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RESEARCH ARTICLE

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Indications to Paul Grammont Prosthesis

Saccomanni Bernardino

Viale Regina Margherita, Altamura (bari), Italy

ABSTRACT

The outcome of an anatomical shoulder replacement depends on an intact rotator cuff. In 1981 Grammont designed a novel large-head reverse shoulder replacement for patients with cuff deficiency. Such has been the success of this replacement that it has led to a rapid expansion of the indications. We performed a systematic review of the literature to evaluate the functional outcome of each indication for the reverse shoulder replacement. Secondary outcome measures of range of movement, pain scores and complication rates are also presented.IN this review, there are not figures and outcomes.

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Introduction

The modern reverse shoulder replacement (RSR) can offer a surgical option for the management of arthritis of the shoulder that would be precluded by a conventional design [1,2]. The success of the prosthesis has led to expansion of the indications from cuff tear arthropathy to any disease about the shoulder where cuff function is deficient. The prosthesis has also been a financial success, leading many companies to introduce their own version with small changes to the original design, such as the Aequalis Reversed Shoulder (Tornier, Saint- Ismier, France) and the SMR Shoulder (Lima, Udine, Italy). As a result of the expansion of the indications for RSR, the procedure now accounts for over a large proportion of all shoulder replacements performed in mainland Europe [3-5].

This article will look at the benefits and risks of RSR for each indication. The original indication for RSR was cuff tear arthropathy. The results obtained for new indications were compared with those for cuff tear arthropathy, with a primary outcome measure as a functional score. Secondary outcome measures were range of movement, rate of complications and pain scores. In order to allow for comparison between groups, the outcome scores, complication rates and pain scores have been converted to percentages.

A systematic review of the English-language literature was undertaken; the keywords used were shoulder and reverse; arthroplasty; inverse or delta. Medline, Embase, NHS Evidence Information for Health, the Biomed Central register and the Cochrane Database were all searched [6-10]. Inclusion criteria included studies presenting new data from more than one case and where functional outcome scores were reported. Exclusion criteria included studies that had a mixture of surgical techniques presented as a single group. Further exclusion criteria for the cuff tear arthropathy group were studies published more than five years ago; studies with less than 50 patients and those from more than one centre. We identified 22 papers, which were reviewed in full. The complications of RSR for any indication were discussed and specific issues for each pathology highlighted. All the abstracts were reviewed independently by two of the authors (CDS, PG) to identify studies for full review and the bibliographies of these articles were also reviewed for additional studies. Any disagreements with regards to inclusion and exclusion were resolved by discussion with the senior author (TDB).

Cuff tear arthropathy

The modern concept of cuff tear arthropathy is the combination of arthritis and a massive cuff tear where the shoulder joint may remain concentric (Seebauer type 1) or the humeral head may migrate superiorly (Seebauer type 2). The Hamada classification takes this further with the acromiohumeral distance, concavity of the acromion, glenohumeral joint space and collapse of the humeral head all taken into account in the grading of cuff tear arthropathy. It has been estimated that 2% of all people > 80 years of age suffer from cuff tear arthropathy [11,12]. These elderly patients usually have severe pain, including night pain, a pseudoparalytic arm, and many are unable to live independently.There was no real effective alternative treatment for these patients prior to the development of the RSR. Many of the studies on RSR for the original indication of cuff tear arthropathy had fewer than 50 patients or had mixed pathology including revision surgery, and many of the original multi-centre studies with ostensibly large numbers had just ten cases from some centres, which are likely to represent the early phase of familiarization with the technique. There have been significant design changes and technical improvements over the last ten years. We have therefore only included those publications that

Contact Saccomanni Bernardino ✉ bernasacco@yahoo.it Viale Regina Margherita, Altamura (bari), Italy

have been produced in the last five years from a single centre and have 50 or more patients with primary cuff tear arthropathy [13-19].

