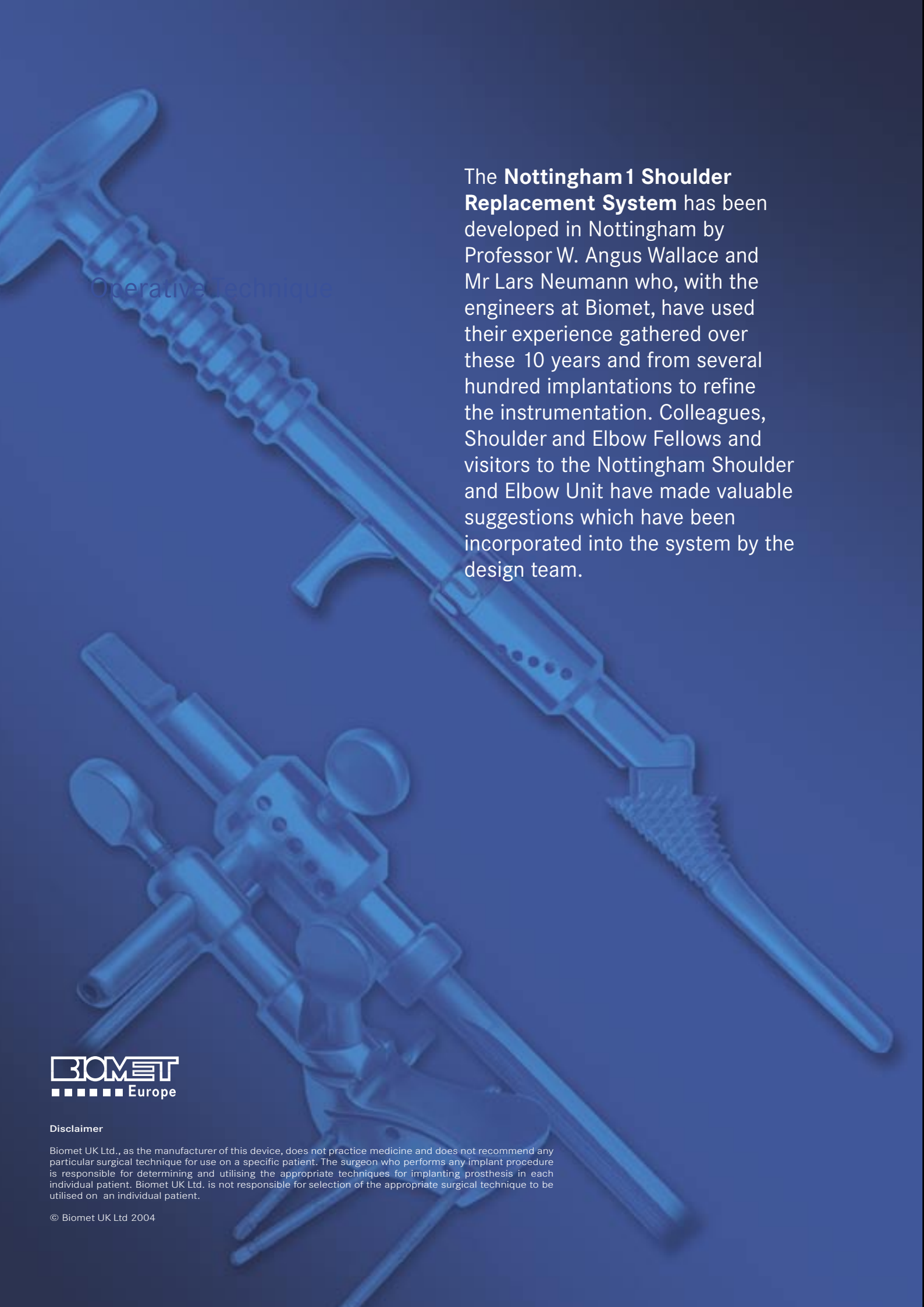
# the Nottingham shoulder

Spine Trauma BioMaterials Ce Joint Replacement

haptic instrumentation

operative technique

BIOMET Europe



# Operative Technique

The **Nottingham 1 Shoulder Replacement System** has been developed in Nottingham by Professor W. Angus Wallace and Mr Lars Neumann who, with the engineers at Biomet, have used their experience gathered over these 10 years and from several hundred implantations to refine the instrumentation. Colleagues, Shoulder and Elbow Fellows and visitors to the Nottingham Shoulder and Elbow Unit have made valuable suggestions which have been incorporated into the system by the design team.

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# The Nottingham 1 Arthroplasty System
# The Nottingham Philosophy

The design of the Nottingham Shoulder was conceived in 1991 and was initially based on the Biomodular implant but incorporating new understanding of the anatomy of the proximal humerus, the fixation mechanisms for humeral stems both cemented and uncemented and the fixation of glenoid components.

## 1. DESIGN CONSIDERATIONS OF THE POSTERIOR OFFSET HEAD

The shape of the proximal humerus is more complex than was appreciated before 1990 and it cannot be replaced anatomically with a standard prosthesis in which the stem is in line with the head. In 1991 Roberts et al[1] published the results from a research project designed to identify the exact shape of the proximal humerus. Their paper on "The Geometry of the Humeral Head and Humeral Prosthesis Design" showed that the centre of the humeral head was offset posteriorly by an average of 4.7mm (4.0-5.5mm (95%CI)). Boileau and Walch[2] subsequently validated these findings. The Nottingham shoulder was the first implant in the world to make use of this new anatomical knowledge, the first offset head in the world was implanted in Nottingham in May 1991.

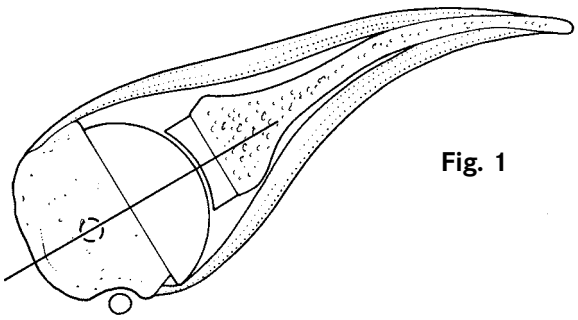


**Fig. 1**

Earlier shoulder systems developed without a posterior offset facility compensate for this deficiency by using a larger head size or neck length and by increasing the retroversion of the humeral component when inserted. However, this may result in the centre of rotation being positioned more laterally, more anteriorly or more distally, resulting in some imbalance in the lengths of the anterior and posterior rotator cuff tendons (Fig. 1). By using a posteriorly offset head placed in a more anatomical position both the joint line and the centre of rotation are returned to a more normal position, the anatomical neck osteotomy is more anatomically covered by the prosthesis and the rotator cuff can be better balanced (Fig.2).

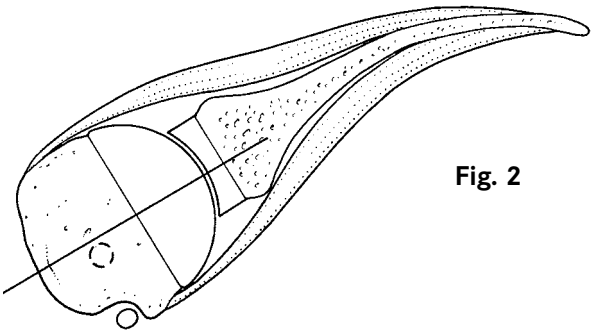


**Fig. 2**

In order to position the trial head in its ideal position of offset (one of 8 options) and reproduce that position with the final implant, we initially developed a pin system within the morse taper. This pin system has been changed to a more robust design with improved instrumentation to control the head position during implantation.

The indexing system (both old and new) are not responsible for the final fixation of the head on the stem – this occurs as a result of impacting the Morse taper and producing what is effectively a cold weld of the two components.

The 6 head sizes have been chosen to provide increments in neck length of 2.5mm from 15mm to 27.5mm. The 15mm head has a 3mm offset whereas all the others have a 5mm offset.

The head diameters are all 48mm in order to ensure a conforming articulation with minimal polyethylene wear of the glenoid bearing which is also 48mm diameter.

We have chosen cobalt chrome for the humeral head as it is currently the most successful metal for artificial joint articulation

## 2. DESIGN CONSIDERATIONS OF THE HUMERAL STEM

The Humeral stem was initially based on the Biomodular stem but has been altered in a number of ways. Our aim was always to develop a universal stem to cater for fractures as well as elective shoulder replacement. We believe that cobalt chrome is a superior material for the stem than titanium alloy. By making the distal stem fluted and polished we are able to use the stem either with or without cement and our experience over 10 years has confirmed that with uncemented use aseptic loosening is extremely uncommon. When it has been necessary to revise stems for malposition or periprosthetic fractures we have confirmed that removing the Nottingham stem is relatively easy, while our experience of revising the Biomodular stem is often of a nightmare scenario due to the excessive biological fixation along the whole length of the roughened stem. We have introduced the following:-

**An** indexing system within the neck to allow reproducible positioning of trial and final implant

A reverse morse taper to improve access to the glenoid not only during primary surgery but more importantly at revision surgery.

A limited proximal porous coating which has been so effective over the past 10 years that no HA coating has been considered necessary.

