CASE REPORT

Formation of a physiological reverse shoulder joint

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SUMMARY

Congenital shoulder deformities are rarely seen in orthopaedic practice. Proximal humeral defects and glenoid hypoplasia have been reported separately in the literature. We present a case involving a 31-year-old woman having a cosmetic problem with her upper arm who was diagnosed with reverse shoulder joint deformity. This article presents the clinical, radiological and biomechanical findings of a physiological reverse shoulder joint. This is the first such reported case.

BACKGROUND

Congenital defects of the shoulder are very rare.^{1 2} Analogous to a proximal femoral defect, a circulatory disorder can lead to defect formation in the proximal humeral metaphysis, causing shortening and varus deformity.³ Other causes of defect formation include a traumatic birth leading to epiphyseal arrest, osteomyelitis or a tumour.⁴⁻⁶ Little is known of the natural formation of a reverse shoulder joint during growth.

CASE PRESENTATION

A 31-year-old woman presented with cosmetically unsatisfactory shortening of the left upper arm. The shortening had been present since childhood, and its cause was unknown. She had no other system involvement or disease. She had no pain and no limitations in everyday life or sports. The examination showed shortening of the left upper arm by about 12 cm due to a defect in the proximal

humerus, with a normally developed elbow and forearm. This was a case of a reverse shoulder joint (figure 1).

The shoulder function was compared with that of the contralateral healthy shoulder using the Constant and American Shoulder and Elbow Surgeons (ASES) scores. Using X-rays and MRI, the shoulder joint was compared with the healthy right opposite side and with a simulated reverse shoulder prosthesis. The simulated reverse shoulder prosthesis was planned on the right shoulder using a reverse shoulder prosthesis template (Delta Xtend; DePuy). The following parameters were compared: line of action, force arm, relative torque and length of the deltoid muscle, position of the centre of rotation relative to the lateral acromion, and inclination and diameter of the glenosphere (table 1).

INVESTIGATIONS

Function: The range of motion (ROM) of the left shoulder was abduction 120°, external rotation 30°, internal rotation 12° and flexion 140°, with full ROM of the right shoulder (figure 2). The Constant score was 75 points for the right shoulder and 56 points (75%) for the left. The ASES score was 100% for the right and 95% for the left.

Anatomy: The left humerus was 12.4 cm shorter than the contralateral side. MRI showed a cartilage layer on the glenosphere and metaglene (figures 1 and 3). The glenosphere formed a semicircle axially (180° circumference) with a diameter of 28 mm. The lateral centre of rotation was mainly

Figure 1 Anteroposterior roentgenographies of left and right upper arm; axial and coronal MRI of the left shoulder.

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Table 1 Biomechanical and radiological comparison of three different types of shoulder joint

	Normal shoulder joint (<i>right shoulder</i>)	Natural reverse shoulder joint (<i>left shoulder</i>)	Simulated reverse shoulder prosthesis
Force arm of the deltoid in 0° abduction	24 mm	51 mm	47 mm
Length of the deltoid	118 mm	78 mm	130 mm
Torque of the deltoid in 0° abduction	100%	213%	196%
Diameter of the glenosphere	–	28 mm	38 mm
Inclination	–	146°	155°
Centre of rotation relative to the lateral acromion	11 mm	46 mm	35 mm

in the deltoid muscle, enabling it to act as an abductor ([figure 3](#)). The metaglene enclosed the glenosphere axially at its centre at 174° of its circumference. The patient had a shaft axis inclination of 146°. The rotator cuff inserted at the metaglene and was not atrophied. The deltoid was shortened to 78 mm (contralateral side, 118 mm) ([figure 4](#)).

Biomechanics: The centre of rotation was medialised 11 mm more in the natural reverse shoulder than in the simulated reverse shoulder prosthesis. An additional varus deformity of 22° at the level of the deltoid insertion on the humerus increased the force arm of the deltoid muscle to 51 mm, which exceeded the force arm of the simulated reverse shoulder

Figure 2 ROM; flexion and internal rotation of the patient. ROM, range of motion.

Figure 3 Axial MRI of the left shoulder; the part of the deltoid muscle that is lateral to the centre of rotation is highlighted yellow and the medial-located part of the muscle is red.

prosthesis by 4 mm. The relative torque (*reference right shoulder=100%*) reached 213% for the reverse shoulder joint versus 196% for the simulated shoulder prosthesis.

DISCUSSION

Proximal humeral hypoplasia and glenoid hypoplasia have been reported separately in the literature.¹ Trout reported nine patients with congenital isolated glenoid hypoplasia; Wirth reported 16 similar patients; and Suryawanshi reported one patient.⁷⁻⁹ Brahman and Samilson each reported one patient with congenital isolated proximal humeral hypoplasia. None of these patients had reverse shoulder formation, but our patient did.¹⁻¹⁰ This is the first reported patient with physiological reverse shoulder joint formation.

Reverse shoulder arthroplasty

Figure 5 Picture of a reverse shoulder arthroplasty.¹²

Reverse shoulder prostheses are used for replacing arthritic shoulder joints or treating proximal humerus comminuted fractures. The procedure differs from standard shoulder replacement surgery, as it switches the shoulder's normal ball-and-socket structure around to allow for more stability in the joint after surgery (*figure 5*). Reverse shoulder arthroplasty is particularly useful for patients who have a damaged rotator cuff along with shoulder arthritis. Thanks to the glenosphere component, prosthesis increases the force arm of the deltoid muscle, medialises the centre of rotation and eliminates the necessity for an intact rotator cuff.^{11 12}

Figure 4 Anteroposterior roentgenographies of the left and right shoulders and simulated reverse prosthesis (from left to right).

A reverse shoulder joint is not directly comparable in all aspects to a reverse shoulder prosthesis because of the arm shortening and conserved rotator cuff.¹³ The muscles, especially the deltoid, can adapt during growth and there is no atrophy. Compared with a reverse shoulder prosthesis, there is even stronger medialisation of the rotation centre and varus position in the shaft area, which together increase the force arm of the deltoid; the muscle sequence is almost completely lateral to the centre of rotation. The highly compliant metaglene can absorb the resulting pressure forces. The limited mobility is balanced partly by the very good mobility of the scapulothoracic joint, so that the complex mobility is sufficient. In the present case, the shortened upper arm helped with this, and the patient had no problem reaching her face or the back of her head. Therefore, we are reluctant to perform lengthening for cosmetic indications.

CONCLUSION

Function that creates form can cause a reverse shoulder joint during growth and compensate for a proximal humeral defect. Our patient underwent adaptive growth to obtain an optimally

adjusted reverse shoulder joint based on the principle of medialisation of the glenohumeral rotation centre of a reverse shoulder prosthesis, as discovered by Grammont. This could enhance our understanding of biomechanics.

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Competing interests None declared.

Patient consent Obtained.

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Learning points

- ▶ A reverse shoulder joint can be a natural compensation for a proximal humeral defect.
- ▶ A varus deformity of the proximal humerus is part of this compensation by increasing the lever arm of the deltoid muscle.
- ▶ Any surgery planned in the future should respect the changed biomechanical situation.

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