Results

Painful pseudoparalysis is the principle indication. Three studies matched the inclusion and exclusion criteriaand had a minimum follow-up of between eight and 24 months [20-22]. Mean active external rotation reached between 7° and 14°,21,22 but showed large variation from -44° to +60°.21 Final median internal rotation reached L3,21,22 but again showed large variation from the greater trochanter to T12.20 Effectively this means that most patients will have a functional reach but that rotation can remain a concern. Pain is also significantly improved. The longest and largest review of 484 shoulders with arthropathy and a cuff tear comes from a multicentre study, which included revision surgery [23]. It shows a survival of the prosthesis at ten years of 89% (95% confidence interval 83 to 96). However, there is a gradual decline in the Constant- Murley score with time. When a Constant-Murley score < 30 points (representing a very poor result) was taken as the endpoint, the rate of survival at ten years fell to 72%. Accordingly the age of the patients should be considered when performing an RSR, with most authors limiting the procedure to patients > 65 years of age who have low demands [24,25].

Complications

Many of the early series showing a high rate of complications had a mixed pathology including many revision RSRs, which would inevitably skew the results [16,17]. Some of the specific complications of this procedure have been overcome by improvements in the design and improvements in the surgical technique. However, five significant complications remain that still need to be addressed, as well as one complication that is obvious on radiographs but may have little or no clinical effect.

Dislocation

Only two of the publications reviewed produced a complication rate specifically for patients with cuff tear arthropathy, citing a dislocation rate of between 2% and 2.8%.20,21 The key to stability is the correct tension in the deltoid and correct version of the components. The tension depends upon implanting the correct thickness of polyethylene spacer. The trial reduction should be sufficiently tight that it is quite difficult to perform [26].

The arm is then forcibly distracted and the trial components should remain touching each other, without a gap. Trial dislocation should also be quite difficult. However, if the tension is excessive, acromial fracture can occur. Judging the correct balance is difficult. Biomechanical studies have suggested that the ideal retroversion of the humeral component and the glenosphere is not > 10° [27]. Inability to repair the subscapularis has also been shown to be a risk factor for dislocation and repair should always be attempted if possible [28]. The larger the diameter of the prosthetic humeral head, the more secure the replacement. Head size is constrained by the size of the metaphysis and some companies offer more than two sizes so that there is an intermediate option that is slightly more stable than the original design of 36 mm. An unusual feature of dislocation of a reverse prosthesis is that it can occur without pain, although the diagnosis is often obvious to the patient and surgeon. However, it should be suspected if the function of an RSR suddenly deteriorates or clinically appears to be medialised. A dislocated RSR normally requires open reduction and a change of spacer.

Infection

The incidence of infection in RSR in these studies was between 0% and 4%,20,21 compared with 1.1% reported for an anatomical replacement [29]. This is likely to be related to the two large dead spaces in RSR, the bursa that has been distended with fluid for many years, and the space underneath the glenosphere. These voids should be limited as much as possible. The dead space within the prosthesis can be reduced with modified design or the insertion of an antibiotic gentamicin collagen sponge.

The two most common organisms that are involved in infections after shoulder surgery are Propionobacterium acnes and Staphylococci, which are mainly coagulase-negative [30]. P. acnes is a commensal of sebum producing hair follicles of the skin and is known to be more prevalent around the shoulder than around the hip and knee [31]. Prophylatic antibiotics such as teicoplanin and gentamicin are essential and should have sensitivity to both of these organisms. P. acnes is known to be resistant to metronidazole, but sensitive to penicillin [32].

Glenoid loosening

The reported incidence of glenoid loosening is between 0% and 4%. The glenoid is often eroded, or medialised, leaving little bone stock for fixation. A fracture of the weakened glenoid or a large osteophyte may occur during reaming in 1% to 4% of cases, which may be ignored if the glenoid is large enough to support the baseplate or may require conversion to a large head hemi-arthroplasty [20,21]. Locking screws have improved with the multi-axial designs that allow the screw to be placed into the most substantial bone, although identifying the ideal location for these screws can still be a problem. Many companies now use hydroxyapatite coatings in an attempt to improve fixation.

Acromial fractures

The acromion is often very thin or even fractured after many years of erosion by the upwardly subluxed humeral head. The pseudoparalytic shoulder is also defunctioned leading to further weakening of the acromion by demineralisation. Post-operative fractures were noted in 1.4% to 4% of patients [20,21]. This may occur at the time of surgery with over-tensioning of the joint. The fracture can occur either through the acromion or at the base of the spine of the scapula [33,34]. The pain may be minimal, but function suddenly deteriorates usually around three months post-operatively [33].