A small tear drop shaped flange allows good positioning of the prosthesis in bone but also allows

access to the proximal stem with a small osteotome to break the bone ingrowth area when revision is required.

The original implant ha a one large dorsal fin for tuberosity fixation but in the new stem we have redesigned this area to provide two low profile antero-lateral and postero-lateral fins which will improve the ease of fixation of the tuberosities particularly for fracture work. In addition the bulk of the new stem has been reduced to encourage better bony union of the tuberosities in fracture cases, around the proximal stem of the implant.

The polished distal stem ensures relatively easy extraction of the stem from the cement or the bone once the proximal bone ingrowth has been released with an osteotome.

The stem flutes improve rotational stability both **in** cemented and uncemented use.

## 3. DESIGN CONSIDERATIONS OF THE GLENOID COMPONENT

**a) The Uncemented Glenoid**

We developed the uncemented glenoid in order to address the recognised problem of loosening of the cemented glenoid – particularly the metal backed cemented components. It was our belief that if we could create a good biological fixation, then long-term loosening would become rare. This has been confirmed with our recent 12 year follow up studies of the survival of the uncemented glenoid components. We wanted an immediate press fit stability with the conical peg, reinforced by the use of 2 cancellous type screws. The polyethylene liner has full conformity with all the head components and as a result of the flat baseplate design the polyethylene rim is considerably thicker than the thinnest central part. For instance, for the 3mm component the peripheral rim is around 7mm thick. The conformity protects the humeral head from upward migration in patients with weak superior rotator cuffs and provides added stability to the shoulder in the AP plane. The prosthesis includes :-

A 3 mm thick baseplate which incorporates a plasma sprayed HA-coated porous surface with 400µ pores to designed maximise the bone ingrowth.

A baseplate which has a conical, porous coated central peg, that provides primary stability through press fit and a large porous surface area for bone

ingrowth. At revision surgery the central peg and the adjacent baseplate area has been found to be the predominant area of dense bony ingrowth.

Two holes - superior and inferior to the peg for low profile screws providing additional primary stability of the implant.

A polyethylene liner with a minimum thickness of polyethylene in its centre of 3mm for the thin bearing and 5mm for the thick bearing. The Radius of curvature of the liner is equal to that of the humeral head implants (48 mm diameter). This confirming design minimizes wear and particular disease. Conforming implants have been shown to have equal stability and mobility to non-conforming implants (Harriman JBJS 1995)

A unique double locking mechanism anchors the polyethylene liner firmly to the base plate.

**b) The Cemented Glenoid**

This has been provided in the set for those surgeons who are more comfortable using a conventional implant for the glenoid.

All polyethylene with a metal marker wire.

Three pegs designed for good cement fixation and rotational control.

A non-conforming design, with a minimum polyethylene thickness of 4mm.

## THE NOTTINGHAM HAPTIC INSTRUMENT SET

The Nottingham total shoulder replacement system has been implanted for over 10 years and the clinical results have demonstrated the efficacy of the system.

The instrumentation originally supplied with the Nottingham system provided the surgeon with a simple and relatively reliable method of implantation.

Haptic means “relating to the sense of touch” and these new instruments have been developed to allow the surgeon to implant the Nottingham system with a greater degree of accuracy and reproducibility through better tactile feedback. Their attractive design is combined with practical elements such as ease of cleaning and multifunctional components.

An additional benefit is the reduced weight of the instrument set and the limitation of potential microbial traps in all instruments. For example, the modular rasp inserter/extractor is designed to act also as the definitive prosthesis impactor and additions to the handle are used to convert the handle into an extraction tool for revision surgery.

## SURGICAL TECHNIQUE FOR IMPLANTATION OF THE NOTTINGHAM SHOULDER

### PRE-OPERATIVE PREPARATION AND PATIENT POSITIONING

Pre-operative prophylactic antibiotics should be given according to the hospital protocol.

The axilla should NOT be shaved but may be clipped no more than 6 hours before the operation.

The patient should be placed in a semi sitting or beach chair position at about 45 to 60 degrees of head-up tilt. It is essential to have the patient close to the edge of the table to permit extension of the shoulder during surgery to facilitate access for instruments and the humeral component when it is inserted into the humeral medullary canal. The shoulder blade may be stabilised by placing a small (500ml) plastic infusion bag or a sand bag under the medial border of the scapula (Fig. 3). Routine antiseptic preparation of the skin of the whole of the arm is carried out using a povidone iodine/alcohol based prep. The preparation is continued as far proximally as the ear and as far distally as the breast. The preparation should also be carried out as far medially as the midline anteriorly and as far as the infusion bag or sandbag posteriorly. The forearm and arm should be covered with a sterile stockinette and either an upper limb isolation drape or a “U” drape should be used to provide a safe sterile field. An adhesive plastic sterile drape (Steridrape® or Ioban®) is then applied to seal the skin surface and will also ensure that the drapes do not “migrate” during the operation.

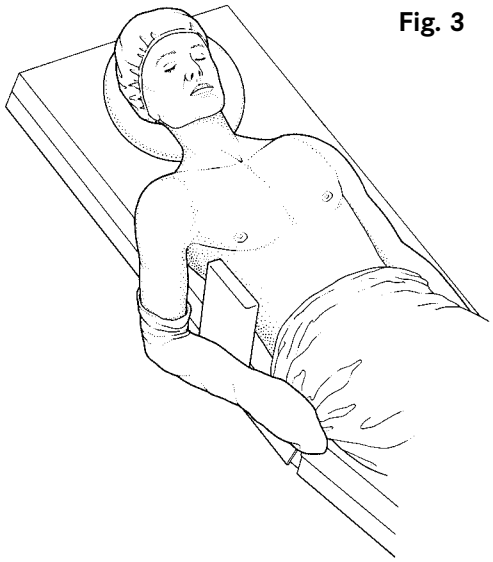


**Fig. 3**

The surgical approaches to the shoulder have been clearly described in detail by Neumann and Almeida Filho (EFORT Treatise SS-160-A-10)

# THE SURGICAL APPROACH FOR HEMIARTHROPLASTY

We recommend as the standard approach for hemiarthroplasty, the long anterior delto-pectoral approach (modified from Neer, Watson and Stanton, 1982[3]). This approach provides an exposure of the front of the gleno-humeral joint, the upper humeral shaft and the humeral head, but limited access to the glenoid.

## INCISION

A 15cm incision is made from just below the clavicle down across the tip of the coracoid and continued in a straight line to the anterior border of the insertion of the deltoid (Fig. 4).

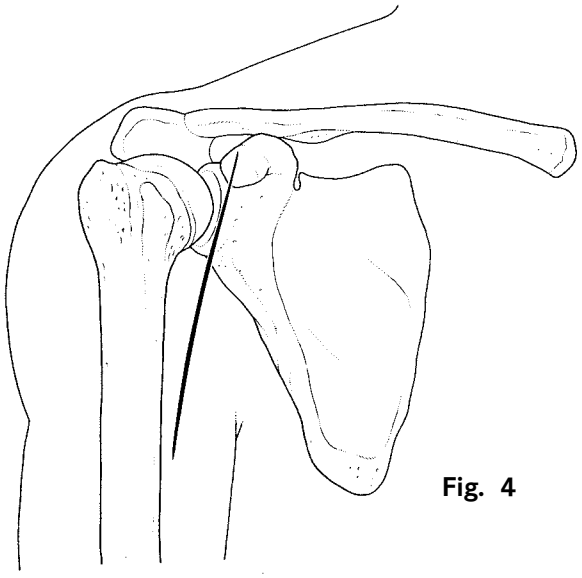


**Fig. 4**

## PRIMARY DISSECTION

The cephalic vein is mobilised by appropriate cauterisation of its lateral tributaries in the deltopectoral groove. The vein is then retracted medially and the deltoid is retracted laterally. The arm is abducted 40° to 60° and may be rested on a suitably draped Mayo table, or arm board. The clavipectoral fascia is incised. The subacromial space is cleared and a broad elevator is placed beneath the acromion as a retractor. At this stage an improved exposure can be obtained by dividing the proximal 2cm of the insertion of pectoralis major.

The shoulder is flexed and externally rotated to facilitate coagulation of the anterior circumflex humeral vessels. It is very important at this stage to insert stay sutures into the subscapularis muscle to control retraction, to manipulate the tendon during mobilization and release of the soft tissues and to protect the brachial plexus which lies quite close, only 2 to 3cm's, medialy. In the original description the tendon and the underlying capsule was divided 2cm medial to the bicipital groove (Fig.5). We prefer to osteotomise the lesser tuberosity as described below, as this allows a much stronger re-attachment. If the subscapularis appears tight it can be mobilised by carrying out a capsulotomy along the anterior glenoid rim and releasing the tendon from the anterior scapula by blunt dissection with a finger as an elevator. We also detach the coraco-humeral ligament from the ???????? to provide an even better mobilization of the soft tissues.

