ORIGINAL ARTICLE

Delta III reverse-ball-and-socket total shoulder prosthesis for acute complex fractures of the proximal humerus in elderly population

J. F. Cazeneuve · Y. Hassan · F. Kermad · A. Brunel

Abstract

Background The Delta III semi-constrained reverse-ball-and-socket total shoulder prosthesis works only with an intact deltoid muscle. Our purpose is to evaluate the results in a consecutive series of acute complex fractures of the proximal humerus in elderly population with a poor bone quality when the main problem is to obtain a reliable and efficient re-fixation of the tubercles with classical orthopaedic devices.

Methods From 1993 to 2005, 36 Delta III were implanted, 27 three-part, and four-part displacements and nine fracture-dislocations, in 3 males for 33 females, for 16 dominant sides, with an average age of 75 years. The surgery was realized under general anaesthesia, in semi-sitting position, by an antero-lateral approach with retroversion of the humeral-cemented stem of 20° to 0°. Post-operative physiotherapy was not always realizable.

Results The results were estimated with the clinical Constant scoring system, AP and lateral view X-rays. Twenty-five cases were reviewed because nine were deceased and two moved out. At a mean follow-up of 71 months, the Constant score was 59 points for a contra-lateral shoulder evaluated at 81. The results were good in respect of pain (14.1), activity (14.3), strength (14.1), anterior elevation (7.5), abduction (6.5), but very poor for external (1.1), and internal (1.4) rotations. The radiographs showed: one aseptic glenoid loosening at 12-year follow-up with surgical revision, 14 inferior scapular notching (seven stages 1, five stages 2, one stage 3, one stage 4), 14 inferior spurs stable after emergence without clinical repercussion, four medial and two lateral proximal humeral bone loose, and two medial humeral lucent lines.

Conclusions For acute complex fractures of the proximal humerus, in elderly population with poor bone quality, when an efficient and reliable re-fixation of the tubercles is difficult or impossible, the Delta III prosthesis is a possible alternative with good functional outcome except rotations but with a lot of worrying inferior scapular notching.

Keywords Traumatic · Humerus proximal · Reverse shoulder prosthesis

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Arthroplastie inversée Delta III en traumatologie aiguë et complexe de l'humérus proximal chez la personne âgée avec un recul de deux à treize ans

Résumé

Introduction Le but de ce travail est d'évaluer les résultats clinique et radiographique de la prothèse inversée Delta III en traumatologie fraîche quand les conditions anatomiques ne permettent pas la ré-insertion efficace des tubérosités sur les moyens classiques de prise en charge.

Méthodes De 1993 à 2005, trente six Delta III étaient implantées pour vingt-sept fractures et neuf fracture-luxations, chez trois hommes et trente trois femmes d'âge moyen soixante quinze ans. L'acte opératoire, toujours réalisé sous anesthésie générale en position demi-assise par un abord antero-latéral, permettait l'implantation d'une tige humérale cimentée avec une rétroversion de 20° à 0° et d'une méta-glène avec bonne tenue mécanique primaire sans difficulté technique majeure. La rééducation post-opératoire n'était pas toujours réalisable.

Résultats Les résultats étaient estimés au moyen du score clinique de Constant et de radiographies de face et de profil selon Lamy. Vingt-cinq cas étaient exploitables en raison de neuf décès et de deux déménagements. Le score de la série était de 59 pour l'épaule opérée et de 81 pour l'épaule opposée. Si les résultats étaient bons pour la douleur (14.1), l'activité (14.3), et la force (14.1), l'élévation active (7.5), l'abduction (6.5), ils étaient très médiocres pour la rotation externe (1.1) et la rotation interne (1.4). Les radiographies montraient un descellement aseptique de la glène à douze ans, quatorze encoches du pilier (sept stades 1, cinq stades 2, un stade 3 et un stade 4), quatorze ostéophytes polaires inférieurs stables dans le temps et sans retentissement clinique, quatre résorptions humérales proximales et deux latérales, et deux liserés huméraux médiaux os-ciment. Il n'y a pas eu de ré-intervention pour cause humérale.

