Anatomic Shoulder Replacement

Anatomic 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 (or in some instances ceramic) 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 (glenoid) side and intact, functioning, rotator cuff tendons.

Anatomic Shoulder Replacement

Anatomic 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 Anatomic Shoulder replacement

Most shoulder surgeons now feel that, in ideal circumstances, total anatomic shoulder replacement is the procedure of choice for Osteoarthritis 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. Most commonly, the humeral head is replaced with a metal ball, and this sits on top of a metal stem which, in turn, is placed in the hollow central canal of the humerus. When in place, this should look very much like the normal joint. 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, back 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 weeks to 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 has become fully integrated into the bone, should never need removal.
the humeral head therefore, it can be very difficult to replace the humeral head such that it sits back in its original anatomic position. One of the ways around this is to use a resurfacing type of component where the head is replaced based on the original humeral head (ball) position, rather than trying to place it on top of a stem, and to then attempt to reproduce the correct rotation, tilt and offset, to make it anatomical.

Originally developed for hemi-arthroplasties (where the socket is not replaced), resurfacing components (where a cup shaped component in placed over a reamed down humeral head) and short fin components (where the humeral head is actually cut off and replaced) now come with glenoid replacements as well. Recently, some makes have been available with a ceramic ball which, theoretically, should last longer given the lower friction of ceramic versus polished metal.

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 created in the worn out bony socket.

Metal Backed Glenoid Components

There are some designs available which use a metal backing for the plastic socket (a 'metal backed' glenoid), a design similar to a standard knee or hip replacement. The potential advantages of this are: firstly, that cement does not have to be used because there is a bone ingrowth surface which can be used instead; and secondly, in some designs, the plastic can be replaced if worn out. For these reasons, and particularly the latter, many such designs have been tried. Unfortunately however, many of these designs have failed prematurely for one reason or another.

Originally developed for hemi-arthroplasties (where the socket is not replaced), resurfacing components (where a cup shaped component in placed over a reamed down humeral head) and short fin components (where the humeral head is actually cut off and replaced) now come with glenoid replacements as well. Recently, some makes have been available with a ceramic ball which, theoretically, should last longer given the lower friction of ceramic versus polished metal.

One of the commonest problems has been due to failure of the locking mechanism between the metal backing and the plastic liner, thus causing premature separation of the components. 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 has 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 toxic when there are high circulating levels. Fortunately however, these levels are rarely reached before revision is undertaken.

An all Polyethylene Glenoid

The socket side of the shoulder (the glenoid) is also replaced when an Anatomic Total Shoulder replacement is performed. In most shoulder replacements, the glenoid component 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 it’s under-surface. These fit into specially prepared holes which are created in the worn out bony socket.
One solution to the problems of the polyethylene component separating from the metal one has been the advent of a polyethylene bearing surface that is industrially bonded onto the metal base. This type of prosthesis, pioneered in the knee, is a bone ingrowth type but, unlike the others, 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.

This prosthesis has been widely used with good results, but the obvious problem is that, if it wears out, the whole component has to be removed; something that is much more difficult than just clipping a new polyethylene component in. On the other hand, there are now some augmented variations available which have been designed specifically to deal with glenoid bone loss. These differ in that they do allow screw fixation through various means, hence allowing the prosthesis to be stabilised until bone ingrowth occurs.

Dealing with bone loss

The most difficult problem to deal with in shoulder replacement is glenoid bone loss. Despite all the problems that have been alluded to regarding metal backed glenoid components, these are, without doubt, the best solution for revision replacement where there is a significant loss of bone stock on the glenoid side.

The versions that have detachable polyethylene inserts allow screws to be used to secure the baseplate. These screws are necessary to hold the prosthetic socket still whilst the bone grows into it. This process requires at least 6 weeks to occur, and it will only occur if the socket doesn’t move. Such ingrowth is what is required for long term success given that, if it does not occur, the screws will start to loosen after a period of time. The glenoid component will then further loosen and will fail.