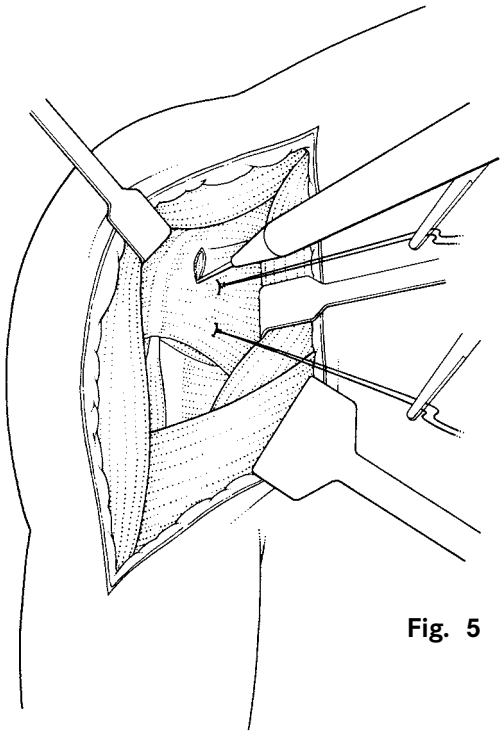


**Fig. 5**

During the whole procedure it is important to protect

the axillary nerve with a blunt elevator where it passes through the quadrilateral space. The glenohumeral joint may now be dislocated anteriorly by external rotation and extension, allowing a full exposure of the humeral head and neck.

The surgical technique for bone resection, implantation and wound closure is described below.

# THE SURGICAL APPROACH FOR TOTAL SHOULDER ARTHROPLASTY

The Modified Anterior Extensile Approach (Redfern, Wallace and Beddow, 1989[4]).

This approach allows a truly wide or extensile exposure from the top and front of the shoulder, providing excellent access to the glenohumeral joint. It provides particularly good access to the face of the glenoid and to the humeral head (including the postero-superior aspect of the head), the subacromial region and the humeral neck distally as far as the insertion of deltoid. It also results in better protection of the leading edge of the deltoid muscle which in the conventional approaches, may be damaged by retraction.

An incision 12 cm long starts 2 cm above the clavicle and passes vertically down across the tip of the coracoid. Distally it extends to the level of, and just lateral to the anterior axillary fold (Fig. 6).

## APPROACH

The cephalic vein is located distally in the deltopectoral groove. In this approach it has to the dissected medially, ligating or cauterising its lateral tributaries. If bleeding is bothersome the vein may have to be ligated at the top and bottom of its exposed section. The lateral third of the clavicle is now exposed and the acromioclavicular joint identified using a needle to probe its joint space. The periosteum lying over the lateral third of the clavicle is divided longitudinally retaining the muscular attachments of the deltoid below and the trapezius above. Using an oscillating saw with a small blade and cutting downwards, a thin sliver of bone, no more than one third of the A-P width of the clavicle is carried out. The clavicle can, in some patients, be very thin at the medial end of the osteotomy, and can fracture if the osteotomy is too aggressive.

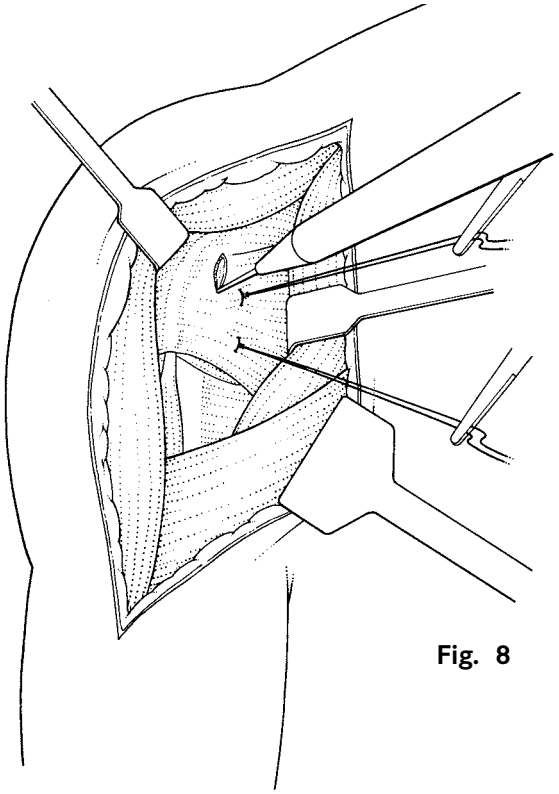


**Fig. 8**

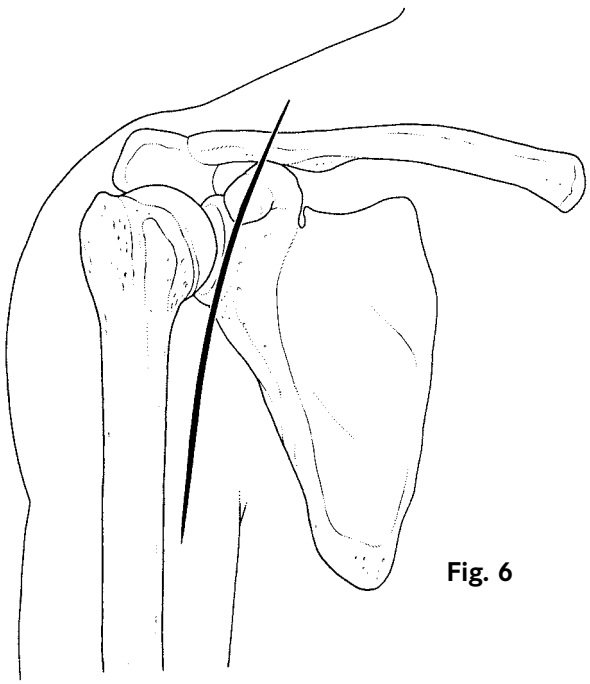


**Fig. 6**

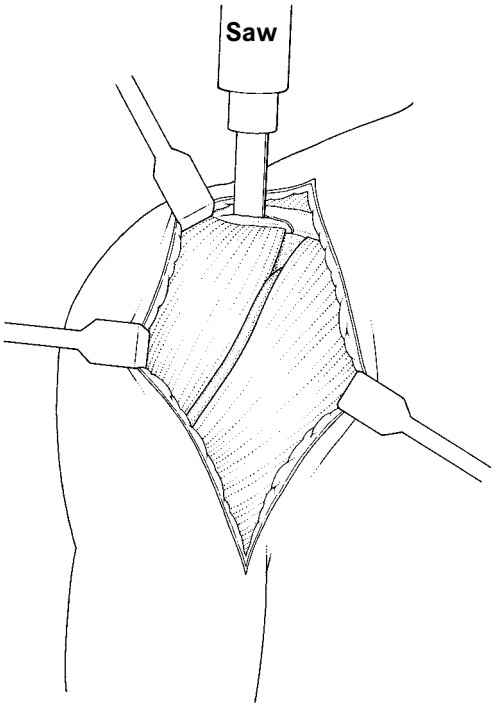
The osteotomy extends along the anterior edge of the lateral end of the clavicle at the AC joint, to the medial border of the deltoid muscle origin. The saw cut must be gently curved, following the contour of the clavicle (Fig.7) and particular care should be taken to avoid a box shaped cut which will create a stress riser which might result in a fracture of the clavicle. The whole of the clavicular attachment of the deltoid will remain firmly attached to the separated bony sliver. At completion of the osteotomy the sliver of bone should fall away from the clavicle without any leverage and the clavicular head of the deltoid can then be gently reflected downwards and laterally.

It may be necessary to release a small amount of the anterior part of the coraco-clavicular ligament in order to swing the anterior clavicle fragment forward and there is always a small artery (a branch of the coraco- acromial artery) which needs to be cauterised during this dissection. The rotator cuff may now be exposed by releasing the coraco-acromial ligament from the acromion as close to bone as possible (We recommend that the CA ligament is repaired later if possible, but it may be excised).

The full Nottingham approach to the shoulder (Fig. 8) involves osteotomising the lesser tuberosity from the humeral head. This is preceded by carefully defining the superior border of the subscapularis tendon by opening up the rotator interval from the upper end of the bicipital groove to the base of the coracoid and then by defining its lower margin along which passes a leash of blood vessels.

The long head of biceps tendon is now exposed distal to the bicipital groove to confirm its position. The medial edge of the bicipital groove can now be exposed by using cautery, without exposing the tendon of the long head of the biceps within the groove. The osteotomy is then made with either an oscillating saw or with an osteotome directed towards the centre of the humeral head initially, and subsequently levered to fracture off the lesser tuberosity which is then retracted using stay sutures. Alternatively, instead of osteotomising the lesser tuberosity, the subscapularis can be divided 1-2cm from its insertion and retracted medially as described for the hemiarthroplasty surgical technique.

A recent study has shown that a tenotomy of the subscapularis leads to decreased strength post-operatively and the lesser tuberosity osteotomy is now recommended as a routine (Miller et al, JSES 2003).



