UNIVERSITATEA „LUCIAN BLAGA” SIBIU
FACULTATEA DE MEDICINĂ „VICTOR PAPILIAN” SIBIU

REVERSED SHOULDER ARTHROPLASTY. INDICATIONS AND PERFORMANCE

Summary

Scientific coordinator,
Prof. dr. Ioan BAIER

Dr. Marinel Drignei

Sibiu, 2014

SUMMARY

The reverse shoulder prosthesis (RSP) is an orthopaedic device used in shoulder endo-arthroplasty and an important therapeutic option in glenohumeral arthropathies with major injuries of the rotator cuff.

Since the promotion of the principles of the reverse shoulder prosthesis in the ’80 by professor Paul Grammont, this special implant has undergone a permanent evolution in terms of the extension of its usage indications towards pathological situations in which there were no effective therapeutic solutions.

The main differences between the reverse shoulder prosthesis and the anatomic prosthesis refer to the positioning of the centre of rotation of the shoulder joint through changing its concavity and conditioning it in terms of the state of the rotator cuff.

The indications of the prosthetic treatment have multiplied and this has lead to a larger spectrum of arthroplasty options.

The most mobile articulation in the human body, the shoulder provides a pathology which is mainly focused on ligaments. The injuries of the cartilage represent a belated evolution, excepted for the particular cases of vascular or metabolic arthropathies. Therefore, the rotator cuff tears represent the most widely-spread degenerative pathology of shoulder joint.

Consequently to the research done by Neer, the shoulder arthroplasty has become a reliable therapeutic solution and has been frequently used in the treatment of gleno-humeral arthropathies.

The reverse shoulder prosthesis arthroplasty has improved the shoulder functionality with a deficient rotator cuff and has supplied essential gains in terms of mobility, which would not be possible with anatomic total shoulder prostheses.

The aim of this thesis is to re-evaluate the indications and techniques used in reverse prosthesis shoulder arthroplasty by means of the analysis of the outcomes of different series of patients who were involved in an operation for reverse shoulder prosthesis used for degenerative shoulders, chronic shoulder slip and proximal humerus fractures, on the one hand, and by means of the evaluation of the revision techniques used for reverse shoulder prostheses.

The thesis contains a presentation of the outcomes of a study that took place in four medical centres as well as a meta-analysis of the latest studies in the field. It also includes an original research meant to extend the indications of the reverse shoulder prosthesis to cases of chronic shoulder slip.

The major operative risks and the difficulties in the post-operative patient survey occur due to the fact that such an operation is reserved to patients aged above 70.

The thesis is structured in two parts, the general and the special one, and begins with the description of the basic concepts used in arthroplasty, more precisely the anatomy of the shoulder area, the presentation and evolution of shoulder prostheses, as well as the biomechanical principles of both normal and prosthetic shoulder. The special part of the thesis contains the actual techniques used in reverse prosthesis shoulder arthroplasty for various types of pathologies, in particular for traumatic pathology, considering that this was the main theme of the experimental study. Further on, the thesis deals with the evaluation of the operative techniques in reverse prosthesis shoulder arthroplasty by means of retroactive studies. Special attention is needed to a an original study of assessment of reverse prosthesis shoulder arthroplasty in the case of chronic shoulder slip, which was published in *European Journal of Orthopaedic Surgery & Traumatology, volume 9*, in November, 2009, and enabled the development of indications of reverse prosthesis shoulder arthroplasty to this category of shoulder injuries.

The examination of the reverse shoulder prosthesis is a real challenge for the orthopaedic surgeon taking into account the age of the patients (above 70) that the reverse shoulder prosthesis is intended for and their comorbidities. The thesis provides a particular technique of glenoid engraftment which reassures the substrate for the performance of reverse shoulder prosthesis revision.

At the end of the special part, there are the results of a multicentric prospective study of reverse prosthesis shoulder arthroplasty, which was done in four medical centres in France in order to study the survival curve of the two types of reverse prostheses used in degenerative and traumatic shoulder pathology.

As a consequence of the research, the indications of reverse shoulder prosthesis set at the end of the meta-analysis of the studies have been reconfirmed and the indication of the reverse shoulder prosthesis in chronic shoulder slip has been confirmed as well.

As far as the performance of reverse prosthesis shoulder arthroplasty is concerned, the special part of the thesis includes a description of the technique using a modular prosthesis. The modularity of the shoulder prosthesis is a condition to arthroplasty in the case of proximal humerus fracture. In this situation the anatomic references are limited and the intra-operative condition of the rotator cuff is the one to require the precise type of prosthesis either anatomic, or reverse.

The shoulder, which is the most mobile articulation in the human body, does not function in charge as other articulations do. This is why its pathology is mainly made of ligaments. The injuries of the cartilage represent a belated evolution excepted for the particular cases of vascular or metabolic arthropathies. Therefore, the rotator cuff tears represent the most widely-spread degenerative pathology of the ball-and-socket joint. The cuff injuries are more frequent at the level of one of the four cuff tendons, more precisely the supraspinatus. The evolution of a tear in the

supraspinatus tendon naturally leads to muscular retraction with hypotrophy. The progression of the tendon injury is initially in the frontal plan, then, in the sagittal one, extending to the other neighbouring tendons, the infraspinatus posteriorly and the subscapularis anteriorly. The teres minor can be affected in some cases.

As a result of the evolution of these tendon injuries, the cuff muscles atrophy and, under the action of the deltoid, the humeral head becomes eccentric, ascending, and its cooptation towards the glenoid cannot be sustained by the cuff. This migration of the humeral head brings about a secondary arthritis, classified in five degrees of evolution by Hamanda. This one is called the eccentric omarthritis.

