help will be required, then this is best discussed with the clinic sister pre-operatively so that everything can be organised in time for discharge.

It is to be remembered that, after your shoulder is replaced, you will not be able to drive a car for at least six to eight weeks, and hence, you may need help with shopping, cooking and so on. Initially some help with showering and other daily activities may also be required. If this looks necessary, then the O.T. may be able to organise such. Please remember however, that services such as silver chain are stretched, and therefore not always available. For this reason, home help from family members may be very important, and indeed, this should form the mainstay of post-operative care.

**Expectations and results**

Shoulder replacement is generally considered to be a good operation. The vast majority are either pain free or give minimal aches and pains. In a lot of ways, it is more akin to hip replacement than to knee replacement.
in that pain relief is often extremely good, and motion returns reasonably quickly. It is not certain as to why hip and shoulder replacements are better than knee replacements in terms of pain, but it may be because these are deep within the body and well surrounded by muscle on all sides, in contra distinction to knee replacements which are relatively superficial. It may also be that these are ball and socket joints which have much simpler mechanics than the more complicated ones seen in the knee. Independent of the reason, shoulder replacements do behave much more like hip replacements than knee replacements, and consequently, good pain relief can reliably be expected. Most people can do normal household and daily activities with the replaced shoulder within 3 months. Most can drive by about eight weeks and return to golf (and other similar activities) sometime between four and six months, depending on progress. Activities such as tennis, may be possible if a good range of motion is achieved but, in general, these are considered to be a little bit much for the shoulder, and they are considered to cause early wear and early failure. For this reason, tennis and other high demand activities such as distance swimming, are not advocated. Golf, on the other hand, seems to be much less harmful to the joint and is allowed.

The longevity of a shoulder replacement is similar to a hip replacement (but not as good as a knee replacement). In general, most people can expect that at the ten year mark 90 percent of all the prostheses will still be functioning, and some of these will continue to function out past twenty years. The commonest reason for failure is loosening of the plastic socket, and sometimes this does need to be either revised or removed.

Wear of the socket can also occur, and although not generally a problem in the short to medium term, it may become a problem in the longer term. Indeed, it is thought that it is the wear particles of the plastic that contribute to the loosening of the socket. The body reacts to, and tries to digest, these microscopic particles of plastic by making some fairly strong chemicals. Unfortunately however, the plastic is not broken down by these. Instead, these chemicals go on to dissolve the bone around the socket and, if this happens, the socket will eventually become loose, and pain will develop. Although not a very frequent occurrence, when this does occur, revision surgery is required.

Complications and problems

Residual pain is rarely a major problem. Occasionally this does occur in the first twelve months, and sometimes it relates to micro-motion of the humeral stem when the bone hasn’t fully grown into it, and stabilised it. If this is the case, then generally it will lessen over a twelve month period as the fixation improves. Other residual aches and pains may occur which are difficult to explain. Some are due to true loosening of the prosthesis, some to infection, some to impingement and rotator cuff disease, and some to mechanical problems (including over-stuffing of the joint). Most of these however, can be diagnosed and treated.

Impingement is a common shoulder complaint, even in an un-replaced shoulder. Just as a normal shoulder can develop acromial spurs which cause impingement of the rotator cuff tendons, so too can a replaced shoulder go on to develop impingement related problems. Indeed, replacement does not change the natural history of the rotator cuff and its pathologies. Hence, these may subsequently require treatment in their own right: and this might include both sub-acromial decompression and rotator cuff repair.

If the rotator cuff goes on to become significantly degenerate such that it becomes dysfunctional, or an unrepairable tear develops, then the procedure of choice may be to revise the replacement to a reverse replacement.

Persistent instability of the shoulder is a difficult problem, particularly when the ball comes out of the back of the shoulder joint (posterior instability) rather than out of the front (anterior instability). Unfortunately, the cause of this is not always apparent. Sometimes it
is associated with large releases of the capsule, made necessary by a significant contraction of that structure (caused by the osteo-arthritis). More usually however, it comes from surgical re-alignment of the glenoid component in a shoulder that has worn so badly at the back, that the shoulder starts to dislocate in that direction.

In osteo-arthritis, the wear is generally at the back of the shoulder joint. As such, the back of the glenoid starts to wear away, gradually increasing the posterior slope of the socket. This then allows the ball part of the joint (the humeral head) to start sliding off the back of the glenoid (the socket) and, as this happens, the posterior capsule (at the back) starts to be stretched up. With time, the posterior glenoid gets more and more worn away and the posterior capsule gets progressively more stretched up. Eventually, in bad cases, the shoulder can be almost completely sitting out the back of a socket that is largely missing. If this is bad enough, a standard replacement may not actually be possible.

When a shoulder is replaced, an attempt is made to correct the slope of the glenoid, by re-orientating that component to a nearer normal angle. This can be done by either grinding off the front of the glenoid to make it square to the joint or, if there is not enough remaining bone to do this, by building up the back of the glenoid with a bone graft or a prosthetic augment. Often full correction cannot be achieved, but it is thought that by correcting the forces so that the glenoid is nearly at right angles to the reaction force of the joint, it will function better and last longer. Unfortunately however, whilst achieving this objective, the back capsule which has been stretched up, remains loose and incompetent. Hence, it may allow the shoulder to dislocate posteriorly. As a consequence, in order to control this abnormal movement at the time of surgery, some tightening of the back capsule may need to be performed. This is technically demanding to do because it is difficult to reach, but nevertheless, if achieved, it can tighten the back of the shoulder and decrease the tendency for the humeral head to dislocate out the back. It is however, not always achievable.