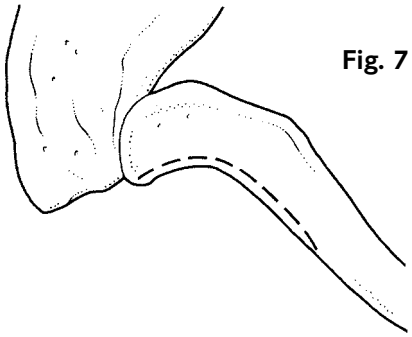



Fig. 7

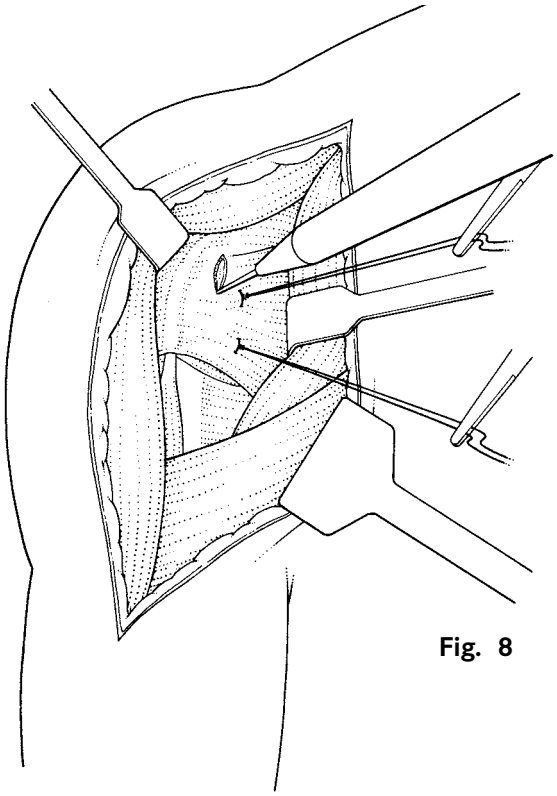


Fig. 8

## INITIAL HUMERAL PREPARATION

Before carrying out the osteotomy of the humeral head, carefully assess and excise the osteophytes, particularly inferiorly, which can be prominent in osteoarthritis and give a false impression of the line of the anatomical neck which is where the osteotomy should be carried out.

The arm should be placed in 90° of external rotation allowing the supraspinatus and long head of biceps to slip posteriorly. Before resection of the head, the long head of biceps tendon should be protected with a periosteal elevator placed under the tendon and over the humeral head. A rectractor in the inferior recess will protect the axillary nerve.

Many anatomical descriptions indicate that the retroversion of the humeral head is 35° to 40° but these observers have not taken into account the posterior offset of the centre of the humeral head in relation to the humeral shaft. Research by Roberts et al[1] has shown that the humeral head is usually in only 25° to 30° of retroversion in relation to the shaft of the humerus, and on average the centre of the humeral head lies about 5 mm posterior to the longitudinal axis of the humerus (Fig.9).

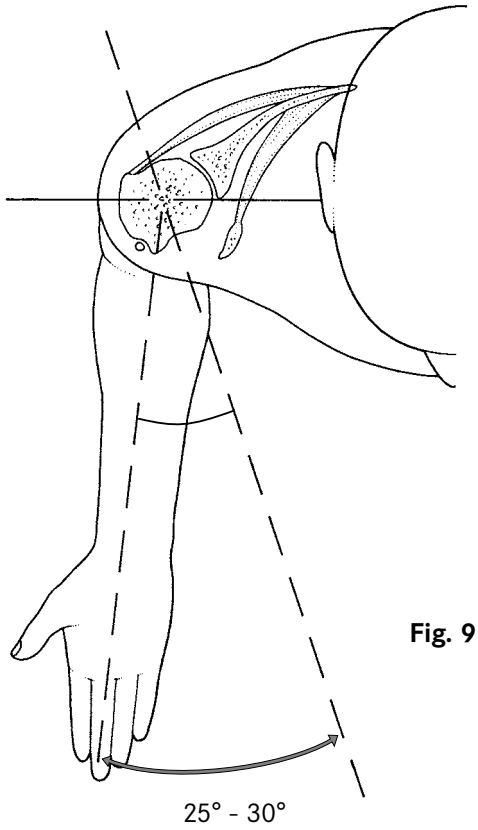



**Fig. 9**

## HUMERAL HEAD RESECTION

The Nottingham1 instruments allow the surgeon the choice of using either an intra-medullary or an extra-medullary guide to ensure the correct angle of osteotomy of the humeral head.

## INTRAMEDULULARY GUIDE

The intramedullary guide references from the centre of the humeral canal, and is attached to one of the humeral canal reamers. You may wish to use a saw or osteotome to remove a sliver of subchondral bone and any remaining cartilage from the apex of the humeral head prior to inserting the reamer. This piece should be only a few millimeters in thickness. The 6mm reamer has a sharp tip to afford an easy entry and is directed through the humeral head into the medullary canal of the humerus (Fig.10).

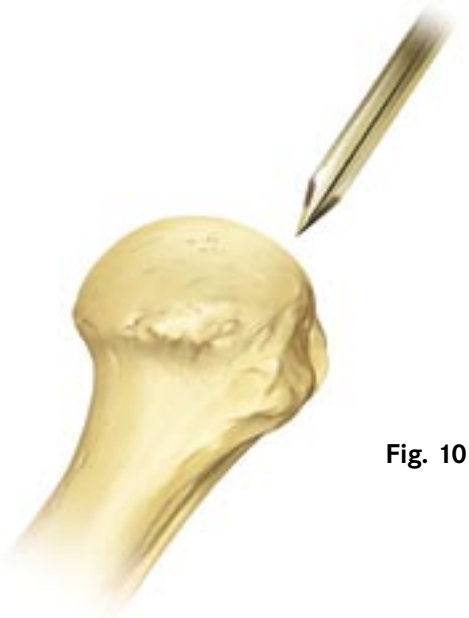


**Fig. 10**

The entry point is usually less than 1cm medial to the most medial insertion of the supraspinatus tendon and just posterior to the bicipital groove. The sequentially larger reamers are then attached to the T-handle, and inserted into the humeral canal right up to the level of the stop ring (Fig. 11).

The surgeon can determine that there is an adequate fill of the canal through the feel of the “Haptic” reamer when there is no toggling movement discernable. The correct axial alignment is achieved when the humeral reamer fits snuggly down the middle of the humeral canal. The T-handle is now detached, and the humeral resection guide assembled and fitted over the shaft of the reamer (Fig.12). The superior end of the humeral cut should lie just medial to the attachment of the supraspinatus tendon to the greater tuberosity so the cutting slot should be positioned just above the level of the rotator cuff insertion.

It is essential that the whole of the rotator cuff attachment to the proximal humerus remains intact after completion of the osteotomy.

The cutting block is slid into contact with the humerus, the amount of retro-version of the humeral cut is determined by the version alignment rod which is inserted into one of the holes in the humeral resection guide. These are marked at 0, 10, 20, 30, 40 and 50 degree intervals. The average retroversion is around 30 degrees (The 30 degree alignment hole is highlighted on the instrument).

The correct retroversion of the cut is achieved by aligning the version rod exactly parallel to the forearm with the elbow at 90 degrees. Once the cutting block has been aligned in all planes it is fixed to the proximal humerus using three drill bits. The cutting block (Fig.13) has both straight and oblique pin holes, it is recommended that 2 straight pin holes from the lower row are used (1), with a single oblique pin to lock the cutting block to the bone. The cutting block can now be unscrewed at its attachment to the vertical arm, detached from the assembly and the reamer can be removed.

The osteotomy is now performed through the slot of the cutting block.

If the initial cut has been too conservative, the oblique pin can be removed and the cutting block repositioned using its higher row of pin holes (Fig.16) this will allow an additional 3mm of bone to be resected.