The symptomatology is variable in eccentric omarthritis, including even the pseudo-paralytic shoulder, which is mobile in passive movements, but impotent in active movements, especially in flexion and abduction, but also the limitation of internal rotations and particularly external rotations. This functional impotency can be associated to pains having a mechanic character, which lead to the loss of autonomy at a high level. These pains can occur at night, but are not inflammatory.

At this stage in the evolution of this scalupohumeral pathology, the surgical interventions in the soft parts prove ineffective. The arthroplasty with anatomic prosthesis is not indicated since the essential condition to its good functioning is not fulfilled, that is having a continent cuff to reassure the boundary humeral head – glenoid.

The idea to reverse the surfaces of the articulations is rather old and, basically, reverse prosthesis shoulder arthroplasty implies the implantation in the scapula of the hemispheric side of the neoarticulation, and not in the humerus as it is the case with the anatomic prostheses which are based on the natural link between the humeral head and the glenoid.

In the ’80, it was professor Paul Grammont who managed to exploit the action of the deltoid in order to change the mechanics of the reverse neoarticulation. Until then the results of the reverse shoulder prostheses had been poor.

Professor Grammont’s principle consists of the descent and medialization of the rotation centre of this new articulation complex. This centre of rotation is at the level of the bony glenoid. The moment of the deltoid strength is optimized, whereas the functionality of the shoulder is recovered, particularly in flexion and abduction.

Unlike the knee or hip, the stability of the shoulder is due to the presence of the short muscles of scapula which form the rotator cuff. The importance of this cuff made of muscles and tendons is highlighted in the case of well-done shoulder arthroplasties when the rotator cuff is intact, but disappointing when there are massive muscular cuff tears. Such situations occur frequently as follow:

- in massive cuff tears arthroplasties;
- in certain forms of rheumatoid polyarthritis when the humeral head is ascendant and the cuff is deficient;
- in some examinations of shoulder prosthesis when the cuff is almost entirely torn or when there are fractures in which tuberosity did not consolidate.

In these cases bio-mechanically comparable, the absence of the rotator cuff is responsible of the superior centring of the humeral head. Therefore, in total arthroplasty this humeral head centring increases the risk of a fast migration of the glenoid component through the tilting effect. In order to avoid this risk, it is possible not to perform glenoid replacement, but only a simple hemiarthroplasty or a bipolar arthroplasty. However the results are disappointing. On the other hand, the progressive excentration of the humeral head towards the acromial space leads to functional degradation. Another solution lies in the use of prostheses with a fixed rotation centre, which prevents the superior excentration of the humerus. The results of using such prostheses have proved a significant level of post-operative complications, especially de-cementation, glanoid fractures and slips, which led progressively to the abandonment of such implants.

Nevertheless, one of these prostheses, called reverse, was improved by professor Paul Grammont and seems to have better results in terms of rotation centre medialization . The studies leading to these results are interesting, still they did not deal with the evolution of these prostheses for a long term. Thus, the wearing and loosening risks are not known. On the other hand, these studies focused on the occurrence of notches at the level of the scapular pillar which could extend to the entire glenoid and foster its migration.

In orthopaedic practice, there are four types of shoulder prostheses:

- The anatomic prosthesis, made of two components reproducing the articulation anatomy: a humeral metallic rod, which is proximally continued by a hemisphere which is articulated to the concave glenoid implant made of polyethylene;

Fig. 1 - Anatomic shoulder prostheses

- Total reverse shoulder prosthesis is made of a humeral rod that is disposed proximally with a cup which is articulated to a glenoid hemisphere fixed with screws at the level of scapula;

Fig. 2 - Reverse shoulder prostheses

- Cephalic prosthesis is formed only of a humeral component of anatomic prosthesis which is articulated directly to the glenoid (hemiarthroplasty);

Fig. 3 – Hemiarthroplasty

- Resurfacing prosthesis of the humeral head.

Fig. 4 – Resurfacing prosthesis

STUDIES

Study on arthroplasty with reverse shoulder prosthesis in massive rotator cuff at Saint Antoine Hospital in Paris

The aim of this study is to analyse short and medium term outcomes in the usage of a new design of reverse shoulder prosthesis, conceived and developed by professor Grammont and further improved in the treatment of various etiologies of glenohumeral arthropathies. The term massive cuff tear is widely used to identify irremediable tears or tears that are difficult to repair.

Material and methods

Between 1996 and 2002 fifty-five reverse shoulder prostheses Delta III (DePuy) were done in two different centres mainly for massive and irremediable cuff tears with or without omarthrosis. The records of 15 men and 40 women average aged 73 were examined with recoil of minimum 2 years and average 34.8 months.

The patients were evaluated post-operatively from a clinical point of view using the balanced Constant functional score in terms of sex and age. The post-operative radiological balance includes systematically front and profile radiographies. The notch on the scapula pillar and heterotopic ossifications were analysed.

Clinical results

Technical perspective

The external shoulder approach seems to be the adequate way to the glenoid access. The glenoid preparation and the implantation of the glenoid component is an essential stage which needs an excellent exposure. Other authors prefer the deltopectoral approach.

Whatever approach is chosen, the functional results of the prosthesis are unlikely to be altered by the fact that the deltoid is being crossed. In a similar manner, the disinsertion or absence of the subscapularis is unlikely to change the efficiency of the procedure.

Clinical perspective

- Pain. The reverse shoulder prosthesis is an efficient procedure in terms of pain. Within the study 83% of the patients were painless or had punctual, minimum pains. Sirveaux provided a study about 96% painless or with minimum pain patients after a time lapse of 9 to 6 months post-operatively.
- Mobility. Reverse prosthesis shoulder arthroplasty has very good results in terms of active abduction which can get to 133°.