Conclusion En cas de ré-insertion difficile voire impossible des tubérosités, la prothèse Delta III peut donc être une alternative possible avec de bons résultats cliniques exceptés pour les rotations mais au prix d'images anormales et inquiétantes dans 60% des cas. Néanmoins, un seul patient a été réopéré pour cause de faillite mécanique à douze ans de recul.

Mots clés Fracture · Humérus proximal · Prothèse inversée

Introduction

The surgical treatment of acute complex fractures of the proximal humerus is still debated and leads to different solutions: extra and intra-medullary osteosynthesis [1–4], the "Bilboquet" device [5], hemi-prosthesis [6–8]. The mechanical viability of these solutions is only achieved if the tubercles consolidate in anatomic position [9]. In elderly population with osteoporosis and rotator cuff diseases, the re-fixation of the tubercles, which is always difficult and sometimes impossible, leads to bone loose, migrations, non-union, and mal-union and therefore, significantly jeopardizes the functional result and consequently places the patient into a situation of dependency.

The inversion of surfaces [10], the fixity and medialization of the centre of rotation, the lowering of the humerus shaft, as proposed by Grammont [11, 12], enable increasing the lever arm and the force of the deltoid muscle—the only muscle necessary for the implant function.

The purpose of this retrospective study was to evaluate the clinical and radiographic outcomes of the Delta III prosthesis (DePuy France) in traumatic indications with 2–13 years follow-up.

Materials and methods

Patient population

Between 1993 and 2005, 36 reversed prosthesis were performed by the same surgeon to treat 27 three-part and four-part displacements and nine fractures–dislocations of the proximal humerus according the Neer [13] classification in 3 males and 33 females, mean age 75 years (range 58–92) for 17 right and 19 left sides, in 50% of dominant arm. Medical antecedents comprised six severe rotator cuff diseases, three type-1 diabetes, two complicated alcoholics, three senile dementias, three social distresses, and three morbid obesities. The pre-operative iconography comprised on the one hand, AP and lateral view X-rays in order to classify the fracture, to look for indirect signs of sub-acromial impingement, to understand the osteoporosis degradation level, and on the other hand a scanner examination to show the exact anatomy of the backbone neck of the scapula in order to implant the glenoid element and to assess the degree of fatty degeneration based on the criteria set by Goutallier [14].

Surgical technique

The surgical procedure was always performed under general anaesthesia in a semi-seated position, using an anterolateral approach without osteotomy of the acromion, thus creating a trapezo–deltoidian digastric muscle. Following the identification of the remaining tubercles, the humeral head was removed for measurement and pathology analysis. No fracture in a sarcoma context has been evidenced by the pathologist. The results showed major osteoporosis associated arthritis in five cases. The anterior, inferior, and posterior capsules were cut out to position the Trouilloud forceps that pushed the humeral shaft distally, thus providing a perfect view on the glenoid. The glenoid was reamed in a circular manner until the sub-chondral bleeding bone was reached. Primary fixation after impaction of the metaglene was always correct and the four-screw fixation was performed in a converging way, with two equatorial screws and one apex screw targeting the foot of the coracoid process. For the lower screw, the drilling was performed at low speed in order to feel permanently the bone contact in the pillar, and with a low downward tilting. The humeral preparation caused no specific problem: the shaft being directly accessible through a movement of adduction-flexion. The trial implants made it possible to adjust the height and the muscle tension. The ideal adjustment consisted in being able to slide effortlessly the pulp of the fifth finger between the trial sphere and polyethylene in a patient who exhibited an optimum anaesthesia with curare. The retroversion of the humeral implant was comprised between 20° and 10°,

leading to a neutral position implantation in order to try increasing the mobility in rotation with one 10° ante-version case. Except for the first case, all stems were cemented with low viscosity antibiotic-loaded cement after insertion of a diaphyseal plug. The lateral fin of the prosthetic epiphysis made it possible to perform a suture of the long portion of the biceps tendon. It was impossible to obtain an efficient re-fixation of the tubercles in each case. Closure of the wound was always associated with a deep suction drainage. The elbow was immobilized with a sling for 21 days.