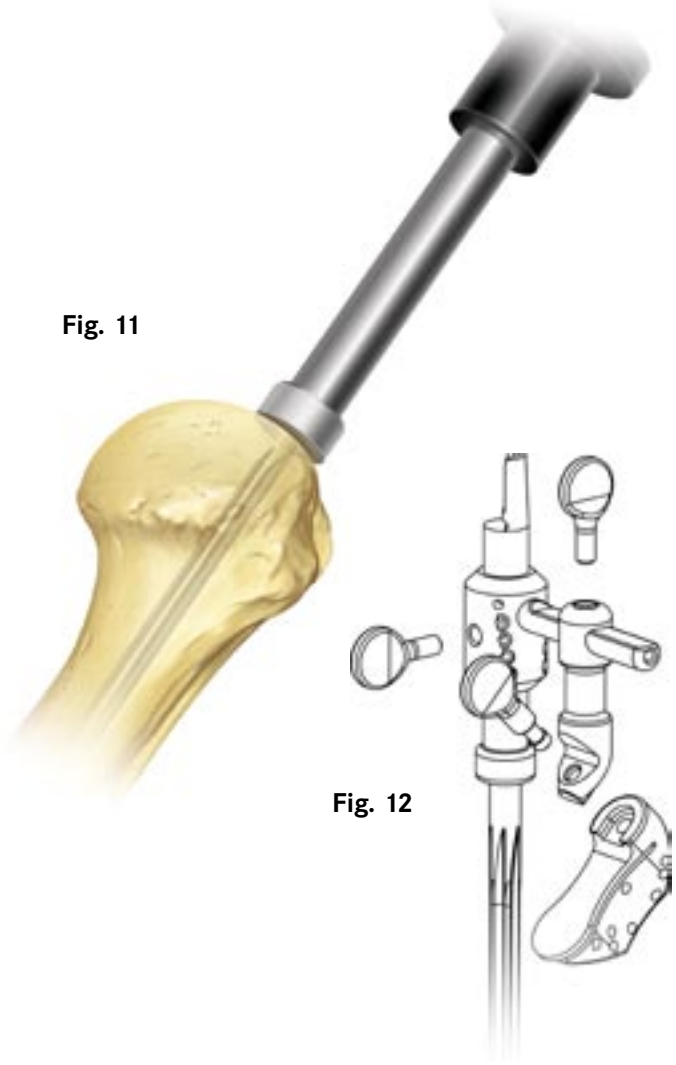


**Fig. 11**

**Fig. 12**

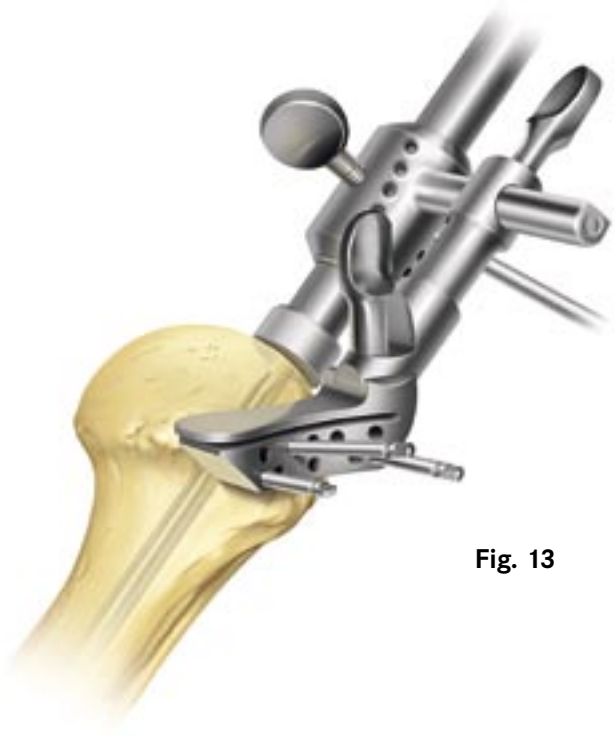


**Fig. 13**

## EXTRAMEDULLARY GUIDE

The universal handle attaches to the left or right side of the extra-medullary cutting guide through one of 3 holes, these holes angle the handle to 20, 30 or 40 degrees, the 30 degree option is usually employed. Lining the universal handle up with the forearm will determine the retro-version of the cut (Fig. 17). The upper end of the cutting flange of the guide should be located just medial to the attachment of the supraspinatus tendon to the greater tuberosity as described above. The osteotomy is performed using an oscillating saw, but care must be taken to ensure that the insertion point of the rotator cuff into the greater tuberosity, both superiorly and posteriorly, is not included in the osteotomy. If there is uncertainty about the level of the cut the osteotomy should be undertaken in 2 slices ("salami" cuts), removing the major part of the articular surface first, re-assessing the cuff insertion and then removing a second slice of bone.

**Fig. 14**

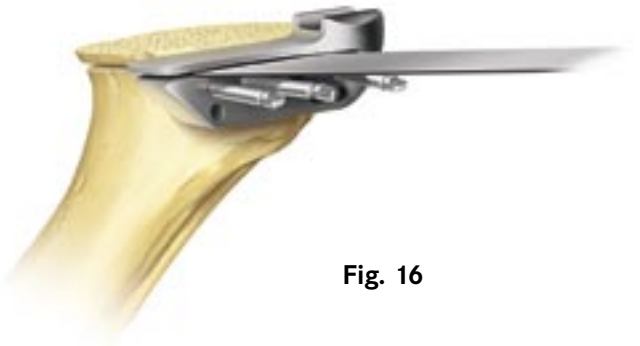


**Fig. 16**

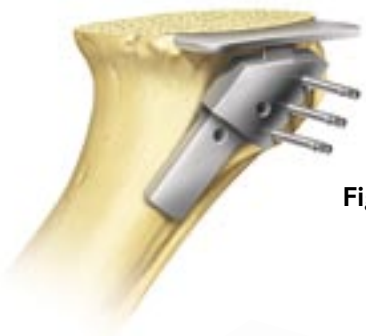
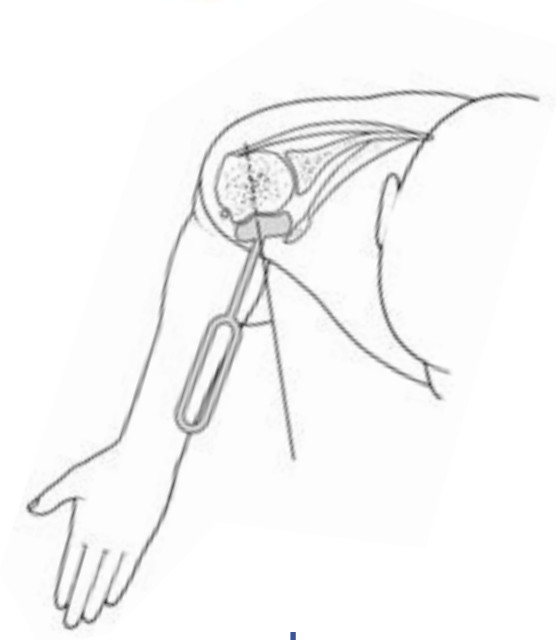


**Fig. 17**

## MOBILISATION OF THE ROTATOR CUFF MUSCLES

This is an important part of the operation, which should be carried out in all cases. It is described in more detail in an EFORT Instructional Course Lecture by Wallace [5], and in his book on Joint Replacement of the Shoulder and Elbow[6]. The rotator cuff tendons and muscles (subscapularis in front and supraspinatus and infraspinatus behind) need to be mobilised both on their superficial, and deep surfaces. Superficially the muscles should be separated from the deltoid above and behind and from the acromion superiorly using both blunt finger dissection and sharp dissection with scissors, but avoiding injury to the suprascapular nerve which lies 2 cm posterior and medial to the face of the glenoid. Then the muscles should be released deeply from the anterior and posterior glenoid rim by sharp dissection with a knife and from the whole of the anterior neck of the scapula usually by blunt dissection with a periosteal elevator. When dissecting inferiorly the Axillary nerve should always be protected with a retractor placed in the inferior recess. This dissection will result in an apparent increase in length of the tendons, particularly subscapularis which may gain as much as 2 to 3 cms as a result of this dissection. At final repair of subscapularis this can result in an improvement of external rotation in the order of 30° or more. The infraspinatus can be mobilised in a similar way but this is required less commonly.

If the intra medullary humeral resection jig has been used the medullary canal has already been prepared



using the sequential reamers. If the extra-medullary option was employed the sequential reamers must now be used, increasing the size until resistance is felt throughout the length of the reamer. It is important to start the reamer well laterally on the cut surface of the proximal humerus and to ream straight down the humerus. There is a tendency in some cases to ream from medial to lateral producing a varus alignment of the stem. This results in "stuffing" of the shoulder joint and the need to use a humeral head which is too narrow with a less anatomical result and possibly a reduction in the final range of movement.

The proximal humeral canal is then shaped using the sequentially sized humeral rasps (Fig. 18). The rasps are attached to the modular handle and are locked on using the trigger to engage the bolt. The rasps should be inserted right down to the level of the last row of teeth and the size of the final rasp corresponds to the largest size of reamer employed. Correct retroversion is maintained by placing the alignment rod in the same position in which the humeral head was cut. The definitive rasp is then used as the trial prosthesis and should be driven home leaving it slightly (approx 3mm) proud of the bone cut. This allows a final "tap home" for the definitive implant if necessary.

If the procedure is to be a hemi-arthroplasty, then the head sizes are trialled as detailed on Page 17.

Fig. 18

## PREPARATION FOR INSERTION OF AN UNCEMENTED GLENOID COMPONENT

The cut surface of the humeral head should be protected by attaching one of the range of surface protectors to the neck of the detached rasp (Fig. 19). The modified Fukuda glenoid retractor is hooked behind the posterior glenoid rim, and by retracting posteriorly it will push the proximal humerus backwards and distally allowing good access directly onto the face of the glenoid. Any soft tissues obscuring the glenoid rim are excised as are any anterior and posterior osteophytes on the glenoid rim.

Fig. 19

The glenoid positional jig attached to the universal handle, is now hooked over the front rim of the glenoid and placed firmly on the glenoid surface. It is important that the anterior flange is checked to be lying along the surface of the anterior glenoid neck to obtain the correct version of the glenoid. The AP alignment of the glenoid jig can also be directed by palpating of the front of the neck of the scapula which may be visualised if the subscapularis is retracted antero-medially.
The pre-operative x-rays are essential for planning the

direction of glenoid reaming – the AP view to guide the inclination of the glenoid and the axial view to guide the degree of version. To ensure the correct rotational alignment, the arrow on the positioning jig should be directed towards the base of the coracoid (Fig.20). A hole is now drilled through the jig into the glenoid using the 5 mm drill bit. It is recommended that initially a very shallow hole is first drilled, the jig is then removed, and the location of the hole is confirmed to be at the centre of the glenoid. The jig is then replaced, and the hole drilled to its full depth if necessary, through the anterior scapular cortex.