Some of these metal backed components have significant bulk in the form of a short stem which is often big enough to avoid bone grafting a defect in the glenoid. In addition, if bone grafting is necessary, then the bone can be placed under the prosthesis, and the composite unit stabilised by the screws. Bone grafting however, is technically difficult and fraught with failure: hence, the current trend is to have custom made metal backed glenoids to make up for very large losses of bone stock.

Augmented Glenoid Components

Recently, off the shelf, augmented glenoid components have been made available, allowing for correction of some degrees of bone loss. These are limited in size and range, but seem to be working well at this stage. It is however, very early in their history, so any tendency for these to loosen prematurely has not yet been detected.
As they are off the shelf however, they are relatively inexpensive and readily available.

**Augmented Metal back Glenoid**

Note the wedge of metal on the baseplate that comes in different sizes. The wedge can be on the front, the back, the top or the bottom, and it comes in a couple of different wedge angles. Not all are yet approved for general use.

These are only for reverse replacement.

**Custom Glenoid Components**

Where there is a substantial deficiency of the bony glenoid, and particularly when it faces very posteriorly, it can be almost impossible to install a satisfactory off the shelf glenoid component: one that faces the correct way, is solidly fixed, and fills up enough of the underlying bony defect to provide long term stability.

To get around this, the prosthetic companies can now make custom implants which are individually designed based on 3D CT scans of the shoulder. Once designed, implants are then manufactured specifically to deal with the bone loss that was found, thereby fully correcting the defect and correcting alignment. These are made to order and come with Trabecular Titanium already attached. They also come with guide blocks that fit accurately into the defect in the glenoid, and allow the definitive screw holes to be drilled in perfect position.

Once the screw holes have been made, the definitive prosthesis can be screwed in. All going well, and if the screws grip well and hold the prosthesis still for 6 - 8 weeks (noting that the bone may be very soft and/or deficient) then the glenoid bone should grow into the prosthesis making the construct solid.

Whilst the success of these custom components seems to be much better than for bone grafting techniques: especially noting that the latter is done without the aid of jigs to get the orientation and placement correct, the technology is still young. The biggest problem to date is the fact that some of the prostheses are in fact a bit too large, hence ‘overstuffed’ the joint. This may then lead to a painful joint that doesn’t move all that well. It can also give rise to excess tension on the subscapularis repair which, in turn, may fail and become unfixable.

Given time however, these teething problems will undoubtedly be overcome, so we can expect to see better prostheses and better results in the years to come.

The other problem is cost. This individualised technology is expensive ($20,000 to $30,000 per component). 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. Often the health funds will help with the cost of this if no other alternatives are available however, currently, not all funds will do this.
**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 in the same fashion as for total shoulder replacement but the socket remains the original bony socket.

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 the younger age group, the tendency nowadays is to do a total replacement (which includes a glenoid component).

Where there is a loss of rotator cuff function, usually being due to unreparable tears of those tendons, the option of choice is now to do a reverse shoulder arthroplasty where the ball is on the glenoid side and the socket is on the humeral side. This changes the mechanics of the shoulder, increasing deltoid power and preventing upward migration of the humeral head. For those who have this problem, this is an excellent procedure, providing both pain relief and improved function.

**Traditional reasons for considering a hemi-arthroplasty might be:**

1. The younger patient with osteoarthritis involving predominantly the humeral side and not the glenoid, or
2. A damaged or destroyed humeral head associated with a totally normal (unworn) socket (e.g. avascular necrosis - being a loss of blood supply leading to death of the bone in, and collapse of, the humeral head), or
3. Inadequate rotator cuff tendon function to make the joint work, or
4. Inadequate bone stock to even consider a custom implant (including those congenital dysplasias of the socket which represent a malformation of that part of the joint).