Other causes include:

1. failure to correct the version of the humeral head, either back to normal (usually 30º - 40º retroverted - facing backwards) or to a position that adequately accommodates for incomplete glenoid slope correction.

2. failure of the sub-scapularis muscle or tendon to heal, or an absent sub-scapularis, leaving the front of the shoulder open

3. failure to restore humeral length, when this is done for fractures or as revision surgery

Over the last ten years or so, our knowledge of how to balance the shoulder has improved and, by adjusting the capsule, by adjusting the alignment of the bones and by adjusting the tension on the muscles at the front of the joint, we can make almost all joints stable. Occasionally however, persistent subluxation or dislocation of the joint does occur, be that from the time of surgery or be that developing at a later time: and this may well require revision surgery. Experience with such revision surgery shows that it is very difficult to control instability, particularly if it is posterior. Sometimes therefore, the only solution to this problem is a conversion to a reverse replacement.

Over-stuffing of the joint is a subtle problem that may not be obvious at the time of surgery. The occasion can arise when stability of the joint cannot be properly achieved, even with what appears to be the correct size humeral head in place. In order to deal with what appears to be an abnormally loose joint, one can put larger size head on the end of the stem thus tightening

An overstuffed TSR

This model was designed to allow conversion to a reverse replacement but, unfortunately, the conversion piece between the stem and the head was sometimes too large. In this case the socket has come loose because of this.
things up and increasing stability. In some instances however, this leads to a joint which is too tight and it puts the muscles, particularly the rotator cuff muscles, under too much tension. This leads to what is called an over-stuffed joint: one which has the problems of a reduced range of motion, sometimes ongoing pain, and occasionally, longer term damage to the rotator cuff tendons (which are now stretched around a larger humeral head). In addition, the forces on the glenoid component may no longer be in the correct direction, ultimately leading to loosening of that component. If this does subsequently become loose, it may then require revision in its own right.

In general, when it is hard to decide between head sizes to correctly balance the shoulder, a smaller head is usually selected. In doing this, a slight instability may be accepted, knowing that, in the recovery period, muscle tension will be restored providing stability again. In addition, a smaller head size is less likely to give residual pain than one that is slightly too large.

Rarely, the degree of instability seems unacceptable despite what appears to be the correct head size. In this instance, a larger head may be opted for, knowing that this could slightly over-stuff the joint. In this situation, if there is residual pain or loss of motion, it is possible to go back and change the humeral head back to a smaller size. This can be done once the capsule re-establishes itself around the joint, and once the soft tissues have fully healed. Usually this would be some nine to twelve months following the initial surgery. If this problem occurs however, then downsizing the humeral head can lead to both an increased range of motion and to some pain relief. Similarly, better long term function can be expected.

Over-stuffing becomes a more difficult problem, where the humeral stem is proud, sticking up out of the humerus. Some models that have been, and are still, on the market, are particularly prone to this. Whilst there have been warnings leading to revised instructions on the insertion of some of these devices, these do not guarantee that they can be seated correctly in every instance. With hind site, it is now easy to see that some of these implants should not have been used, but there have been a good number of these devices inserted and, whilst these will not all become problematic, those that do will require removal of that stem. If this is solidly fixed with good bony ingrowth, this can be extremely difficult surgery, and the bone is at definite risk of being fractured. What is generally done, is to take a large window out of the front of the humerus, extending the whole length of the stem, thus exposing the stem directly. This then facilitates removal of that stem. When the new stem is subsequently inserted, the window is replaced and held in place by circlage wires (or sutures) tied around the humerus. The window bone then goes on to unite around the new stem. Whilst this gives good restitution of the bone, this sort of extensive surgery can interfere with the muscle and tendon attachments to that bone. Hence, long term strength may be somewhat sacrificed.

**Revision TSR**
*(note windowed humerus)*

**Infection** is fortunately uncommon and, in most series, it occurs in less than 1 percent of cases. Obviously it is higher in those who are at risk of infection, such as in diabetics, haemophiliacs, those on anticoagulation, and those with poor white cell function (such as some rheumatoid arthritics, particularly those on drugs like the TNF blockers). To decrease the risk of infection, all patients are given antibiotics at the time of surgery, and special precautions are taken. This includes the use of special operating theatres with laminar flow air-conditioning, and the use of space suits to isolate theatre staff from the wound.

Whilst the shoulder can become infected at the time of surgery, late infection is probably more common. It is thought that the organisms reach the prosthesis through the bloodstream and then land on the metal. Because the metal is not living, the organisms can hide from the body’s defences, and hence can grow and multiply to the extent whereby a significant infection
Further information can be obtained on this and other related topics such as:

Impingement and rotator cuff tears
Frozen shoulder
Arthritis

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