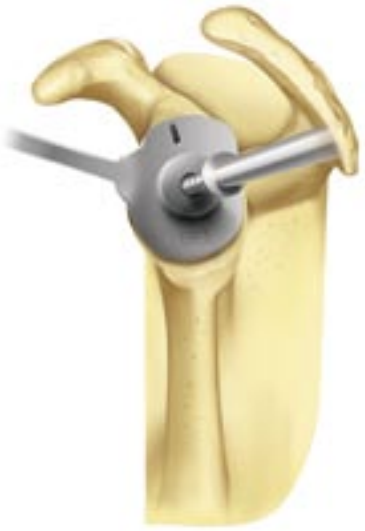


**Fig. 20**

The powered glenoid reamer, using the smaller diameter cutter, is now inserted into the drill hole and a flat recessed face cut is developed centrally in the glenoid (Fig. 21 & 22). This will leave a central boss (which ensures that a maximum depth of 3 mm is reamed from the centre of the glenoid in one reaming process) and a peripheral rim of bone. This allows the surgeon to judge whether the desired version has been achieved and to judge the amount of bone that has been removed.

**Fig. 21**

The exact alignment of the reaming should now be compared with the pre-operative radiographs. The aim is to produce a glenoid which faces either directly laterally or with a slight downward tilt of no more than 5°.

The glenoid should not be prepared in such a way that an upward tilt of the glenoid component is produced as this will result in a reduction of the sub-acromial space because of superior migration of the head and possibly a reduction in the final range of movement of the shoulder. The surgeon again needs to carefully check the AP direction of reaming, being guided by the pre-operative radiographs, and correct any abnormal retroversion or anteversion. If the glenoid needs to be further medialised the central boss should now be removed using the two bladed reamer (fig 22) and the glenoid reamed a second time to the desired depth. After initial preparation with the smaller diameter cutter, the glenoid preparation is finally completed with the larger cutter which removes the peripheral bony rim and finally the two bladed reamer is used to remove the central boss. This will produce a completely flat glenoid face resection, reamed down to bleeding subchondral bone.

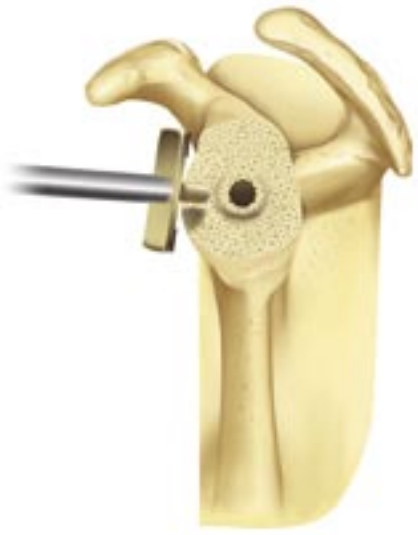


**Fig. 22**

Now the central stem tapered reamer is used to enlarge the central hole to the correct depth and width to accept the tapered peg on the back of the glenoid base plate. The definitive modular glenoid metal tray is now inserted into the prepared area mounted on its inserter, and is impacted with a hammer once the correct rotational position has

been established with its anterior marker pointing to the base of the coracoid (Fig. 24). It is essential to check at this stage that no soft tissue is trapped underneath the base plate, to ensure optimal implant-bone contact.

The superior and inferior drill holes are now created for the screws using the gold plated 2.9 mm drill.

The superior hole is first drilled in a converging direction (with the second screw) and the first screw should be inserted and loosely tightened before drilling the second (inferior) hole and inserting the second screw (Fig. 25). If the screw holes perforate the anterior scapula cortical bone use screws of a length that allows grip in this bone, if the hole does not perforate, use a 30mm screw. Even in rheumatoid patients these screws usually provide very firm fixation (Fig.26).

The trial 3mm polyethylene glenoid insert should be applied to protect the baseplate. Only at the final stage, once the definitive humeral stem has been inserted, should the trial glenoid insert be exchanged for the definitive glenoid insert. In Nottingham the 3mm glenoid insert is used routinely with the 5mm insert reserved for difficult problems and revision cases.

N.B. Should the need occur to revise The Nottingham Glenoid either for loosening, malpositioning or disassociation of the polyethylene bearing from the base plate, it is advisable to consider revising both the base plate and the liner, as it might not be clear whether the locking mechanism on the original glenoid tray is undamaged. If damaged it might not provide a secure hold for the new bearing.

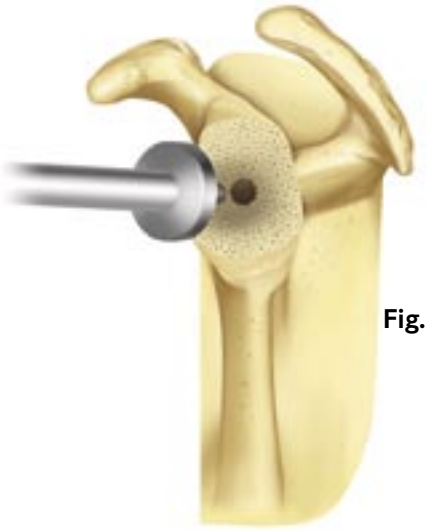


**Fig. 23**

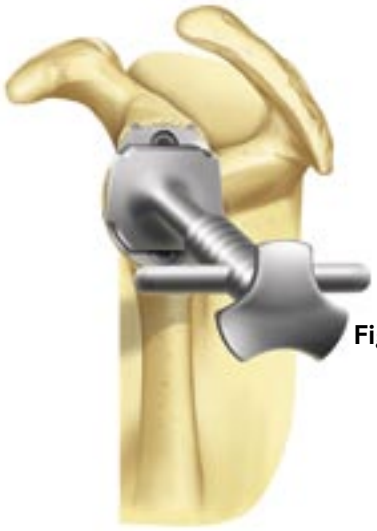


**Fig. 24**

## GLENOID PREPARATION (CEMENTED COMPONENT)

If the surgeon has chosen to use a cemented polyethylene component, the size is determined with the Glenoid template pegs guide. A 3mm hole is drilled through the central hole of the pegged glenoid guide (Fig. 27). The glenoid fossa is then prepared using the glenoid surface rasp (Fig 28). A high speed burr is employed to begin creating the glenoid fin vault. A glenoid fin rasp then enlarges the slot to accept the glenoid fin. Sequential curettes are used to undercut the glenoid vault, in order to accommodate the keel of the polyethylene component, and to allow for better cement fixation (Fig. 29). Prior to cementing the glenoid component, a high speed irrigation lavage system should be utilised to cleanse

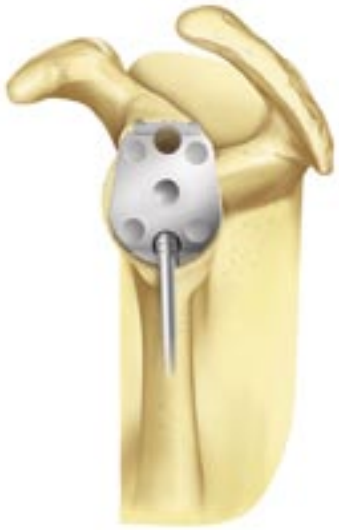


**Fig. 25**

the cortical cancellous surface. This completed, the final polythylene component is now introduced after bone cement has been applied, with digital pressure, to ensure proper fixation. All excess cement is then carefully removed, particularly posterior to the component.

## CHECKING THE POSITION OF THE COMPONENTS AND THE TENSION IN THE ROTATOR CUFF

The modular head trials should now be utilised to confirm proper sizing of the prosthesis. The modular trials are black and have thicknesses of 15, 17.5, 20, 22.5, 25, and 27.5mm. The 15mm head has a 3mm offset, the remainder a 5mm offset **(Fig. 30).**

The size of the trial head which should be used first is best gauged with the surgeon's index finger. The shoulder is initially "reduced" without a trial head and the surgeon's index finger is placed between the top of the stem, (where the morse taper is located) and the glenoid trial component. If the finger can be inserted comfortably the shoulder will accept at least a 20 mm thick head. If not a 17.5mm or 15mm head should be trialled.

The humeral components have an indexing facility to provide an offset, or concentric positions relative to the humeral axis (Fig. 31). The humeral component is placed onto the humeral stem, with the "fork" placed between the head and the stem - this disengages the indexing lock mechanism and allows the head to rotate freely. The head-indexing tool is positioned and with the "fork" in place the humeral head trial can then be rotated using the humeral head positioning forceps to identify the most suitable position for the head to cover the cut surface of the humerus. On palpation, the implant should be flush with the superior and posterior aspects of the cut humerus. When the correct offset has been identified the "fork" and head indexing tool are removed. The trial head is now in place, and the joint can be reduced and both the stability of the implant and the ability to close the subscapularis over the implant with the arm in external rotation can be tested. The joint should be reduced carefully if necessary using the "shoehorn" which prevents the trial bearing dislocating out of the glenoid base plate. If a large (over 25 mm) head is required consider whether it may be preferable to use the 5mm rather than the 3mm glenoid bearing.