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
**Humeral Head Resurfacing**

This is a procedure that was designed with the aim of obtaining a better result from traditional hemi-arthroplasty. It was based on the premise that the sizing and positioning of the humeral component could be achieved more accurately by reaming down the humeral head and putting a shell head over the top of it, than by removing the head and putting a ball on top of a stem.

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**Resurfacing of the humerus plus a Glenoid Component**

Low friction materials for isolated humeral head replacement (hemi-arthroplasty) are currently being investigated as substitutes for polished metal components. The reason to consider this is that the main problem with polished metal components is erosion into the underlying un-resurfaced glenoid. It turns out that there are materials that can provide significantly less friction than polished metal and, if these are used, then theoretically, the glenoid wear could be prevented or significantly reduced, thus obviating the need to replace that part of the joint.

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**Conventional Hemi-Arthroplasty**

A standard humerus and no socket. Note the early glenoid erosion.

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**Conventional Hemi-Arthroplasty**

Massive glenoid erosion is now present making revision very difficult.

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Results from Copeland’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 National Joint Replacement Registry, is identical to that of the conventional hemi-arthroplasty. Accordingly, whilst there is still some argument for resurfacing the humeral head in isolation, most think that such resurfacing should only be done in combination with a glenoid replacement. In essence therefore, a total shoulder replacement and not a hemi-arthroplasty.
The most promising of the materials that have been so far tried, and a material that has been used elsewhere for replacement (hand and elbow), is one made of pyrocarbon. This is currently being trialled based on laboratory studies that show that these have a much lower tendency for wear of the native glenoid than do traditional polished metal surfaces.

The first available pyrocarbon prosthesis, whilst showing very good clinical results, has not proven strong enough for the task, and failures due to cracking and breakage have been seen.

More recently, pyrocarbon heads that sit on a stem have been introduced with good early results and, perhaps, this may be the way forwards for a replacement utilising a pyrocarbon head.

(i.e. a true resurfacing), models that replace the humeral head, rather than sitting over the old one, are being produced. These require a stem of sorts, but the stem has been reduced to small fins which do not go down the humeral shaft.

The advantage of the above is two fold. Firstly, removal of the humeral head creates a lot more room, thus making the glenoid replacement easier. Such space is not created in a true resurfacing where the humeral head is just reduced in size to accommodate a cap like shell that fits over it. Secondly, the ball component can be placed very accurately once the old humeral head has been removed and, because the fin placement is dependent on where the ball is put, and not the other way around, the fins do not dictate the ball position. This is the opposite of using a stem, where the ball position is, to some degree, dictated by where the stem is put, how it is rotated etc.

Short Fin Humeral Replacement

Using a short finned humeral component for total shoulder replacement, rather than a stemmed one, is increasing in popularity. Given the accuracy of humeral head replacement that can be achieved by a component without a big stem, there is reason to consider using such a component in combination with a glenoid component.

Rather than just reaming down over the humeral head to allow a shell type component to be used however
Navigation and Image Derived Instrumentation

In the last year or so, the computer based design and insertion tools that have been used for knee replacement, have finally come to shoulder replacement. Like the knee, these come as 2 options, and both require acquisition of digital information which is uploaded from a 3D CT scan of the shoulder region. The aim of this technology is to get the replacement ever closer to the original shoulder that is being replaced; that being thought to be most likely outcome to provide the best results.

1) Computer navigation

At the time of surgery, the shoulder anatomy is marked out with a probe to which is attached a tracker that provides detailed position information to a computer. Once landmarks have been defined, these are overlaid onto the digital information that the CT has provided. Once obtained, planning can be done on the computer model of the shoulder, and components can then be implanted using the model as a guide.

This is new technology in the shoulder and, whilst showing much promise, there have been some problems with loosening of the pins that hold the base trackers to the scapular; hence leading to some imperfect placement of components. This is a problem that will ultimately be overcome with the development of better ways of achieving, and maintaining, tracker attachment, or by the use of trackers that are implanted in the bone (e.g. RF trackers) rather than attached to it.