  The results of this study show that the teres minor influences significantly the post-operative Constant score. If the teres minor is intact, the post-operative Constant score is better than if it is affected.

- Strength. The results in terms of strength are disappointing within all the series that have been studied, the maximum being 5 kg.

Radiological approach

The notch is the mechanic result between the humeral implant and the glenoid in relaxation due to the progressive embedment of the medial ledge of cupula under the edge of scapula more than osteolysis caused by wear particles. The notch is an undesirable phenomenon since it gets worse and culminates with the loosening of the metaglenoid-glenosphere block. It influences negatively the post-operative Constant score.

If the notch is a consequence of a mechanic phenomenon and not of osteolysis caused by wear particles, it is logical to remove the polyethylene cup in order to foster arm adduction without the embedment in the scapula.

Another phenomenon that was radiologically visible can occur: the heterotopic ossifications which influence significantly the Constant score and reduce mobility.

The survival curve

The survival ratio of this prosthesis is good for medium term, but it decreases significantly 7 years after the implant was done. To Sirveaux, the survival of this prosthesis, taking into account the cumulated probability of not being revised, is as follows: 95.1% after 6 months, without revision and implant migration; 91.3% after 5 years; 74.6% after 7 years and only 29.8% after 8 years.

Conclusions

The reverse shoulder prosthesis in indications of massive and irremediable rotator cuff tear is, for short and medium term, the best indication among other arthroplasties indicated in the past.

It leads to excellent results in terms of pain and mobility in active abduction. The outcomes are modest in terms of external rotation and muscular strength which does not alter patients satisfaction.

The long term results seem challenging, as the survival curve points out, in terms of notch occurrence which can lead to the loss of glenoid fixation. One of the solutions can be the removal of the polyethylene cup which restricts the medial cupula ledge under the scapula edge.

The arthroplasty with reverse shoulder prosthesis in chronic shoulder slip

The serious alteration of the anterior glenoid edge and the subscapularis tendon restricts therapeutic options. This study provides an original procedure to stabilize the shoulder joint if it was affected by reverse prosthesis shoulder arthroplasty throughout a five-year survey of 24 cases, operated by doctor Marius Scarlat at Saint Michel Hospital in Toulon, France, between 2005-2010.

The patients were suffering of fracture or irreducible shoulder slip. An orthopaedic or surgical treatment was applied to these patients in emergency departments of several hospitals in the region Cote d'Azur where they were first examined.

The time lapse between the initial injury and the surgical intervention with reverse shoulder prosthesis was between 4 and 82 months. The patients were aged 57 to 84.

There were no neurological complications, and the deltoid functioned in all cases.

In all cases the treatment was surgical because the important glenoid destruction and the bony flaws of the humeral head, as well as the weak quality of the subscapularis, would have compromised any conservatory treatment.

The therapeutic option was reverse prosthesis shoulder arthroplasty with retentive cup for all 24 patients. The debridement and reparation of subscapularis was also done with all 24 cases as a necessary surgical procedure.

The shoulder stabilization by means of a reverse shoulder prosthesis led to the improvement of mobility, shoulder stability, quality of life, scores in all cases.

This surgical procedure contributes to pain improvement and the increase of the shoulder joint mobility.

The restrictions in terms of movement amplitude are perfectly accepted by patients, particularly since it is a saving procedure.

The chronic shoulder slip is a rare pathology. The therapeutic option of reverse prosthesis shoulder arthroplasty could be acceptable when the bony stock is limited and the subscapularis tendon is affected. A computed tomography examination or a 3D CT is useful to define the glenoid morphology in order to establish the dimensions and orientation of the implant, as well as the bony graft. The number of cases in this study is not large, but the originality of the method has raised the interest of orthopaedic surgeons all around the world, the article being cited in publications from Japan, Canada, Holland.

Multicentric study of reverse shoulder prosthesis within a 8 year-period

This study has a double aim:

- the analysis of several series of operated patients using reverse prosthesis of Grammont type, whose indications are degenerative or traumatic pathologies, with a minimum recoil of 8 years in order to establish the survival curve;
- the assessment of the clinical and radiological results for long term in reverse shoulder prosthesis arthroplasty in cases of arthropathy with massive cuff tear excluding other pathologies.

Material and methods:

Between 2002 and 2010, 240 reverse shoulder prostheses were implanted to 229 patients in four Centres for Shoulder Surgery in France, two University Hospitals and two private clinics.

The study involved 196 women and 33 men, that is a ratio of 1/6.

The average age at the time of the intervention was 72, starting from 52 up to 92. Right shoulder arthropathy was done in 207 cases, left shoulder, in 33 cases and bilateral in 9 cases, the dominant part being operated in 180 cases. The counter-lateral shoulder was affected in 168 cases. The reverse shoulder prostheses used were produced by two laboratories, ZIMMER with the TRABECULAR-METAL prosthesis and ASTON with the DUOCENTRIC prosthesis.

Each of the two types of reverse shoulder prostheses was used in a university centre and a private clinic of the four involved in the study. The prostheses were implanted by senior orthopaedic surgeons for the following pathologies:

- arthropathy with massive cuff injury (pseudo-paralytic shoulder) in 180 cases;
- rheumatoid polyarthritis in 25 cases;
- recent fracture in 20 cases;
- revision of anatomic prostheses in 15 cases.

Of all these cases, a number of 54 articulations were previously infiltrated with cortisone solutions, 36 were previously operated: 15 were already operated with anatomic prostheses, 6 for acromioplasty through arthroscopy, 9 for the reparation of rotator cuff (of which one deltoid labrum), 5 for the long biceps tenotomy and a resection of the external extremity of the clavicle.