Post-operative rehabilitation

Post-operative rehabilitation was not possible in the cases of social distress, senile dementia, and morbid obesity. For the other patients, rehabilitation was started after removal of the drainage and was active in all cases. It was always associated with a slight pain and it was rapidly effective. It never lasted more than 3 months.

Post-operative assessment

The shoulder operated was compared with the contra-lateral shoulder. The results were estimated with the clinical Constant scoring system [15] and AP and lateral view X-rays.

The assessments were carried out monthly during the first quarter, then quarterly during the first year, and then once a year.

Results

Losses to follow-up

Only 25 cases were reviewed with a follow-up from 2 to 13 years because nine were deceased and two moved out.

Complications

Four complications were reported: two complex sympathetic dystrophies solved in 6 and 9 months with a medical treatment, one early (3 weeks) post-operative Acinetobacter infection in a type-1 diabetes patient with cleanse and drainage revision permitting prosthesis preservation and one anterior dislocation at one month caused by a voluntary ante-version of 10° of the humeral implant leading to re-orientation of the stem. The results of these four cases were included in the series.

Clinical outcome

With the mean follow-up of 6 years, the raw Constant's score was 59 points, with a score of 81 points for the contra-

lateral shoulder. Although the results were good for pain with quasi-painlessness (14.1/15 points possible = total absence of pain), and for the activity with a preservation of the autonomy (14.3/20), they were mediocre for the strength (14.1/25), and disappointing for the mobility (16.5/40). Active anterior elevation (7.5/10) and abduction (6.5/10) were always between 120° and 170°, except for the two cases reviewed for infection and dislocation, which only allowed motions below 90°. The internal rotation (1.4/10) rarely allowed the hand to be moved to the sacrum and thus the lumbar level could not be reached. The very limited external rotation (1.1/10) did not allow the hand to be placed behind the head, elbow forward. In the nine cases with a 10° retroversion, the internal rotation scored 5/10 with the hand capable to reach the twelfth thoracic vertebra. The voluntary ante-version intended to increase the external rotation was a mistake because it induced our only dislocation case.

Radiographic outcome

One aseptic glenoid loosening with a surgical revision: a 2-mm thick border appeared at 8 years, aggravated by a notching of the pillar at 11 years, and a broken distal screw with mobilisation of the base plate at 12 years (Fig. 1). This concerned our first case, a type-1 diabetic male patient with a 42-mm diameter sphere on whom we replaced the standard base plate in June 2005 without special operative difficulties thanks to a well preserved bone stock. After 1 year, his Constant's score was 43 points.

According to the Nérot classification [16, 17], 14 inferior scapular notching were observed (56%) with a mean occurrence time of 4.7 years. The mean occurrence time of the seven type-1 notches (50%) was 2 and 4.3 years for the five type-2 notches (35%). In 15% of the cases, we observed a type-3 notch reaching the lower polar screw and a type-4 notch reaching beyond the screw, respectively, at 5 and 7-year follow-up (Fig. 2).

Fig. 1 Aseptic loosening at 12-year follow-up with broken screw and mobilisation of the base plate

Fig. 2 Scapular notching grade 4

Fourteen inferior spurs stable after emergence without functional impact or radiographic evolution were reported with a mean occurrence time of 2.5 years, range 1–6 (Fig. 3).

Two heterotopic ossifications occurred at 6 months and were stable at 6 years follow up.