The advantage of this technology is that it can be used as soon as the CT information has been uploaded and processed: often just a matter of days given that no specific manufacturing of jigs or guides is required.

2) Image derived cutting blocks

Based on the 3D CT information, a computer model of the shoulder can be created by company engineers. The surgery can then be planned, optimising component size and position. Nylon cutting blocks can then be made, usually by 3D printing. One block is made to fit exactly onto the humerus, and contains pin holes, or a cutting slot, to allow precise cutting of the bone. The ‘designed for’ prosthesis can then be inserted. A second guide is usually provided to prepare the glenoid.

The downside of this technology is that it requires not just a CT scan, but also a design and manufacturing process. This generally takes about 6 weeks from the time of scanning to implantation, but as some of these processes are starting to be done in Australia, and as the implants are off the shelf and not custom made, this time is getting shorter. It is currently thought that this process could be reduced to about a week.

Current opinion is that these sorts of technologies will be the future of shoulder replacement, but only time and follow up will prove this to be the case.
Shoulder Replacement - the procedure

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 to an hour and a half to perform 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 before hand, 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 (sometimes called retro-version because the socket faces somewhat to the back rather than square to the scapular - see page 12), then it may take some time to either build the bone up at the back (augmented components and / or bone graft), or to bevel 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 12-15cm). It usually 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 1 - 2 days.

Shoulder Replacement - after surgery

Traditionally, the glenoid component is cemented into place, and hence, is fixed from the outset. The humeral component is un-cemented, however, it is made to be a tight (press) fit into the humeral shaft, and is therefore also very stable right from the outset. What limits, or slows down, recovery is neither of these factors, but rather, the subscapularis muscle and its re-attachment to the humerus.

The subscapularis is a large muscle which forms the part of the rotator cuff that sits at the front of the shoulder. It lies underneath the pectoral muscles and the deltoid, and 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 repaired 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 somewhat 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 when using a stemmed humeral component. When using a resurfacing or short finned component however, this technique cannot be utilised, and hence, other methods of re-attachment, often using bone anchors, must be utilised instead.
tendon to bone repairs take a bit longer and require a bit more care not to damage them.

The other limiting factor 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, or is incorporated into the subscapularis 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 expected whilst in hospital is usually within the 90° range. 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 how much motion is 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.

**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 that are used, so, whilst obtaining a good range of motion is important, it should be done carefully and not too often.

Following discharge, physiotherapy outside the hospital can be organised. In general however, 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 problems associated with travelling. In addition, too much activity can damage the subscapularis repair. 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 etc.**

If not noted at the pre-operative clinic, then certainly whilst in hospital, you can be assessed 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 you 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 your post-operative care.

**Expectations and Results**

Shoulder replacement is generally considered to be a good operation. The vast majority end up being 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, knee replacements are relatively superficial and have no muscle cover. It may also be that these are ball and socket joints, and hence have much simpler mechanics than the more complicated one seen in the knee. Independent of the reason however, 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 strenuous for the shoulder and perhaps risk early wear and failure. For this reason, tennis and other high demand activities such as distance swimming, are not advocated. Golf and bowls, on the other hand, seem to be much less harmful to the joint.

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 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 residual problem. Occasionally it is seen 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 it can be expected to 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 (see other information sheets).

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. This procedure (described on page 5 above) is of a design which compensates for rotator cuff failure and can provide much improved function and pain relief in that setting.

**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 osteoarthritis). More usually however, it is seen in a shoulder that has worn so badly at the back that the shoulder has already started to dislocate in that direction, hence stretching up the capsule at the back of the shoulder making it non-functional.

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**Posterior Dislocation of a TSR**

*Note: uncorrected retroversion of the socket*

**Axis of Scapula**

90° to scapula axis (correct socket alignment)

Actual alignment of socket - facing posteriorly (to the back = retroversion)

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In osteoarthritis, 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 to...
(the humeral head) to start sliding off the back of the glenoid (the socket). 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.