The supra-external approach was employed in 159 cases and the deltoid-pectoral approach in 78 cases. In three cases the transacromial approach was used using the method described by Grammont.

All the glenoid implants were not cemented. The humeral components of the prostheses were cemented in 123 cases and not cemented in 117 cases.

All the patients were re-evaluated by the surgeon and an independent examiner.

The clinical outcomes were evaluated using the CONSTANT and MURLEY score. This way the patients had the opportunity to evaluate their own evolution (improved, stationary, altered) by completing some questionnaires each time they were examined post-operatively.

A clinical examination of the rotator cuff was systematically done.

A complete radiological report was done pre-operatively and while the post-operative re-evaluations. The condition of the residual cuff was analysed pre-operatively by means of the arthro-scanner or RMI. An investigation using the 3D computed tomography was used in cases of glenoid bony flaws or vicious calluses.

The patients suffering fractures with 3 or 4 fragments in Neer's classification or those suffering intra-articulation fractures with slips benefited pre-operatively from a computed tomography with tri-dimensional reconstruction.

Results

In 2011, at the moment of the outcomes evaluation, 84 patients undergoing reverse shoulder prosthesis arthroplasty were dead. Of 156 patients alive, 122 were re-evaluated, of which in 12 cases there passed 8 years since the arthroplasty, and 34 were out of reach at the end of the study.

For the re-evaluated patients the average recoil was 4.2 years, starting from 2 years up to 8 years.

The average age at the moment of the evaluation was 78.5, from 68 up to 93.

The evaluation of the prosthesis endurance

The 13 patients who needed implant replacement were divided as follow:

- 5 patients treated of septic loosening, of whom 2 were submitted to a double-time operation, with the ablation and re-implantation of a reverse shoulder prosthesis; the other 3 were treated surgically using the prosthesis ablation and the implantation of a spacer made of acrylic cement and antibiotic.
- 2 patients were treated of precocious replacement of reverse shoulder prosthesis, after 1 year, respectively 11/2 year due to an aseptic loosening of metaglenoid resulting from some positioning vices which led to the defective repartition of forces on metaglenoid. The revision involved a hemioarthroplasty;
- 2 patients who suffered a glenoid migration after 3 and 6 months since the operation, which led to a metaglenoid loosening and required a complete replacement of the old reverse shoulder prosthesis with a new one;
- 1 patient suffered a complete glenoid loosening which required a replacement of reverse shoulder prosthesis with a bipolar one;
- 3 patients suffered a periprosthetic fracture at the level of the humeral rod and were treated by means of the prosthesis revision with a long rod.

The analysis of the prosthesis survival curve in cases of massive rotator cuff pointed out the fact that 8 years after the operation, 88% of implants with reverse shoulder prosthesis were not subject to any surgical revision (survival curve in replacement).

Speaking of the other ethiologies (rheumatoid arthritis, fractures), the analysis of the prosthesis survival curves revealed that, after 8 years, 75 prostheses were not subject to any surgical re-intervention. This difference was significant (p=0.015) comparatively to arthroplasty in cases of massive rotator cuff tears.

The survival curve after prosthetic loosening highlighted a survival ratio of 90% after 8 years and 85% after 10 years in the case of patients operated for arthropathy on massive cuff tears.

All 15 patients suffering a prosthetic loosening needed a surgical intervention in order to replace their prosthesis, but only 13 were actually operated. The other 2 patients were not operated because of important comorbidities.

In cases of arthropaties with massive rotator cuff tear, the prosthesis survival was 95% after 5 years and 85% after 10 years.

For the other ethiologies the prosthesis survival without the glenoid alteration was 70% after 10 years, which is a significant difference.

1. **The evolution of general CONSTANT score**

The post-operative analysis of patient evolution by means of the CONSTANT score proved that 75% of patients had a CONSTANT score above 30 points, which indicates a favourable evolution 5 years after the operation and 55% of patients had a CONSTANT score above 30 points 10 years after the operation.

2. **The evolution of general CONSTANT score in painful cases (<10 points)**

The survival with patients who had a CONSTANT score below 10 points was 78% 5 years after the operation, and 60% 10 years after the operation.

The survival curve with a CONSTANT score below 10 points did not show significant differences between arthropaties with massive rotator cuff tears and arthropaties of other etiology.

3. **The survival curve depending on the access manner**

There were no important differences between the arthropasties using deltopectoral approach and the ones using supra-external approach in terms of the need for prosthesis revision neither for a CONSTANT score below 30 points, or a CONSTANT score in painful cases below 10 points.

4. **The survival curve depending on the type of prosthesis**

There were no major differences between the survival period of the two types of prosthesis involved in the study.

DISCUSSIONS

The reverse shoulder prosthesis is a concept introduced by professor Grammont in the ’80 as a solution to shoulder arthropaties with massive cuff tears for which the anatomic prosthesis was followed by a dissatisfactory functional evolution. The extension of reverse prosthesis indications to old patients who suffered fractures of humerus proximal extremity and cuff injuries was made by the inventor of this prosthesis himself (22 cases between 1989 and 1993), but the results haven’t been published. The design of this reverse prosthesis is based on the transformation of the contact surface between the glenoid and humerus from a concave into a convex to exterior one, which leads to a medialization and descent of the genoid-humeral rotation centre (the Grammont concept). This neo-position of the rotation centre allows an increase in the moment of the deltoid strength onto the humerus in abduction, which compensates for the absence of the rotator cuff. This concept has been modified by Bigliani and Boileau in order to reduce the complications, which were not to neglect, occurring as a result of this position, such as the osteolysis and wearing phenomenon at the inferior glenoid pole, notch formation, even degradation of prosthetic components. Bigliani and Boileua modified this concept considering that a lateralization of the glenoid-humeral rotation centre through a higher metaglenoid or a sponge graft would lead to better results for medium and long term without a significant functional decrease.