**The 5 tests for the final shoulder replacement components.**

1. Humeral head height – Is the height of the humeral

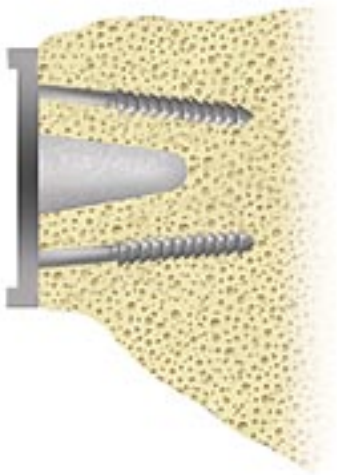


**Fig. 26**

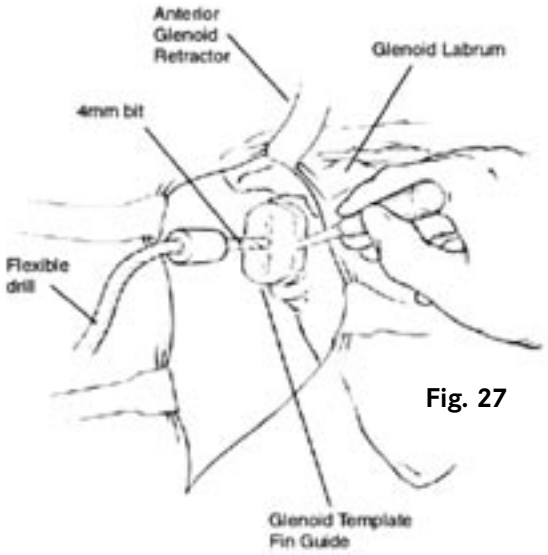



**Fig. 27**

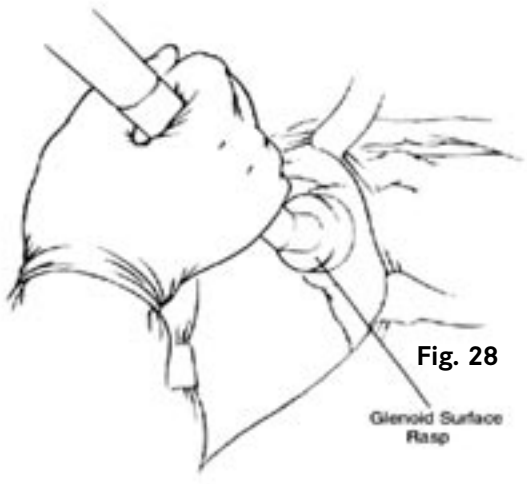



**Fig. 28**

head just above the apex of the greater tuberosity (by no more than 4mm). Impingement may occur if the head is too low or the supraspinatus tendon may be damaged if the head is too high.

2. Posterior offset – Is the back of the prosthetic head flush with the back of the remaining posterior peripheral edge of the humeral head? If there is a ridge caused by a protruding edge of the prosthesis, cuff damage may occur later.

3. The subacromial space - Is there a gap between the supraspinatus and the acromion and can you insert your little finger into the gap? If not you may need to revise the position of the glenoid or carry out an acromioplasty.

4. The posterior cuff tightness – Can you internally rotate the arm such that the back of the hand can reach the ipsilateral buttock? If not consider a smaller humeral head to balance the cuff tightness.

5. The anterior cuff tightness – Can you externally rotate the shoulder to at least 40 degrees with the lesser tuberosity still reduced? If not consider a smaller humeral head or a further anterior soft tissue release.

Only once these 5 tests are satisfactory should you proceed to definitive insertion of the prosthetic components. Williams (JBJS 2001 Vol 10) showed that components inserted with less than 4mm mismatch of offset would allow the optimal range of movement. Of course, ideally the implant should match the anatomy accurately, but some limited mismatch is acceptable.

## FINAL FIXATION OF THE HUMERAL STEM

If the humeral component is being cemented a stem the same size as the final humeral rasp should be selected as the flute design allows an appropriate cement mantle. Cement around the proximal porous coated portion of the stem should be avoided. If there is any bone defect here use autograft from the excised head to fill any gaps in order to obtain a biological proximal fixation. For a press fit implantation, a stem is selected corresponding to the last humeral shaft rasp used.

Whether the humeral stem is inserted with or without cement, it is now attached to the impactor by fitting it onto the instrument's Morse taper and then screwing the locking screw into the hole on the face of the

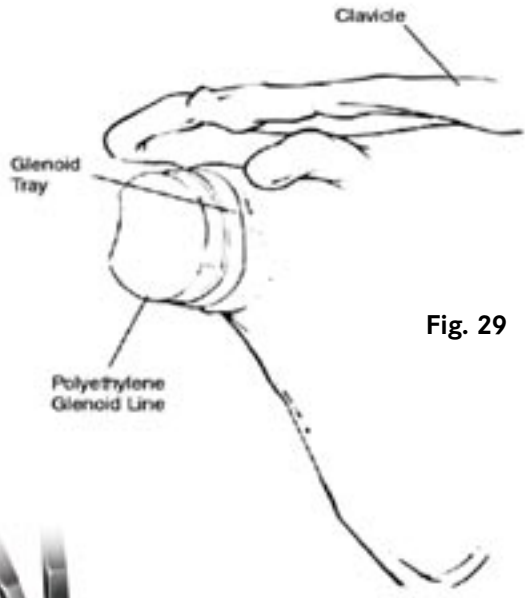



**Fig. 29**

**Fig. 30**

**Fig. 31**

implant collar through the recess on the anterior face of the universal impactor. The retroversion guide is used to position the implant at the same retroversion as was used for the humeral head cuts and medullary canal rasping. The prosthesis is now driven into the humeral shaft until it lies at the appropriate level as defined by the trial stem position identified above (Fig.32)


**Fig. 32**

## APPLICATION OF THE UNCEMENTED GLENOID BEARING.

The glenoid bearing trial (black) is now exchanged for the definitive glenoid bearing (white). Usually 3mm thick, this is carefully positioned onto the base plate using the introducer/impactor and impacted with one blow of the hammer on the impactor. Always check that the bearing is fully seated onto the bearing tray and there is no gap between the bearing and the base plate (Fig. 33).

**Fig. 33**

## HUMERAL HEAD INSERTION

Prior to insertion of the final head component we recommend a second trial reduction with the selected trial head and the 5 tests (as described above) should now be repeated. Once the appropriate head component size and rotation has been established, care should be taken to thoroughly clean and dry both the male and the female parts of the morse taper prior to the attachment of the head to the stem. Foam tipped cleaning buds are provided with the head components for this purpose. The definitive humeral head component should now be attached to its suction cup introducer (Fig. 34) and aligned in the same orientation as the trial head.

During positioning, the indexing location guide is disengaged by placing the fork under the head components. There is an additional small indexing tool which can be inserted into the holes on the periphery of the head component at this stage to help position the head correctly. When satisfactorily positioned the head component is impacted with the impactor utilizing a firm blow in order to fully engage the morse taper. The fixation of the morse taper is checked using a lever and the shoulder is reduced, if necessary with the help of the shoe horn.

**Fig. 34**

## CLOSURE

After reduction of the shoulder replacement the whole joint should be irrigated with saline. Next, the lesser tuberosity is reattached to the humerus. In patients where the long head of biceps tendon has been damaged or is degenerate a tenotomy and tenodesis can be carried out. We use two or three intraosseous double loops of Ethibond No. 2 sutures around the bicipital groove and the lesser tuberosity fragment. Cheese wiring of the sutures through the bone using this technique does not occur. This reattachment allows rehabilitation to begin on the first post-operative day, even including external rotation. The lateral part of the rotator interval can be closed with a No 1 Vicryl suture at the bicipital groove but only as far medially as the tip of the coracoid. If closed any further shoulder movement may be restricted (the rotator interval is an interval for a very good reason - it allows the rotator cuff tendons to move, on the outside of the coracoid).

The coraco-acromial ligament is now re-attached to the front edge of the acromion or the undersurface of the deltoid using a No 1 Vicryl suture. The clavicle fragment is brought back to its anatomical position and using three double cerclage No 1 Vicryl surures on a blunt needle around the clavicle it is anchored back. This repair allows full mobilisation immediately after surgery, without the need to protect the deltiod. We recommend one vacuum type drain to be inserted deep to the deltoid in case of some post-operative oozing. This drain is removed at 24 hours. The deltoid interval is closed with three loose vicryl sutures. A significant cosmetic defect can be the result if the muscles are not opposed. Finally skin closure can be carried out according to the surgeon's own preference. In Nottingham we use subcutaneous Vicryl for the fat and a subcuticular No 2-0 Prolene suture for this which gives a very nice cosmetic result. The patient is placed in a Polysling or broad arm sling in the operating theatre and returned to the ward.

## POST OPERATIVE CARE

At the end of the operation the surgeon should measure the amount of external rotation on the operating table. Knowing this, he can decide on the amount of external rotation to be allowed during the rehabilitation period. The patient is immobilized in a sling for 24 hours. Active motion of the hand and elbow are encouraged immediately postoperatively and gentle passive range of motion is begun from

the first or second postoperative day. If there are concerns over the strength of the fixation of the lesser tuberosity, or repair of subscapularis a more conservative mobilisation regime can be used.

Generally active assisted elevation can be initiated 2 to 3 days after surgery.