The final range of movement, functional score and subjective satisfaction are reduced in patients who sustain this complication [20,33]. Treatment is difficult as there is little bone left for fixation. However, a pre-operative os acromiale and fragmentation of the acromion secondary to cuff tear arthropathy do not appear to be contraindications to performing a RSR, as no difference in functional outcome was seen between these cases and those without [33].

Nerve palsy

Clinically apparent nerve palsy is rare and tends to involve the musculocutaneous nerve, with an incidence between 0% and 1.4%.20,21 However, a recent electromyography study has shown subclinical neurological disturbance in 45% of patients; this predominantly involves the axillary nerve and is probably related to the amount by which the arm is lengthened [35]. It appears to be transient, but may cause post-operative pain and possible

instability. Lengthening should be performed with caution.

Notching

Notching is a complication specific to RSR and is defined as resorption of the lateral pillar of the scapula. It is very common, being seen in 49% to 70% of patients, and the incidence increases with time [20,21]. The appearance of notching was originally viewed with some alarm as it was uncertain whether the appearance would be progressive and would affect function or lead to loosening of the prosthesis [17]. Although notching might turn out to have little clinical effect, it would seem sensible to avoid it if at all possible.

The easiest way to reduce the incidence of notching is to place the glenosphere as low as possible on the glenoid. An overhang of a just 1 mm is predicted to reduce the incidence of notching significantly [36]. Other adjustments to the method of implantation have been made in an attempt to avoid notching but could carry a secondary risk. Modifications in design or technique must be introduced with caution, although definitive evidence of the consequences of these changes is not currently available. Even when placing the glenosphere as low as possible, the deltoid is lengthened, which could lead to a higher incidence of acromial fracture. Altering the angle of the humeral osteotomy could lead to a higher incidence of dislocation and using an eccentric glenosphere could lead to an increased incidence of glenoid loosening. Finally, the use of shallow polyethylene spacers could lead to a higher incidence of instability. Another option is to lateralise the centre of rotation by placing bone graft under the base-plate, but this complicates the procedure, and deals with a problem that might be of no clinical significance, as well as reducing the lever arm available for the deltoid muscle [37].

Irreparable massive cuff tear without osteoarthritis

Primary repair is the aim of treatment for rotator cuff tears. If this cannot be achieved with standard techniques an RSR can be considered as a treatment option in the elderly. Three studies have specifically reported on the outcomes of RSR in patients after failed massive cuff surgery or with a massive cuff tear, but no osteoarthritis.

One described the outcomes of 42 shoulders, of which 25 did not have osteoarthritis [22,38,39]. The minimum follow-up in all three studies was 24 months and the age of the patients was between 70 and 73 years. Improvements in outcome scores and combined active flexion appear similar to that obtained for patients with cuff tear arthropathy. Improvements in external rotation varied considerably and median internal rotation reached L2-3. There was no significant difference in outcome between the patients who had undergone previous rotator cuff surgery and those who had not [22,38,39]. The key finding from two of the studies demonstrated that patients with < 90° of active forward flexion prior to surgery had a significantly better range of movement and functional outcome with higher patient satisfaction than those who had > 90° forward flexion prior to surgery [38,39]. Both studies concluded that other procedures such as debridement, and/or partial or complete rotator cuff repair should be considered in patients with > 90° of active forward flexion.

Other options

Arthroscopic debridement has given satisfactory results in the short-term in low-demand patients40 but may be no better than a biceps tenotomy and may have a higher rate of progression of joint degeneration [41,42].

Reverse arthroscopic decompression or arthroscopic tuberoplasty with debridement of the subacromial space may have some short-term benefitbut no long-term studies are available [43,44]. These procedures have a very limited role in patients with a massive cuff tear. A latissimus dorsi transfer has been reported by some authors to improve function, increase combined active flexion to 135° with improved outcome scores and good to moderate results in the medium term [45-48]. However, a large proportion of these patients (23% to 42%) develop osteoarthritic changes within three years of the procedure and have a risk of late rupture of 20% to 30% [45-48].

Disastrous results have been reported with the use of porcine small intestinal submucosa as an augment to rotator cuff repair, with a failure rate of 73% to 91% within one year [49,50]. Short-term reports with use of graft jacket and Dacron are encouraging but long-term results are awaited [51-53]. As yet there is no ideal solution for patients with irreparable symptomatic cuff tears. An RSR is a possible solution but only if the patient has significant pain and < 90° of active forward flexion.