The humeral radiographic results comprised four medial (5, 6, 7 and 10 years) and two lateral proximal bones looses at 10 years. Two bone–cement interface medial and proximal borders on the two-thirds of the height of the prosthetic stem were present at 5-year follow-up (Fig. 4).
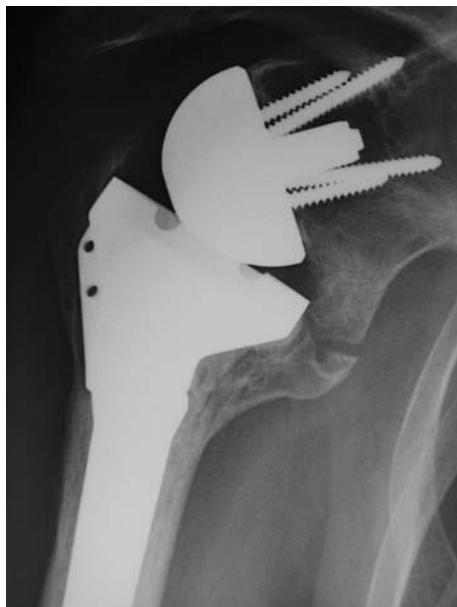

Fig. 3 Inferior spur at 10-year follow-up stable from its apparition and without clinically expression

Fig. 4 Medial proximal humeral resorption with radiolucent line between bone and cement

We did not report a case of humeral loosening.

At the mean follow-up of 6 years, except for the two cases re-operated for early infection and dislocation, despite the high number of abnormal radiographic images, only one patient exhibited a mechanical failure at 12 years follow up calling for revision surgery.

Discussion

The treatment of acute complex fractures of the proximal humerus in elderly patients is not univocal. We did not find any publication dealing with the utilization of a reversed prosthesis for these indications.

Osteosynthesis with rigid screwed plates ensure high quality stabilization and reduction [18–20]. However, they are difficult to perform when the bone fragments are small and the risk of severe devascularization increases the potential for secondary necrosis [21]. The solution could be the use of the new locked screw plates [22, 23] in order to improve the stability of the reconstruction to promote the revascularization phase [24] and to authorize early rehabilitation, even in patients who are affected by acute osteoporosis.

In the case of complex dislocated and displaced fractures, a light anterograde nailing with auto-stable screws seems to be a proper alternative to prosthesis in order to ensure a correct fixation of the various bone fragments in the three anatomical planes, which again promotes the vascularization of the humeral head with very few cases of secondary necrosis [25]. These remarkable and reproducible results—assuming the surgical technique is strictly respected without sub-acromial impingement by a nail insufficiently

introduced—are confirmed at 4 year follow-up and thus make it possible to widen the indications for a conservative treatment [26, 27]. In the case of a severe osteoporosis, however, this type of osteosynthesis seems to reach its limits and the prosthesis is still the treatment of choice [28].

"Bilboquet" implant belongs to warden techniques. It authorizes the consolidation of the tubercles in anatomic position through the preservation of the bone stock of the metaphysis and an early rehabilitation. Very few cases of secondary necrosis are reported [5]. It seems to be better indicated for three-part than for four-part fractures. A longer follow-up is necessary to validate this surgical possibility because of the problem of late necroses. Moreover, this operative technique is complex and difficult to learn [29].

The first publications concerning the utilization of the prosthesis implanted for four-part displacements and fracture–dislocations report good results in terms of pain and autonomy recovery if the operative technique is perfect [4, 5, 30, 31]. In case of rotator cuff disease, the results for pain remains acceptable [32] but the functional gain becomes disappointing [33]. Limited functional results are also observed [34–37]. Becker et al. [38] report a limited gleno–humeral mobility except in young patients [39]. For others, the results achievable in mobility are doubtful [40, 41] because of a non-efficient reconstruction of the tubercles [9, 42]. The functional score would be directly linked to their consolidation in anatomic position [43]; hence, the realization of a specific implant for fractures that would restore the lateral offset and the humeral length with a window inside the epiphysis in order to provide cancellous bone that would promote the consolidation of the tubercles in the anatomic position and more specifically the greater tubercle [44, 45]. Although the experience of the surgeon remains essential, this implant improves the anatomical and clinical outcomes [46]. However, in the case of severe osteoporosis and rotator cuff disease—which make the fixation of the tubercles difficult or impossible—this type of implant finds its limits and the reversed concept could be an alternative as demonstrated by our series with a mean follow-up of 6 years.