**Please Note:** A Biomet Shoulder Systems Rehabilitation Kit is available to facilitate the rehabilitation programme. This includes a fully illustrated guide to all excercises, a video and pulley system.

# NOTTINGHAM SHOULDER CATALOGUE LISTINGS

## IMPLANTS

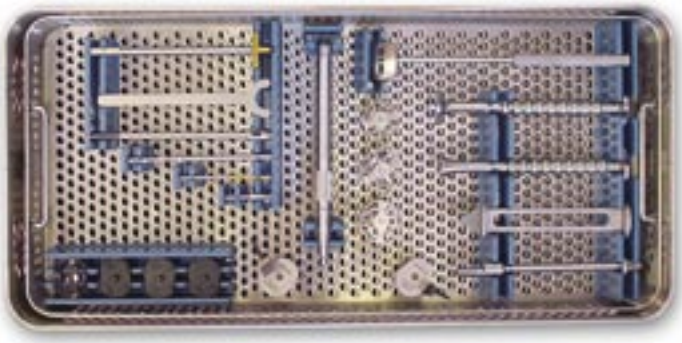
| | | | |
|---|---|---|---|
| 114100 | NOTTINGHAM SHOULDER GLENOID TRAY | | |
| 114101 | NOTTINGHAM SHOULDER GLENOID BEARING | | 3mm |
| 114103 | NOTTINGHAM SHOULDER GLENOID BEARING | | 5mm |
| 114106 | HUMERAL STEM | 6mm | |
| 114108 | HUMERAL STEM | 8mm | |
| 114110 | HUMERAL STEM | 10mm | |
| 114112 | HUMERAL STEM | 12mm | |
| 114111 | Revision Humeral Stem | | 10mm x 190mm |
| 113760 | HUMERAL HEAD | 48mm x 15mm | |
| 114124 | HUMERAL HEAD | 48mm x 17.5mm | |
| 114143 | HUMERAL HEAD | 48mm x 20mm | |
| 114125 | HUMERAL HEAD | 48mm x 22.5mm | |
| 114126 | HUMERAL HEAD | 48mm x 25mm | |
| 114127 | HUMERAL HEAD | 48mm x 27.5mm | |
| 113843 | GLENOID LP SCREW | | 5mm x 15mm |
| 113844 | GLENOID LP SCREW | | 5mm x 20mm |
| 113845 | GLENOID LP SCREW | | 5mm x 25mm |
| 113846 | GLENOID LP SCREW | | 5mm x 30mm |
| 113847 | GLENOID LP SCREW | | 5mm x 35mm |
| 113848 | GLENOID LP SCREW | | 5mm x 40m |

# NOTTINGHAM SHOULDER CATALOGUE LISTINGS

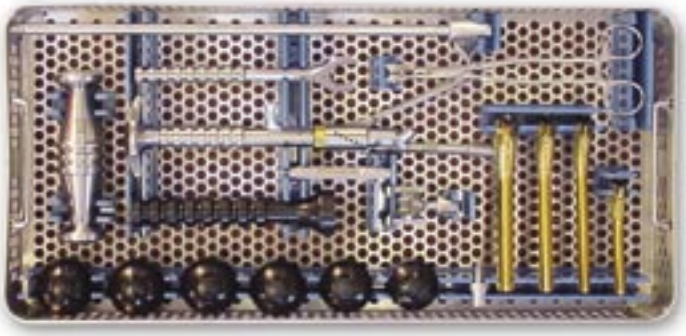
| Nottingham Haptic Instrument Set | |
|---|---|
| ITEM | Cat No |
| **Nottingham Shoulder Instrument Case c/w Instruments** | **402434** |
| Nottingham Shoulder Head Removal Instrument | 402462 |
| Nottingham Shoulder Glenoid Tray Impactor | 402464 |
| Nottingham Shoulder Glenoid Bearing Impactor | 402461 |
| Humeral Head Impactor | 402465 |
| Nottingham Shoulder Quick Release Straight Handle | 402459 |
| Nottingham Shoulder Slide Hammer Shaft Assembly | 402456 |
| Nottingham Shoulder Slide Hammer Weight | 402418 |
| Nottingham Shoulder Humeral Stem Extraction Clamp (R2D2) | 402463 |
| Nottingham Shoulder Humeral Stem Inserter/Extractor | 402415 |
| Nottingham Shoulder IM Resection Jig Cutting Block | 402458 |
| Nottingham Shoulder IM Resection Jig Thumb Screw, quantity 2 | 402425 |
| Nottingham Shoulder IM ResectionJig Cutting Block Connector | 402426 |
| Nottingham Shoulder IM Resection Jig Cutting Block Connector Screw | 402427 |
| Nottingham Shoulder IM Resection Jig Barrel/Arm Assembly | 402424 |
| Nottingham Shoulder Extramedullary Neck Resection Guide, LH | 402419 |
| Nottingham Shoulder Extramedullary Neck Resection Guide, RH | 402420 |
| Nottingham Shoulder Quick Release T Handle | 402416 |
| Nottingham Shoulder Alignment Rod | 402455 |
| Nottingham Shoulder Glenoid Positioner LH | 402454 |
| Nottingham Shoulder Glenoid Positioner RH | 402453 |
| Nottingham Shoulder Glenoid Peg Reamer | 402450 |
| Nottingham Shoulder Glenoid Screwdriver Bit | 402452 |
| Nottingham Shoulder Trial Humeral Head Positioning Tool (From Copeland kit) | 402327 |
| Nottingham Shoulder Instrument Case | 402433 |
| Nottingham Shoulder Tapped Stem Insertion Screw | 402428 |
| Nottingham Shoulder Hex Driver | 402421 |
| Nottingham Shoulder Drill Bit Extension Rod | 402422 |
| Nottingham Shoulder Glenoid Step Removal Reamer | 402423 |
| Nottingham Shoulder Humeral Stem Reamers (sizes 6,8,10,12) | 402435/36/37/38 |
| Nottingham Shoulder Quick Release Drill Bit 3.0mm | 402429 |
| Nottingham Shoulder Glenoid Retractor (using the one from the old kit) | 400299 |
| Nottingham Shoulder Trial Glenoid Bearing 3mm (using the one from the old kit) | 400241 |
| Nottingham Shoulder Trial Glenoid Bearing 4mm (using the one from the old kit) | 400242 |
| Nottingham Shoulder Trial Glenoid Bearing 5mm (using the one from the old kit) | 400243 |
| Nottingham Shoulder Face Cutter "C" Spanner (using the one from the old kit) | 400476 |
| Nottingham Shoulder Offset Head Alignment Tool (using the one from the old kit) | 400329 |
| Bio-Modular Glenoid Trial (using the one from the old kit) | 406575 |
| Bio-Modular Drill Guide Template (using the one from the old kit) | 406591 |
| Bio-Modular Glenoid Fin Broach (using the one from the old kit) | 406587 |
| Nottingham Shoulder 5mm Glenoid Drill (using the one from the old kit) | 400282 |
| Bio-Modular Choice Glenoid Reamer Medium (from new Biomod kit) | 406633 |
| 3.2mm Diameter Quick-Release Drill, quantity 4 | 32-467619 |
| Nottingham Shoulder Humeral Stem Rasps (sizes 6,8,10,12) (PO) | 402446/47/48/49 |
| Nottingham Shoulder Trial Humeral Heads (PO) | 402440/41/42/43/44/45 |
| Nottingham Shoulder Small Glenoid Face Cutter (PO) | 402430 |
| Nottingham Shoulder Large Glenoid Face Cutter (PO) | 402432 |
| Angled Glenoid Reamer Handle (PO) | 402431 |

# INSTANT TRAY LAYOUT

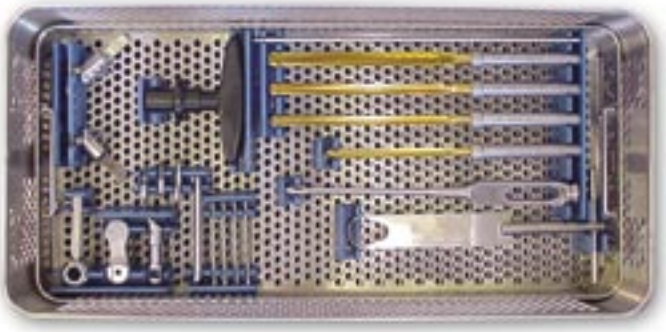
**Glenoid Tray**



**Top Humeral Tray**



**Bottom Humeral Tray**



## The System Comprises:

4 Humeral Stem sizes (6, 8, 10 & 12 mm) for use with and without bone cement
Modular Heads of 48mm spherical diameter in 6 head heights (15, 17.5, 20, 22.5, 25 & 27.5 mm)
Cementless and Cemented Glenoid components.

The Nottingham Shoulder Arthroplasty System has been designed for implantation entirely without cement using a low profile screw anchored porous coated tray with the option of 2 liners, 3 and 5mm. A cemented glenoid option is also available.

A comprehensive educational package is available including a videotape and DVD/CD and illustrated surgical technique and Postoperative rehabilitation guidelines.

the Nottingham 1 shoulder

# Notes

# Notes

the Nottingham shoulder operative technique

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FLU 091 09/04