The results of reverse shoulder prosthesis arthroplasty in cuff injuries arthropathy and after tumour resections have shown that the special design of this prosthesis rehabilitates the shoulder mobility despite the functional impotency of the rotator cuff.

The results about patients suffering a fracture of humerus proximal extremity, whose treatment consisted in hemioarthroplasty, have demonstrated a low efficiency of this prosthesis due to the inefficiency of the cuff that was affected either by the migration of the fractured metaphysis fragments after the intervention, or by the metaphysis pseudoarthrisis. Moreover, in the case of failed hemioarthroplasty revision, the reverse prosthesis improves shoulder functions. The use of reverse prosthesis in selected cases of old patients has been reported in small series, with a low level of clinical registration.

Which are the elements to indicate the selection of certain prostheses in cases of proximal humerus fracture?

Considering the epidemiological data, the incidence of proximal humerus fractures with old people will grow three times in the next twenty years.

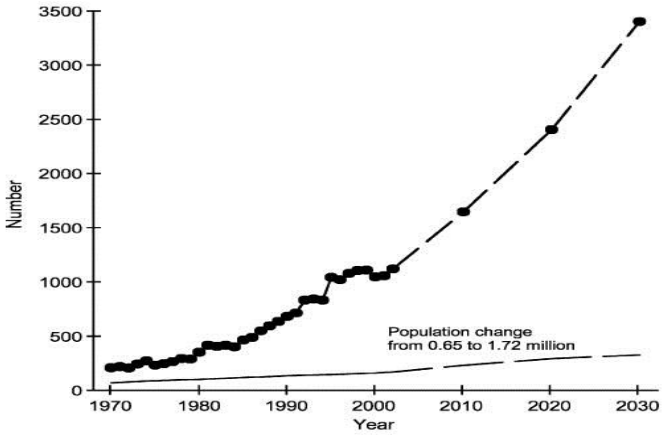

Fig. Fracture prediction on proximal shoulder osteoporosis with patients above 60 calculated with the regression model (Palvanen, Clinical Orthopaedics&Related Research, 2006)

Predictive factors for the success of reverse shoulder prosthesis with patients suffering a fracture of humerus superior extremity

- patients and their comorbidities;
- the surgeon's experience and the accurracy of the intervention;
- the type of implant.

The patient

- the average age: over 50% of the patients need a shoulder prosthesis after they turn 70, the results decreasing proportionally with age;
- comorbidities: alcoholism, demency (over 20%), infection risk, other complications;
- associated injuries (25%), superior membre (11%), inferior membre (5%);
- falling.

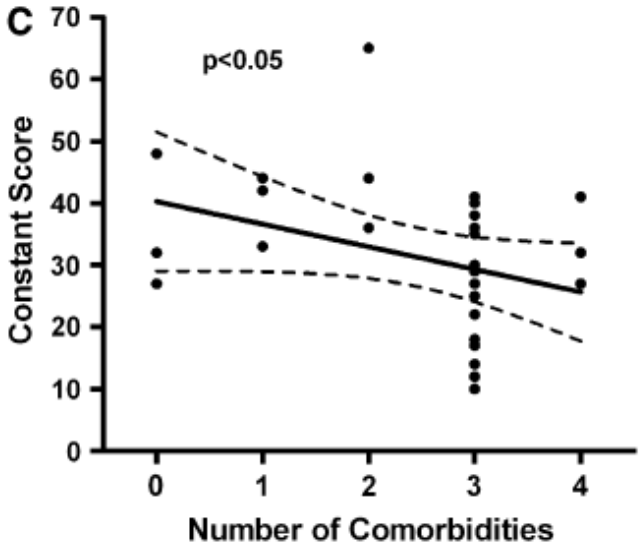

Fig. The evolution of the CONSTANT score depending on the number of comorbidities

A major factor in the selection of the implant is the condition of the rotator cuff. Some correlations between the dislocation of fracture fragments and cuff injuries were also made. Therefore, the rotator cuff was injured in most cases that presented glenoid-tuberosity dislocations bigger than 5 mm. Boileau (JSES 2002) considers that the risk of movement is higher with patients older than 75. The low consolidation ratio post-operatively and the poor results caused by it with old patients was also dealt with by Kralinger (JBJS Br 2004).

