# Chapter 38
# Biomedical Image Processing Software Development for Shoulder Arthroplasty

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## ABSTRACT

*Shoulder arthroplasty is an important operation for the treatment of shoulder joints, with an increasing rate of operations per year around the world. Although this operation is generally achieved successfully, there are a number of complications which increase the risks in the operation. Preoperative planning for a surgery can help reduce the amount of risks resulting from complications and increase the success rate of the operation. Three-dimensional visualization software can be helpful in preoperative planning. This chapter aims to provide such software to help reduce the risks of the operation by visualizing 3D joint anatomy of the specific patient for the surgeon, and letting surgeons observe the geometrical properties of the joint.*

## INTRODUCTION

Shoulder arthroplasty is a shoulder joint replacement surgery, performed when pain prevails or shoulder joint functionality including strength or mobility has deteriorated or has been lost and conservative treatments like analgesics and physiotherapy are not affective (Buck, Jost, & Hodler, 2008).

DOI: 10.4018/978-1-6684-7544-7.ch038

A great number of shoulder arthroplasty is performed every year around the world. There were 200,000 shoulder arthroplasty surgeries in the USA from 2000 to 2010 (Trofa, Rajaee, & Smith, 2014) and the number of operations performed is increasing (Kim, Wise, Zhang, & Szabo, 2011). In Australia, 37,849 shoulder arthroplasty operations were performed from 2006 to 2016 ("Reported Shoulder Procedures," 2017).

Common issues which can result in shoulder arthroplasty include osteoarthritis, rheumatoid arthritis, complex fractures of the proximal humerus and osteonecrosis of the humeral head. Shoulder arthroplasty is performed also as revisions of failed prosthesis (Buck et al., 2008).

Shoulder arthroplasty operations include humeral hemiarthroplasty, total shoulder arthroplasty, and reverse shoulder arthroplasty (Buck et al., 2008). Humeral hemiarthroplasty is replacing the humeral head with an artificial implant in the joint. Total shoulder arthroplasty is performed by replacing both humeral head and glenoid section of the scapula bone. Major indications for total shoulder arthroplasty are primary and secondary osteoarthritis, as well as early rheumatoid arthritis (Buck et al., 2008). In reverse shoulder arthroplasty, the anatomy of the joint is reversed in a way that the prostheses attached to the glenoid has a ball shape, and the prostheses attached to the humeral bone has a concave shape. Reverse shoulder arthroplasty has been proved as a successful method for treatment in cases with rotator cuff deficiency (Boileau, Watkinson, Hatzidakis, & Hovorka, 2006; Boileau, Watkinson, Hatzidakis, & Balg, 2005).

In Reverse shoulder arthroplasty, medialization and distalisation in the shoulder joint, meaning that the center of rotation is moved downwards and closer to the body, prevents the shoulder from moving upward out of its center and also it increases the force moment that the deltoid muscle can create. As a result, lifting of the arm is improved which is the advantage of this method over previous types of shoulder arthroplasty in many cases (Farshad & Gerber, 2010).

Shoulder arthroplasty is generally achieved successfully, although complications can occur. The number of complications reported varies based on the reporting institution (Hammond, Queale, Kim, & McFarland, 2003; Hasan, Leith, Smith, & Matsen, 2003), however, a meta-analysis has reported a 14.7% rate of complication in a total of 2,810 shoulder arthroplasty operations from 1996 to 2005. The most frequent complication was component loosening (with a higher glenoid loosening rate than humeral loosening), followed by instability, periprosthetic fracture and other less common complications (Bohsali, Wirth, Rockwood, Material, & Surgery, 2010; Matsen et al., 2008). Likewise, in reverse shoulder arthroplasty the most common complication is glenoid component loosening (Deutsch et al., 2007; Walch, Boileau, & Noël, 2010; Zumstein, Pinedo, Old, & Boileau, 2011). Glenohumeral instability, which is the second most common complication, can be caused by a misalignment of the joint prostheses components. Any misplacement of the component in distance or angle can cause instability (Buck et al., 2008). Periprosthetic fracture can be caused during the operation or after the operation resulting from an accident or a fatigue fracture (Buck et al., 2008).

In shoulder arthroplasty, highly experienced surgeons who operate on about 200 patients a year can do their best without preoperative planning, but if the patient's anatomy is much deteriorated or deformed, the risk of complication is higher. For instance, the implant inferior version and tilt angle have shown a 16 and 12 degree variation respectively in traditional surgery methods (Nguyen et al., 2009; Verborgt et al., 2011). Conventional methods in implantation are observed as not being able to restore the retroversion angle when the glenoid is severely damaged (Iannotti, Greeson, Downing, Sabesan, & Bryan, 2012; Karelse et al., 2014).