This reversed concept used in the case of gleno-humeral arthritis associated with severe rotator cuff deficiency is not free of specific complications. Humeral cortical perforations, humeral shaft fracture, intra-operative glenoid fracture, post-operative haematomas, infection, dislocation, fracture of the acromion, neurological injuries, unscrewing of the sphere, and loosening of the glenoid component secondary to trauma or insecurely anchored or glenoid bone deficiency or sub optimal positioning may occur [47]. Nevertheless, the main problem is the scapular notching because of a mechanical impingement between the scapular

neck and the epiphysis of the humeral component aggravated when the arm is placed alongside the body and during adduction movements. The epiphysis can reach the lower fixation screw of the metaglene causing its rupture and the loosening of the implant [48, 49]. To prevent this phenomenon, that affects the intermediate term clinical outcome, a preoperative planning, and proper selection of glenoid implants as well as very precise surgical positioning of the glenoid component may assist in preventing inferior scapular notching [50].

In summary, for acute complex fractures of the proximal humerus in elderly population with poor bone quality and severe rotator cuff deficiency, when an efficient and reliable re-fixation of the tubercles is difficult or impossible with classical orthopaedic devices, the Delta III prosthesis is a possible alternative with good functional outcome except rotations, but with a lot of worrying inferior scapular notching. New developments in design and bearing surfaces and more long-term results will probably provide more durable utilization of the reverse concept in this indication.

References

1. Neer CS II (1970) Displaced proximal humeral fractures. Part II. Treatment of three-part and four-part displacement. J Bone Joint Surg 52A:1090–1103
2. Cuny C, Scarlat M, Irrazi M, Slimani S, Turell P (2000) Enclouage des fractures proximales de l'humérus par clou Telegraph à verrouillage autostable. Technique et premiers résultats, à propos de 66 cas. Rev Chir Orthop 86 (suppl n°2) 54
3. Cuny C et al (2000) Telegraph nail used for internal fixation of proximal humerus fractures. Eur J Orthop Surg Traumatol 10:21–26
4. Schwartz C, Cuny C (2003) Fractures of the proximal humerus: a prospective review of 188 cases. Eur J Orthop Surg Traumatol 13:1–12
5. Doursounian L, Grimberg J, Cazeau C (1996) Une nouvelle méthode d'ostéosynthèse des fractures de l'extrémité supérieure de l'humérus : l'implant bilboquet. Rev Chir Orthop 82:743–752
6. Tanner MW, Cofield RH (1983) Prosthetic arthroplasty for fractures and fracture–dislocations of the proximal humerus. Clin Orthop Relat Res 179:116–128
7. Cofield RH (1988) Comminuted fractures of the proximal humerus. Clin Orthop Relat Res 230:49–57
8. Worland RL, Arredondo J (1998) Bipolar shoulder arthroplasty for painful conditions of the shoulder. J Arthroplasty 13:631–637
9. Boileau P, Krishnan SG, Tinsi L, Walch G, Coste JS, Molé D (2002) Tuberosity malposition and migration : reasons for poor outcome after hemiarthroplasty for displaced fractures of the proximal humerus. J Shoulder Elbow Surg 11:401–412
10. Kolbel R, Freidebold G (1972) Moglichkeiten der Alloarthroplastik an der Schulter. Arch Orthop Unfall 76:31–39
11. Grammont P, Trouilloud P, Laffay JP, Deries X (1987) Etude et réalisation d'une nouvelle prothèse d'épaule. Rhumatologie 39:17–22
12. Grammont P, Baulot E (1993) Delta shoulder prosthesis for rotator cuff rupture. Orthopedics 16:65–68
13. Neer CS II (1970) Displaced proximal humerus fractures part 1: classification and evaluation. J Bone Joint Surg 52A:1077–1089

14. Goutallier D, Postel JM, Bernageau J, Lavau L, Voisin MC (1994) Fatty muscle degeneration in cuff ruptures pre and post-operative evaluation by CT scan. Clin Orthop Relat Res 304:78–83

15. Constant CR, Murley AHG (1987) A clinical method of functional assessment of the shoulder. Clin Orthop Relat Res 214:160–164