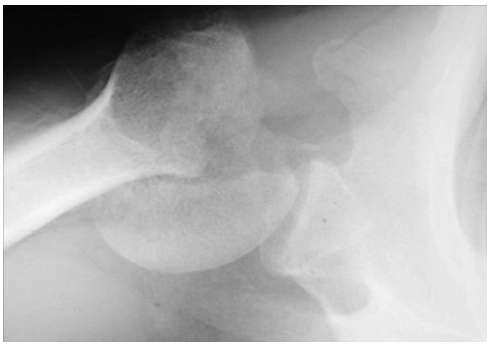

Fig. Glenotuberositar movement bigger than 5 mm

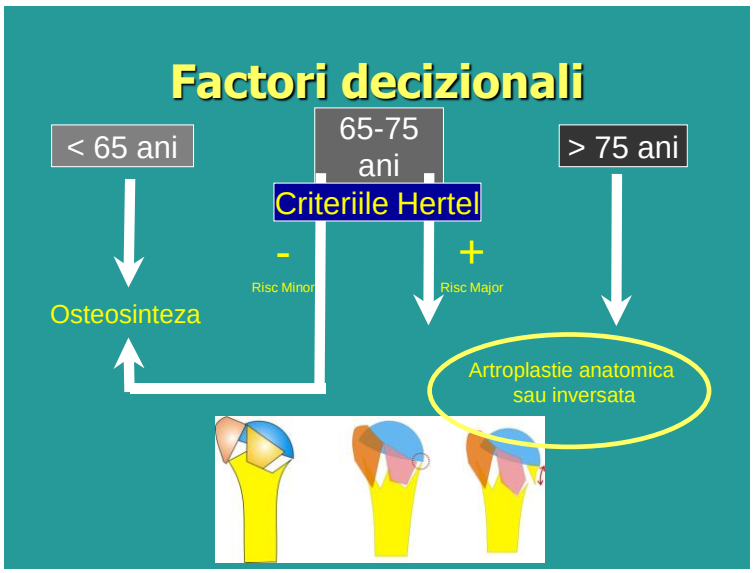

Fig. Hertel criteria in the selection of the therapeutic method used for the fracture of superior extremity of the humerus

Factors depending on the surgeon

These factors refer to the surgical procedure that should be done at a time and with an optimal duration of the intervention. The stability of the montage and the redoing of the anatomic plans must lead to a precocious mobilization of the operated shoulder by involving a rehabilitation programme as soon as possible.

Factors depending on the implant

The selection of the implant depends on the consideration of both advantages and disadvantages of the prosthesis.

Hemiarthroplasty	
Advantages	Inconveniences
One time procedure	Difficulty in fixation of humeral rod height
Avoidance of avascular necrosis	It requires a good fixation and consolidation of tuberosities
Rapid rehabilitation	Inefficiency of rotator cuff followed by unfavorable results

Reverse prosthesis	
Advantages	Inconveniences
One time procedure	Difficult technique requiring experience
Avoidance of avascular necrosis	Very limited revision possibilities
The fixation of the rod height can be done by means of the polyethylene insert	

The results of the studies dealing with the long term evolution of reverse shoulder prosthesis arthroplasty have confirmed good results in unicentric clinical studies with a small number of patients. The evolution systematized in the survival curves does not show a belated failure of these arthroplasties. 90% of the arthroplasties were not revised after 10 years, whereas the survival with cases of glenoid loosening was 85% after 10 years.

The issues related to massive rotator cuff tears arthropathy are complex and there are several therapeutic alternatives.

In the case of massive rotator cuff tears, without any degenerative arthrosic injuries, the arthroscopic or open treatment (consisting in debridation, suture or reinsertion and acromioplasty) had good results, particularly in painful cases. The association of the long biceps tenodesis improves these results even more.

These medical techniques for cuff reparation (arthroscopic and open) are useful with massive cuff tears without arthrosic injuries, but seem overcome when the diagnostic includes massive cuff tears arthropathy. The optimal solution in this pathology (arthrosis on cuff injury) is arthroplasty.

Arthroplasties can be performed with anatomic or reverse prostheses.

The major problem of these arthroplasties is in terms of the glenoid and the fixation of the glenoid component. Thus, for arthroplasty, total anatomic prostheses are meant to fail because of the loosening of the glenoid component with the lever effect described by Frankle. These issues related to the glenoid loosening occurred more frequently with the retentive implants and, for this reason, their usage was abandoned. Facing this inconveniency, a lot of surgeons have chosen hemi-arthroplasty, which led to satisfactory results in terms of pain whereas the gain in terms of active mobility was quite low, only 110° in active flexion (after Pollock) up to 120° (after Rockwood).

Comparative studies oftotal arthroplasty and hemiarthroplasty have shown a significant improvement of pain in hemiarthroplasty comparatively to arthroplasty. On the other hand, authors signal the necessity of prudence in arthroplasty indications with a retentive prosthesis taking into account the secondary risks of acromio-clavicular space deterioration due to the ascension of the

humeral head, which occurs particularly with shoulders that were previously operated and the E2 glenoid type.

A comparative study between reverse shoulder prosthesis and hemioarthroplasty done by Sirveaux has proved the superiority of the reverse prosthesis functionally speaking and underlined the long term risk of wearing of the acromioclavicular joint in cases of hemiarthriplasty.

The good results in terms of pain were obtained with bipolar prostheses where the results in terms of mobility were unsatisfactory since the active flexion did not undergo 90°.

On the whole these studies show that the results in terms of pain are equivalent to the results of the studies presented throughout the thesis.

On the other hand, the study presented in the thesis shows that mobility is superior in reverse shoulder prosthesis arthroplasty. The average active flexion is 127° and the active abduction is 114°. The difference is less important on rotation, only 5.5° in active extern rotation in the position elbow-body and 30° in active extern rotation in arm abduction.

The actual performance of these rotation movements is considerably influenced by the efficiency of the small round muscle.

These good results are confirmed by the survival curves that pointed out, in cases of arthropathy with massive cuff tears, a ratio of 85% survival of reverse shoulder prosthesis with glenoid loosening after 10 years and a general survival ratio of 90%.

Among others, all the revisions were made in the former two years because of the metaglenoid migration in particular. The glenosphere migration and the possible consequences of loosening have not been pointed out in the studies since 1996 when it was decided to do glenosphere fixation by cone.

Another cause of revision was infection which required prosthesis extraction and implantation of a spacer made of acrylic cement and antibiotic. After treating the infection, a new reverse prosthesis was implanted in all cases of revision due to infection, except for two cases which required hemiarthroplasty. This complication inherent to any prosthetic surgery is even more known in arthroplasty with reverse shoulder prosthesis when the dead space in the prosthesis room is larger and associated to another factor that is favourable to the occurrence of periprosthetic infection, that is the patient’s age.