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 of instability include:

1. Failure to correct the version of the humeral head (not the glenoid), either back to normal (usually 30° or so retroverted - i.e. facing backwards), or to a position that adequately accommodates for incomplete glenoid slope correction. Either one leading to instability in one or other direction.

2. Failure of the subscapularis muscle or tendon to heal, or an absent subscapularis, leaving the front of the shoulder open; in turn leading to anterior instability (the shoulder coming out the front)

3. Failure to restore humeral length when this is done for fractures, in revision, or in difficult 1st 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 now 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 (see page 5 above for details).

Over-stuffing of the joint is a subtle problem that may not be obvious at the time of surgery. A situation can arise whereby 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 a larger size head on the end of the stem, thus tightening 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; now being upwards onto the top of the socket instead of the middle. Such misdirected force may then lead
to a levering out of, and progressive loosening of, the glenoid component, ultimately requiring revision of that component in its own right.

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 some that still are, 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 sight, 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 humeral bone is at definite risk of being fractured.

What is generally done to remove such a well bonded stem, is to take a large bony 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.

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:
1. All patients are given special antibacterial solutions to wash their skin with pre-operatively
2. A double skin preparation is performed at the time of surgery
3. Antibiotics are given at the time of surgery
4. Special operating theatres with laminar flow air-conditioning are used
5. And space suits are used to isolate all operating personnel from the wound area

Whilst the shoulder can still become infected at the time of surgery, late infection is probably more common. It is thought that the organisms reach the prosthesis through
the blood stream and then land on the metal. Because the metal is not living, the organisms can hide from the bodies defences, and hence can grow and multiply to the extent whereby a significant infection evolves.

**If an infection occurs, and it is detected early**, it can be treated with a wash out of the joint, revision of the humeral head to deal with any dead space underneath it, plus antibiotics. If the glenoid is a metal backed one where the polyethylene component is removable, then this should also be removed and replaced with a new one.

**If an infection is detected late**, or if a washout does not work, then the most expedient treatment, and the one with the highest success rate, is to remove the prosthesis, insert a cement spacer full of antibiotics, and then to give high dose systemic antibiotics until the site is sterile. The antibiotics are then ceased and, if there is no flare up of the infection, a revision replacement is undertaken. This whole process usually takes about 3 months and has a reasonable chance of success, albeit not guaranteed. This is known as a 2 stage revision.

Just as has happened in the knee, there has been much interest in trying to reduce a 2 stage revision into a '2 in 1' stage. This means just one operation in which:

1. **Stage 1** - The old prosthesis is removed
2. Tissue and fluid samples are taken for microbiology (culture and antibiotic sensitivity)
3. I.V. antibiotics are then commenced under the guidance of an infectious disease consultant (if they have not already been started)
4. The joint is then thoroughly debrided (cleared with removal of any seemingly infected material and soft tissue)
5. It is then washed with a high volume of fluid to remove as much debris and bacteria as possible
6. And finally, it is soaked in antibiotic and anti-bacterial solutions for up to half an hour

**Stage 2** - After the break
8. The theatre is cleaned
9. The scrub team re-washes and re-gowns
10. The wound is re-prepared and re-draped
11. New instruments are brought in
12. And then a new prosthesis is inserted.

In the knee, if done well and very thoroughly, that process can be successful in up to 90% or so of cases, and that is nearly as good as a 2 stage procedure but with just 1 operation. In the shoulder, this is perhaps less successful, but sometimes worth trying given that a 2 (separate) stage revision is still not 100% guaranteed.