16. Valenti PH, Boutens D, Nérot C (2001) Delta 3 reversed prosthesis for osteoarthritis with massive rotator cuff tear : long term results. In: Walch G, Mole D (eds) 2000 shoulders prostheses ƒtwo to ten years follow-up. Sauramp Medical, Montpellier, pp 253–259

17. Sirveaux F, Favard L, Oudet D, Huguet D, Lautman S (2001) Grammont inverted total shoulder arthroplasty in the treatment of glenohumeral osteoarthritis with massive and non repairable cuff rupture. In: Walch G, Boileau P, Molé D (eds) 2000 Prothèses d'épaule ƒrecul de 2 à 10 ans. Sauramps Medical, Paris, pp 247–252

18. Olivier H, Largier A, Lajoie D, Duparc J (1981) Les fractures de l'extrémité supérieure de l'humérus. Cahier d'enseignement de la SOFCOT n° 13. Expansion Scientifique Française, Paris, pp 117–128

19. Paavolainen P, Christensen SW (1983) Operative treatment of severe proximal humeral fractures. Acta Orthop Scand 58:124–127

20. Szyskowitz R, Seggl W, Schleifer P (1993) Proximal humeral fractures. Management techniques and expected results. Clin Orthop Relat Res 292:13–25

21. Kristiansen B, Christensen SW (1986) Plate fixation of the proximal humerus fractures. Acta Orthop Scand 57:302–323

22. Hersan A, Talha A, Gournay A, Hubert L, Cronier P, Toulemonde JL, Massin P (2004) Une nouvelle plaque verrouillée pour les fractures de l'extrémité proximale de l'humérus: étude prospective à propos de 31 cas. Rev Chir Orthop 90:2S82

23. Ehlinger M, Gicquel P, Clavert P, Bonnomet F, Kempf JF (2003) Un nouvel implant pour les fractures de l'humérus proximal: la plaque à corbeille. Etude expérimentale. Rev Chir Orthop 89:3S71

24. Lee CK, Hansen RH (1981) Post-traumatic avascular necrosis of the humeral head in displaced proximal humeral fractures. J Trauma 21:788–791

25. Cuny C, Darbelley L, Touchard O, Irrazi M, Beau P, Berrichi A, Empereur F (2003) Fractures à quatre fragments de l'humérus proximal traitées par enclouage léger antérograde à vis auto-stables. Rev Chir Orthop 89:507–514

26. Chassat R, Guillon P, Dauzac C, Leroux R, Meunier C, Carcopino JM (2004) Résultats de l'ostéosynthèse par clou Telegraph des fractures complexes de l'humérus proximal chez le sujet de plus de 50 ans. Rev Chir Orthop 90:2S81

27. Cuny C, Raphoz AL, Khalife M, Berrichi A, Ionescu N, Irrazi B, Beau P (2004) Enclouage léger antérograde des fractures de l'humérus proximal: résultats à quatre ans. Rev Chir Orthop 90:2S82

28. Beguin L, Adam P, Vanel O, Fessy MH (2002) Indications et échecs du clou verrouillé à vis auto-stables pour les fractures proximales de l'humérus: étude prospective de 50 clous Telegraph. Rev Chir Orthop 88:2S75

29. Le Du C, Favard L (2004) Les fractures complexes de l'extrémité supérieure de l'humérus traitées par implant Bilboquet: résultats cliniques et radiologiques. Rev Chir Orthop 90:2S81

30. Compito CA, Edward BS, Bigliani LU (1994) Arthroplasty and acute shoulder trauma: reasons for success and failure. Clin Orthop Relat Res 307:27–36

31. Schai P, Imhoff A, Staubli AE (1993) Differentialdiagnostik und–therapie der mehrfragmentaren Humeruskopffraktur eine analyse aus drei klinischen studien. Z Unfallchir Vers Med 86:27–39

32. Naranja RJ, Iannotti JP (2000) Displaced three- and four-part proximal humerus fracture: evaluation and management. J Am Acad Orthop Surg 8:373–382