Rheumatoid arthritis with cuff tears

Two studies report on the outcomes of RSR for primary cuff tear arthropathy in rheumatoid patients [3,54]. The mean age in the two studies was 60 and 72 years, respectively, although a third of the patients were < 60 years and the minimum age was 34 years. The mean pre-operative functional scores were low. One study did not document a specific range of movement but reported all were able to perform perianal care [54]. There was a huge variation in external rotation achieved post-operatively and < 50% of the patients had an increase in internal rotation [3]. It would appear that patients with rheumatoid arthritis can expect at least as good if not better improvements in functional and pain scores. This may reflect the pre-operative pain and functional limitation and the generally reduced demands of these patients. However, there appears to be a higher infection rate in this group, as would be expected with rheumatoid patients [3,54].

Acute proximal humeral fractures

The attraction of using a RSR in patients with a fracture of the proximal humerus relates to the problems associated with the use of hemi-arthroplasty; specifically, the potentially poor quality of the rotator cuff and the reliance on the successful healing of the tuberosities in this elderly population [55]. In nine published cohort studies on the use of the RSR under these circumstances, all have a short follow-up, ranging from three months to two years [4,56-63]. Four of the studies were reported by the same group using the same cohort of patients. The indication for a RSR in these studies was a Neer three- or four-part fracture64 or fracture/dislocation [58-61].

The mean ages of the patients ranged from 74 to 78 years, although the youngest was 58 years. The outcomes appear to be less good than those achieved in the treatment of cuff tear arthropathy [56,59]. Post-operative abduction of around 90° to 100° has been reported, with a huge variation in external rotation and poor internal rotation. One of the studies reduced the amount of retroversion of the humeral head to neutral halfway through the study in an attempt to increase internal rotation, without

achieving a difference [4, 20,56,57,59,63].

After injury the tissues are more oedematous and the tissue planes can be adherent, which makes the surgery more challenging. Reflex sympathetic dystrophy seems to be a peculiar complication in this group of patients, with an incidence of up to 7.5%.56 Two studies also mention heterotopic ossification, although the incidence varied considerably. This difference may be partially explained by the different lengths of follow-up [4,59].

Other options

The current standard treatment of three- or four-part fractures or fracture/dislocations in the elderly is a hemi-arthroplasty, with very similar post-operative Constant- Murley scores. The risks with this technique include non- or malunion of the tuberosities, cuff failure and erosion of the glenoid.55,65-67 Malposition of the tuberosities may be present in up to 50% of patients and some degree of subluxation in up to 85%.55 However, the overall rate of revision for these problems may be less than 5%.67 [55,65,66]. The expected combined active flexion is similar to that achieved with the RSR, but with much better rotation. Two small retrospective studies directly compared the two treatments and found no difference between functional outcomes and range of movements between them, except for better internal rotation in the hemiarthroplasty group in one study [55,56,57,65-67]. Concerns that are shared with both hemi-arthroplasty and RSR are achieving the correct height and retroversion of the implants when the anatomy is distorted. Complex proximal humeral fractures in the elderly are difficult to treat. Expectations have to be limited, but good pain relief and reasonable combined active flexion can be expected with both hemiarthroplasty and RSR. RSR could be considered when the quality of the tuberosities is in doubt, due to comminution or poor bone quality. Where possible the tuberosities should be repaired anatomically to help active rotation, but rotation is likely to be less than that achieved with a well-functioning hemiarthroplasty. The long-term outcome and failure of both groups is not really known.

Fracture sequelae

Painful and stiff shoulders can result from conservatively treated proximal humeral fractures. They face distorted anatomy, potential cuff failure and possible glenoid wear [68,69]. Three studies specifically address this problem of sequelae after using an RSR17, for predominantly Boileau and Walch70 types III and IV fractures [68,69]. Again the minimum follow-up was small (8 to 24 months) and the mean age of the patients was between 68 and 72 years [17]. The outcomes from this small group of studies are not dissimilar to the results obtained in patients with cuff tear arthropathy [17,68,69]. They resulted in a mean improvement of external rotation from 11° to 25° and of internal rotation from the buttock to L3 or T12. The incidence of complications was low [17,69]. The important aspect for these patients is that they have limited function and high levels of pain pre-operatively and therefore have a lot to gain from surgery.