**C. Acnes.** Of concern in the shoulder, is an organism called Cutibacterium Acnes. This is an organism that we all have on our skin. It is a weak organism and, up until the last few years, its appearance in the laboratory was always thought to be contamination. Certainly, if you blink over a Petri dish with standard culture medium in it, you will see colonies of C. Acnes growing. We now know however, that this organism can cause infection. It is slow growing, often presents as pain in what is seemingly a good and well functioning replacement, and there may be little in the way of swelling or other signs. The infection markers in the blood (ESR and CRP) can be near normal or normal, and culture of fluid from the joint may not yield anything.

The organism is very difficult to grow in the laboratory, and often, only 1 colony may eventuate even from prolonged culture. This often means that repeated fluid samples may need to be sent off along with several tissue samples: and to achieve this may mean one or more arthroscopies, or even open surgery. The diagnosis often takes months or more to arrive at, and even then may be uncertain. The treatment however, is revision by a 2, or '2 in 1', stage revision.

Interestingly, if swabs from arthritic joints that are being replaced are sent to the laboratory, something like 40% will grow this organism. Is this a cause of shoulder arthritis in some, or is this just a surgical contaminant? No one knows; Clearly however, we need better ways to diagnose this problem and better ways to prevent it.

**DVT's** (deep venous thromboses or clots in the vein) generally do not occur in upper limb surgery and, as a consequence, prophylaxis is not routinely given. Where the risk is high (e.g. a prior DVT or pulmonary embolus), some prophylaxis will be used. Note however, that preventing a DVT may not prevent a PE. The latter requires full anticoagulation - with all the inherent risks of significant bleeding. This is particularly a problem in the first week or so after surgery.

**Nerve injury** at the time of surgery is perhaps the most feared complication. The nerves are extremely close to the area being operated upon, and two nerves in particular (the axillary and the musculocutaneous) are close. The commonest injury is in the form of a stretch to one of these two nerves leading to some transient weakness of the arm and some loss of sensation. Recovery of such a stretch (neuropraxia) is usually within days, but certainly within three months. More significant injuries, such as a full scale tearing or division of the nerve is, fortunately, extremely uncommon in most series.
Vascular injury is very uncommon because the main artery and veins of the arm are some distance from the wound itself. Nevertheless, it is theoretically possible for this to occur, particularly when the surgery is difficult.

**Revision Replacement**

This is a technically demanding procedure, particularly if a humeral stem has to be removed. Such removal can lead to humeral fractures and loss of bone. It can also require removal of a window of bone to loosen the stem enough to allow removal, thereby risking further humeral fractures, some of which are not repairable.

If the glenoid also needs replacing, which is usually the case, then there may be a loss of bone stock there as well. As described above, this may therefore mean having to use a metal backed glenoid component, perhaps with augments to fill defects; or very occasionally, a custom made implant.

Ultimately, if revision to an Anatomic Replacement seems too technically difficult or unlikely to succeed, then revision to a reverse replacement may be necessary. Such a decision is made based on the known outcomes of revision to a Total Anatomic Shoulder Replacement compared to revision to a Reverse Replacement, in difficult cases. In essence, whilst this may be a limited goals procedure, the chances of pain relief, with still reasonable function, should make this a very real consideration.

In the elderly, where an Total Anatomic Shoulder Replacement has failed due to rotator cuff failure, be that by degeneration, tearing, or both, revision to a Reverse Shoulder Arthroplasty is required.

**Summary**

Anatomic Total Shoulder Replacement is now a commonly performed, and generally very successful, procedure. It does have complications, but the majority of these can be avoided or treated. For those with severe arthritic pain and an intact rotator cuff, the results can be extremely gratifying.

For those with unrepairable tears of the rotator cuff tendons who have developed arthritis because of that, the results of reverse replacement are also good, though it is to be understood that this does not restore normal anatomy, and that this procedure has limited goals. Having said that, reverse replacement is still a very good operation for pain, and it does improve function for most.
Further information can be obtained on this and other related topics such as:

Shoulder Replacement - The Journey
Reverse Replacement
Impingement and rotator cuff tears
Arthritis

at: https://www.keithholt.com.au