33. Neer CS II, Watson KC, Stanton FJ (1982) Recent experience in total shoulder replacement. J Bone Joint Surg 64A:319–337

34. Huten D, Duparc J (1986) L'arthroplastie prothétique dans les traumatismes complexes récents et anciens de l'épaule. Rev Chir Orthop 72:517–529

35. Hawkins RJ, Switlyk P (1993) Acute prosthetic replacement for severe fractures of the proximal humerus. Clin Orthop Relat Res 289:156–160

36. Pietu G, Deluzarches P, Goin F, Letenneur J (1992) Traumatismes complexes de l'extrémité supérieure de l'humérus traités par prothèse céphalique: à propos de 21 cas revus avec un recul de 4 ans. Acta Orthop Belgica 58:159–169

37. Movin T, Sjoden GO, Ahrengart L (1998) Poor function after shoulder replacement in fracture patients. A retrospective evaluation of 29 patients followed for 2–12 years. Acta Orthop Scand 69:392–396

38. Becker R, Pap G, Machner A, Neumann WH (2002) Strength and motion after hemiarthroplasty in displaced four-fragment fracture of the proximal humerus: 27 patients followed for 1–6 years. Acta Orthop Scand 73:44–49

39. Wretenberg P, Ekelund A (1997) Acute hemiarthroplasty after proximal humerus fracture in old patients. A retrospective evaluation of 18 patients followed for 2–7 years. Acta Orthop Scand 68:121–123

40. Goldman RT, Koval KJ, Cuomo F, Gallacher MA, Zuckerman N (1995) Functional outcome after humeral head replacement for acute three- and four-part proximal humeral fractures. J Shoulder Elbow Surg 4:81–86

41. Larrouy M, Duranthon LD, Vandenbussche E, Augereau B (2001) Résultats de l'arthroplastie humérale dans le traitement des fractures céphalo-tubérositaires de l'extrémité supérieure de l'humérus. Rev Chir Orthop 87:2S115

42. Coste JS, Trojani C, Ahrens PM, Boileau P (2002) Prothèse humérale pour fracture et complication tubérositaire. Rev Chir Orthop 88:2S39

43. Le Huec JC, Boileau P, Tinsi L, Molé D (1997) Influence de la synthèse des tubérosités sur le résultat des prothèses humérales pour fractures. Rev Chir Orthop 83:72–73

44. Boileau P, Chau E, Perraud M, Arcamone H, Argenson C (1993) Restauration du déport latéral et de la longueur humérale après hémi-arthroplastie pour fracture à 4 fragments de l'extrémité supérieure de l'humérus. Rev Chir Orthop 73:1–15

45. Boileau P, Walch G (1999) Shoulder arthroplasty for proximal humerus fractures: problems and solutions. In: Walch G, Boileau P (eds) Shoulder arthroplasty. Springer, Berlin, pp 297–314

46. Jacquot N, Kempf JF, Favard L, Le Huec JC, Molé D, Walch G, Boileau P (2004) Résultats d'une prothèse d'épaule spécifiquement dessinée pour les fractures de l'extrémité supérieure de l'humérus. Rev Chir Orthop 90:2S145

47. Matsen III FA, Boileau P, Walch G, Gerber C, Bicknell RT (2006) The reverse total shoulder arthroplasty. J Bone Joint Surg 88A:660–666

48. Delloye C, Joris D, Colette A, Eudier A, Dubuc JE (2002) Complications de la prothèse totale inversée de l'épaule. Rev Chir Orthop 88:410–414

49. Werner CML, Steinmann PA, Gilbart M, Gerber C (2005) Treatement of painful pseudoparesis due to irreparable rotator cuff dysfunction with the Delta III reverse-ball-and-socket total shoulder prosthesis. J Bone Joint Surg 87A:1476–1487

50. Simovitch RW, Zumstein MA, Lohri E, Helmy N, Gerber C (2007) Predictors of scapular notching in patients managed with the Delta III reverse total shoulder replacement. J Bone Joint Surg 89A:588–600