Revision surgery

Revision surgery can be performed for many reasons. In our experience, all revisions should be regarded as infected until multiple biopsies taken at open surgery have excluded this possibility, with extended culture for three weeks specifically investigating P. acnes growth. A total of nine publications met the inclusion and exclusion criteria for examination of the role of RSR in revision

surgery. Revision was performed for failed treatment of proximal humeral fractures in patients with severe pain and loss of function [5,17,22,71-76]. All patients treated in this way also had one or more of the following: tuberosity reabsorption, radiolucency around the humeral stem, osteoarthritis of the glenoid or a rotator cuff tear of > 2 cm [17,71,74].

In addition deep shoulder infection following surgery was described with either with a single-stage revision for infected RSR76 or a single- or two-stage revision following infected hemiarthroplasty or rotator cuff surgery. Further RSR was described after cuff failure following a total or hemiarthroplasty and revision RSR after baseplate failure when 79% of patients (11 of 14) were managed by insertion of a larger glenosphere [5,22,72,73].

The gains in range of movement and pain relief were limited and there was minimal gain or even worsening of rotation. The rate of complications was higher with revision surgery, with much higher rates of loosening and haematoma formation [5,17,22,71,73]. Humeral loosening is related to the high number of intra-operative fractures encountered during the revision [3,5,72,76]. One retrospective study compared 28 revisions for all types of failed arthroplasty with 28 age- and gendermatched primary RSRs and showed significantly lower functional scores and ranges of movement in the revision group compared with the primary group and double the early complication rate at a minimum follow-up of one month [75].

The indication for a revision is key to deciding on the correct implant. It is well-documented that revision from a hemiarthroplasty to a total shoulder replacement for glenoid wear with an intact rotator cuff can yield good results. However, when the integrity of the cuff is poor, total shoulder replacement is not ideal, with arthrodesis being an option [77]. However, the results of arthrodesis following failed arthroplasty with poor rotator cuff are poor and it has been suggested that it should only be considered a salvage operation when a reverse prosthesis is not feasible [78].

The expansion of indications for the RSR reflects the fact that there are significant problems with the other options for each pathology. There are many confounding issues in the literature, such as type of prosthesis used, whether the stem is cemented or cementless, the surgical approach and the rehabilitation protocols. The individual surgeon's experience is also important. It has been suggested that for this procedure between 40 and 60 cases have to be undertaken before a significant reduction in the complication rate is seen. Some of the studies in this review will have included patients within in the surgeon's learning period. It may be wise for them to become experienced initially in treating patients with cuff tear arthropathy, where the outcomes are more predictable and the expected complication rate is low, before considering RSR for other indications [79].

Active and passive rotation following RSR for any indication is a concern. It is very variable and depends upon two factors. The first is the amount of residual active rotator cuff. Poor external rotators and pre-operative fatty infiltration of teres minor on MR scans has been associated with decreased external rotation and worse Constant-Murley scores, compared with those with little

fatty infiltration. Lack of active external rotation pre-operatively can be detected clinically and treated by a latissimus dorsi and teres major transfer (the modified L'Episcopo transfer) at the time of RSR, although this problem remains unresolved [80-82].

The second concern is impingement of the insert against the anterior and posterior borders of the glenoid and relates to the extra excursion of the tuberosities required for the same range of movement in comparison with that required by an anatomical shoulder replacement or the natural shoulder. Augmenting the glenoid with a bone graft from the humeral head has been advocated to avoid impingement but makes the surgery more exacting and introduces a further step that may carry complications.

Patients should be warned pre-operatively about the probable poor range of rotation, especially internal rotation, that will be obtained. This is more of a concern when a RSR is being implanted in the opposite shoulder as well, which may affect the patient's capacity to maintain personal hygiene. The RSR has traditionally been thought to carry a high rate of complications but there is good evidence from the more recent literature that for patients with cuff tear arthropathy the rate of complications is improving and good results can be achieved. The rate of complications is comparable to that of a recent meta-analysis of over 4000 anatomical total and hemiarthroplasties, which quotes an overall complication rate of 40% with a reoperation rate of 11%.29.

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