The glenoid loosening, secondary to the vice of positioning the metaglenoid, occurred quickly taking into account the eccentric forces that act upon the implant.

Therefore the glenoid orientation becomes a vital factor in the implant survival.

All in all, the glenoid loosening ratio is relatively low, but represents a serious complication with serious consequences, the prosthesis revision being impossible to make with old patients. When this is possible, it is followed by unsatisfactory results.

The main problem with the reverse shoulder prosthesis is the scapular pillar notch. Sirveaux's studies proved that 50% of the reverse shoulder prostheses presented notch in different degrees after 2 years. Valenti's studies showed that 50% of the reverse shoulder prostheses presented notches in various degrees after 7 years.

In the series considered throughout this study, 20% of the patients developed a notch in various stages after 2 years and 60% after 10 years. These notches are progressive in time without causing a greater metaglanoid loosening ratio.

In the current study we searched for predictive factors of notches, particularly related to the retroversion of the humeral component of the implant, the approach, the initial genoid form, and we did not find any significant differences, which is contrary to the results of Sirveaux's studies who found a correlation between the type of initial glenoid, pre-operative and the dimension of the notch.

The occurrence of a notch in any stage, as well as the presence of a limitation line, did not change significantly the CONSTANT score, and therefore the results of the prosthesis. On the other hand we noticed a significant decrease of the CONSTANT score in the case of the glenoid loosening. The analysis of the survival curves was based on the idea that there was a loosening only in the case of metaglenoid mobilization and not in the case of notches in advanced stages.

The occurrence of a notch was described by Delloye as a purely mechanical problem due to a progressive insertion of the medial edge of the humeral cup under the glenosphere. This hypothesis of a purely mechanical problem seems unreliable because the notch continues to progress in most of the cases without a fracture of the inferior screw. There must be inflammatory phenomena such as the formation of a glanuloma which permits this progression. However throughout the current study we were not able to highlight the correlation between inflammatory factors and notch progression.

The surgical access either deltoid-pectoral, or anterior-external did not influence the prosthesis endurance, whereas the deltoid-pectoral access requires reinsertion or suture of the subscapularis in order to get the efficiency of the internal rotation.

There is a major difference about the survival to loosening and revision between the group of athropathies with massive cuff tears and the groups of other ethiologies that require reverse shoulder prosthesis, favourable to cuff tear arthropathy. Poor results were recorded with rheumatoid polyarthritis and fractures with 3 or 4 fragments, with or without scalupohumeral slip.

These differences confirm that the ideal indication for reverse shoulder prosthesis is massive cuff tear arthropathy in cases of old patients.

In order to assess evolution after the revision of reverse shoulder prosthesis, there should be other studies involving a larger number of patients and a longer period of time.

The good results for short and medium term that the current study obtained encourage the idea of extending the reverse shoulder prosthesis indications to old patients suffering of a painful pseudo-paralytic shoulder with massive cuff injury and without associated arthrosis.

Speaking of post-operative recovery there is no evidence of a superior rehabilitation method. Most authors recommend immobilization for 4 weeks in abduction and neutral rotation with precocious passive mobilization while others suggest a simple brachio-thorax immobilization.

There is a convenience in terms of restrictions of active rotations at the level of the shoulder for 6 weeks in order to consolidate tuberosities and prevent their secondary movement dislocation.

CONCLUSIONS

Reverse shoulder prosthesis arthroplasty has improved shoulder functionality in cases of deficient rotator cuff and provided important gains in terms of mobility which would not be possible if a total anatomic shoulder prosthesis was used. Reverse shoulder prosthesis arthroplasty used in proximal humerus fractures with deficient rotator cuff is a saving solution for old patients.

Hemiarthoplasty, that was considered a standard in proximal humerus fractures requiring prosthesis, is marked by a functional failure ratio due to a non-septic factor in approximately 40% of the cases, which occurs because of the deficient rotator cuff, mainly the lack of consolidation of the metaphysis elements fixed around the prosthesis.

The reverse shoulder prosthesis has been used in Europe ever since 1985, but only since 2004 in the USA. In the latest ten years there has been a growing interest in the reverse shoulder prosthesis, which is illustrated in the number of clinical studies all around the world, particularly in France and the USA.

The indications for reverse shoulder prosthesis with the degenerative or sequela shoulder :

- in massive cuff tears arthroplasties of various kinds;
- in certain forms of rheumatoid polyarthritis when the humeral head is ascendant and the cuff is deficient;
- in chronical cuff slip or invalidated vicious calluses;
- in some shoulder prosthesis revisions when the cuff is almost entirely torn or shows signs of metaphysis pseudo-arthrisis.

The indications for this reverse prosthesis in traumatology are reserved to:

- fractures of proximal extremity of the humerus type IV, after Neer's classification, with or without the slip of the humeral head (pluri-segmental or comminuted fractures of the humeral head accompanied by the alteration of the vascularization of bony fragments);
- fracture of the humeral head higher than 40% of the affected articulation surface;
- some fractures of three segments accompanied by important dislocation and reduced bony stock;
- migration of the bony fragments after osteosynthesis;
- fractures of neoplasic pathologic bone.

The age factor (above 75) can be decisive in the choice between hemiarthoplasty and reverse prosthesis with a patient suffering of humerus proximal extremity fracture and needing arthroplasty. Comorbidities and the metaphysic quality of the proximal humerus (accentuated osteoporosis) also favour a reverse prosthesis.

