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Review article

Shoulder arthroplasty—Past, present and future

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ABSTRACT

Shoulder arthroplasty is one of the most successful procedures to treat end stage arthritis of glenohumeral joint. It was popularised and pioneered by Dr Charles Neer around 50 years ago but the indications, implant designs as well as techniques for performing this procedure are continuously evolving. Amongst all orthopaedic joint replacements, it is the most rapidly growing with a seven fold increase envisaged over the next 15 years. This article discusses the evolution, current trends and the future direction of shoulder arthroplasty.

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1. Introduction

Shoulder arthroplasty is one of the most successful procedures to treat end stage arthritis of glenohumeral joint. It was popularised and pioneered by Dr Charles Neer around 50 years ago but the indications, implant designs as well as techniques for performing this procedure are continuously evolving. Shoulder arthroplasty is the most rapidly growing procedure amongst all orthopaedic joint replacements with a seven-fold increase envisaged over next 15 years. This article discusses the evolution, current trends and the future direction of shoulder arthroplasty.

2. Indications

Shoulder arthroplasty is indicated for Primary as well as secondary glenohumeral arthritis, inflammatory arthropathy (rheumatoid arthritis), osteonecrosis, post-traumatic arthritis, cuff arthropathy. It is also increasingly used for proximal humeral fractures. The two main types of shoulder arthritis are glenohumeral arthritis and rotator cuff arthropathy. These two conditions completely differ in terms of biomechanics as rotator cuff is mostly preserved in pure glenohumeral arthritis, whereas in the cuff deficient shoulder the humeral head subluxes superiorly due to unopposed deltoid force causing it to articulate with undersurface of acromion. Patients with glenohumeral arthritis usually require an anatomical replacement, whereas the patients with cuff arthropathy require reverse geometry shoulder replacement. Combined data from national arthroplasty registries to cover

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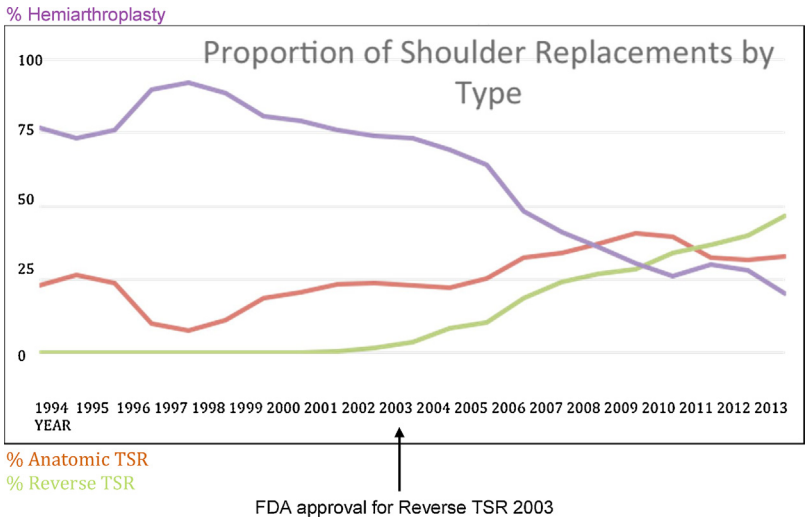

Fig. 1. Shoulder Arthroplasty Trends: Combined data from international shoulder registries- Presented at the Wrightington Arthroplasty meet March 2016. (E Griffiths, P Monga).
% Hemiarthroplasty FDA approval for Reverse TSR 2003.
% Anatomic TSR.
% Reverse TSR.

the period from 1994 to 2003 are depicted in Fig. 1 and reveal the changing trends over the recent years. It can be seen that since FDA approval of Reverse geometry TSR in 2003 there has been dramatic rise in the use of reverse TSR, where as the use of hemiarthroplasty has steadily declined and the anatomic TSR has remained the same. The resurfacing arthroplasty has steadily declined in popularity.

The American Academy of Orthopaedic Surgeons now recommends Total Shoulder replacement over hemi-resurfacing arthroplasty for glenohumeral arthritis.[1] The demand for shoulder arthroplasty is projected to increase by 755.4% by 2030.[2] Such an increase is not only related to improvement in prosthetic design, but also represents the influence of training. Surgeons with Fellowship training in shoulder surgery are more likely to perform total shoulder replacement over hemiarthroplasty for glenohumeral arthritis.[3] It has also been noted that fellowship trained surgeons are 5 times more likely to use arthroplasty for fractures and 20 times more likely to use a reverse polarity shoulder replacement.[4]

The exact reason for decline in resurfacing is difficult to explain. However there is growing evidence to show that long-term results of TSR are better than hemi-resurfacing arthroplasty for pain relief, range of motion and patient satisfaction.[29] The notion that the resurfacing will have advantage of preserved bone stock in a younger patient has to be weighed against potential glenoid erosion due to resurfacing making further revision surgery more challenging and difficult.

3. Evolution and design

The first recorded shoulder arthroplasty was carried out by Jules-Emile Péan in Paris in 1893 for a patient with tubercular arthritis. His prosthesis was made of rubber head and platinum stem. This prosthesis was removed at 2 years for persistent tubercular infection.[5] Thermistocles Gluck (1853-1942) was a Romanian surgeon working in Germany. He is widely credited as the first arthroplasty surgeon. He implanted Ivory prostheses in wrists, elbows, shoulders, hips, knees and ankles during 1880s.[6] However his results were not published and fate of these prostheses remains unknown.

The first generation humeral Implants were mono-block implants. In 1950, Krueger performed first modern shoulder arthroplasty with an anatomic shaped humeral implant for a patient with osteonecrosis.[7] Dr Charles Neer pioneered the modern era of shoulder arthroplasty. His mono-block stem was designed for proximal humeral fractures and such a prosthesis was in use from 1953.[8] It was in 1974, that he implanted the first Total shoulder replacement for glenohumeral arthritis.[9] Neer's original prosthesis had single fixed humeral head with variable stem diameters. But this was modified to articulate with glenoid resurfacing and 2 head size options were available in mono-block stem.

The second-generation humeral implants incorporated the concept of modular humeral head sizes and coating for bone ingrowth. Modular heads with different radii of curvature were available. These head components were articulated with the stem through a Morse taper mechanism. It was also possible to alter the height of prosthesis due to different length of stem sizes. Based on the hip joint implants some designs incorporated a collar at the neck of the stem to aid stability when resting against the calcar. These second generation implants, however, did not cater to normal proximal humeral anatomy.

The third generation humeral implants were modeled on anatomic study of proximal humeri. They allow for variability in humeral head diameter, articular surface thickness, inclination, retroversion, posterior offset, medial offset.[11] These components are commonly referred to as anatomic or adaptable. Boileau et al. in an anthropometric study defined these parameters of proximal humerus. According to this study the diameter of curvature of articular surface of humeral head is measured in both the coronal and axial planes. The articular surface diameter is defined as the diameter of articular surface at the level of margin of cartilage (in both coronal and axial planes). The articular surface thickness is defined as perpendicular distance from articular margin to the apex of the diameter of curvature. The inclination angle is the angle between proximal metaphysical axis and that perpendicular to the articular margin plane. The retroversion angle is the angle between a perpendicular to articular margin plane and the trans-epicondylar axis. The medial offset is the perpendicular distance between axial plane containing the center of epiphyseal sphere and the central axis of metaphysical cylinder. The posterior offset is the perpendicular distance between coronal plane containing center of epiphyseal sphere and the axis containing the central axis

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