The reverse shoulder prosthesis is not indicated to young patients (except for saving procedures), active infections, paralysis of the armhole nerve (deltoid inefficiency, the main motor of abduction), low glenoid bone stock (which would prevent a good fixation of the glenoid component), bone tumours in the areas where the implant would be fixed, neurogenous articulation degradation in syringomyelie or Charcot disease, important bone flaw at the level of the humeral diaphysis, hypersensitivity to materials used throughout the intervention.

Research will be done in order to get an optimal modular implant which would produce the lowest notch ratio at the level of the glenoid and maintain the deltoid strength.

Key words: Grammont, reverse shoulder prosthesis, shoulder arthroplasty, massive cuff tear, omarthrosis, fracture of proximal humerus, chronical shoulder slip, Constant score, notch, modular prosthesis, glenoid bony flaw, heterotopical ossifications.

SELECTIVE BIBLIOGRAPHY

1. Balg, F.: Grammont Reverse Prosthesis: Design, Rationale, and Biomechanics. J Shoulder Elbow Surg,14(1SupplS):147S-161S,2005.

2. Baulot, E., D. Chabernaud, and P.M. Grammont, [Results of Grammont's inverted prosthesis in omarthritis associated with major cuff destruction. Apropos of 16 cases]. Acta Orthop Belg, 1995. 61 Suppl 1: p. 112-9.

3.Boileau P, Mole D, eds. Reverse Shoulder Arthroplasty, Clinical ResultsVComplicationsVRevision. Montpellier: Sauramps Medical; 2006:217Y227..

4. Drignei M, Scarlat M. Treatment of chronic dislocations of the shoulder by reverse total shoulder arthroplasty: a clinical study of six cases**.** *European Journal of Orthopaedic Surgery & Traumatology* November 2009, Volume 19, Issue 8, pp 541-546

5. Drignei M, Baier I. Reverse shoulder prosthesis in traumathology. Principles and results. Numarul 4din 2013 al revistei *Acta Medica Transilvanica*

6. Grammont, P.; Trouilloud, P.; Laffay, J.; and Deries, X.: Etude et réalisation d'une nouvelle prothèse d'épaule. Rhumatologie, 1987; 39: 407-18,.

7. Guery J, Favard L, Sirveaux F, et al. Reverse total shoulder arthroplasty. Survivorship analysis of eighty replacements followed for five to ten years. J Bone Joint Surg Am. 2006; 88:1742Y1747.

8. Hamada, K., et al., Roentgenographic findings in massive rotator cuff tears. A long-term observation. Clin Orthop, 1990$^{(254)}$: p. 92-6.

9. Hatzidakis AM, Norris TR, Boileau P. Reverse shoulder arthroplasty, indications, technique and results. Tech Shoulder Elbow Surg. 2005;6:135Y149.

10. Kralinger F, Schwaiger R, Wambacher M, et al. Outcome after primary hemiarthroplasty for fracture of the head of the humerus. A retrospective multicentre study of 167 patients. J Bone Joint Surg Br. 2004;86:217Y219.

11. Lévigne, C.; Boileau, P.; Favard, L.; Garaud, P.; Mole, D.; Sirveaux, F.; and Walch, G.: Scapular notching in reverse shoulder arthroplazsty. In Reverse Shoulder Arthrosplasty, Edited by Walch, Boileau et al. Sauramps Medical , France, 2006, pp. 353.

12. Neer, C. S., 2nd; Watson, K. C.; and Stanton, F. J.: Recent experience in total shoulder replacement. J Bone Joint Surg Am, 64$^{(3)}$: 319-37, 1982

13. Nove-Josserand L, Walch G, Wall B. Instability of the reverse prosthesis. In: Walch G, Boileau P, Mole D, eds. Reverse Shoulder Arthroplasty, Clinical Results, Complications, Revision. Montpellier: Sauramps Medical; 2006: 247Y260.

14. Paladini P, Collu A, Campi E, et al. The inverse prosthesis as a revision prosthesis in failures of shoulder hemiarthroplasty.Chir Organi Mov. 2005;90:11Y21.

15. Pollock R, Deliz E, Mcllveen S, Flatow E and Bigliani L, Prosthetic replacement in rotator cuff deficient shoulders. J Shoulder Elbow Surg1992; 1:173-186

16. Scarlat M, Shoulder Surgery. Basic Knowledge and How to Start. Springer 2014

17. Scarlat M, Complications with reverse total shoulder arthroplasty and recent evolutions. *International Orthopaedics* May 2013, Volume 37, Issue 5, pp 843-851

18. Sirveaux F, Favard L, Oudet D, et al. Grammont inverted total shoulder arthroplasty in the treatment of glenohumeralosteoarthritis with massive rupture of the cuff. Results of amulticentre study of 80 shoulders. J Bone Joint Surg Br.2004;86:388Y395.

19. Sirveaux F, Navez G, Favard L, et al. Reverse prosthesis for acute proximal humerus fracture, the multicentric study. In: Sirveaux F, ed. Reverse Shoulder Arthroplasty. Clinical Results, Complications, Revision. Montpellier: Sauramps Me´dical; 2006:73Y80.

20. Valenti Ph, B.D., Nerot C et al., Delta 3 Reversed Prosthesis for osteoarthritis with massive rotator cuff tear : long term results (>5 years). in 2000 Prothèses d'Epaule...recul de 2 à 10 ans., B.P. Walch G, Mole D., Editor. 2001, Sauramps Médical: Montpellier. p. 253-259.

21. Williams, G.R., Jr. and C.A. Rockwood, Jr., Hemiarthroplasty in rotator cuff-deficient shoulders. J Shoulder Elbow Surg, 1996. $5^{(5)}$: p. 362-7.