THE CONGENITAL UNDESCENDED SCAPULA

SURGICAL CORRECTION BY THE WOODWARD PROCEDURE

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At The Hospital for Sick Children in Toronto, 21 undescended scapulae were corrected by the Woodward procedure in 20 patients over the past 18 years. The average age at operation was six years six months. The average follow-up period after operation was 8 years 9 months. Fifteen patients were girls and five were boys. All the patients had other associated abnormalities. Only one patient had a concomitant clavicular osteotomy. The average increase in glenohumeral abduction was 37 degrees. The average scapular lowering was two centimetres. Excellent or good cosmetic results were obtained in 80 per cent of patients. Ninety-three per cent of patients expressed satisfaction with the operative results. Complications were few. The Woodward procedure is a safe and relatively straightforward surgical means to effect a good cosmetic and functional improvement in a patient with a congenital undescended scapula. We do not recommend clavicular osteotomy as a routine, but it may be added to gain more correction with less risk of neurovascular compression.

The first clinical description of congenital undescended scapula is thought to be the three cases reported by Eulenberg in the German literature in 1863. Willet and Walsham described the pathological anatomy of two cases including a description of the omovertebral bone in 1880 and 1883. In 1891 Sprengel reported four cases, together with a theory of the aetiology; since his publication the condition has been referred to as "Sprengel's deformity", perhaps an undeserved eponym.

The clinical appearance of these patients is the result of retention of the fetal position of the scapula (Horwitz 1908). Normally, at about five weeks, the fetal scapula differentiates opposite the fourth, fifth and sixth cervical vertebrae. Between the ninth and twelfth weeks it undergoes caudal migration to its usual thoracic position between the second and seventh ribs. As development proceeds, the scapula also undergoes alteration in shape. Initially the horizontal diameter exceeds the vertical, the ratio gradually decreasing until the mature dimensions are reached. The early shape is equivalent to that of the quadruped; the later shape is an adaptation to provide upright man with increased freedom of movement of the upper limb (Horwitz 1908). However, this process is impeded in those patients with an undescended scapula. The deformity that results is therefore a failure of normal

scapular descent and subsequent abnormal development of bone and soft tissues affecting the entire shoulder girdle: the scapula, its attached muscles, the shoulder joint and the clavicle. Congenital abnormalities of other organ systems are commonly associated (Jeannopoulos 1952; Woodward 1961; Cavendish 1972; Carson, Lovell and Whitesides 1981).

Several theories have been put forward to explain this arrest in the development process (Horwitz 1908; Engel 1943), but none offers convincing evidence. However, it is clear from the embryology that the deformity should be referred to as an "undescended" scapula rather than the popular term "elevated" scapula. It should also be appreciated that it is more than an isolated problem of the scapula.

The scapula remains high on the chest wall, its normal descent halted at this point. The inferior pole is adducted and the superior angle prominent in the web of the neck. The superior aspect may be curved over the apex of the chest wall anteriorly. The scapula is hypoplastic, generally smaller than on the normal side, and the ratio of its horizontal to its vertical diameter is increased. An omovertebral connection is present in 25 to 30 per cent of cases reported in the literature (Schrock 1926; Jeannopoulos 1952; Cavendish 1972; Carson *et al.* 1981). It may be composed of fibrous tissue, cartilage or bone (or both) and it connects the superior angle of the scapula to the cervical spine (Figs 1 to 3). There have been reports of an actual joint present at its scapular end (Jeannopoulos 1952). It has been considered homologous to the suprascapular bone of some lower vertebrates (Willet and Walsham 1880). Other fibrous connections also may be found between the scapula and the chest wall. The muscles involved with scapular movement, especially the trapezius, levator scapulae and rhomboids, are often hypoplastic or infiltrated with fibrofatty tissue

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(Cavendish 1972). The serratus anterior muscle may be weak, adding scapular winging to the clinical deformity.

The rotational component of the deformity makes the glenoid face downward. This is partly responsible for the decreased shoulder abduction. The anomalous connections of the scapula to the chest wall and to the spine, and the anterior curve of the suprascapular portion may also contribute to the limitation of scapulothoracic movement.

The reported options for surgical correction of the deformity are numerous, but may be summarised as follows: those that merely resect the prominent bony parts contributing to the clinical deformity (Smith 1941; Jeannopoulos 1952); those that lower the scapula by detaching the muscles at their scapular insertion (Schrock 1926; Jeannopoulos 1952; Green 1957; Klisić *et al.* 1981); those that lower the scapula by detaching and transplanting the muscles at their midline origins (Woodward 1961); and combinations of all three.

In 1961 Woodward described a procedure that has become, in most centres, the operation of choice. He was the first to suggest detaching the muscles at their midline origin and transplanting them distally to lower the scapula. He also advocated removal of prominent bony portions of the scapula and, where necessary, excision of the omovertebral bone. His original report comprised

nine patients, all of whom achieved satisfactory results with an increase in abduction ranging from 20 to 70 degrees and lowering of the scapula of from four to eight centimetres.

Subsequent long-term follow-up studies have been few. Pinsky, Pizzutillo and MacEwen (1980) reported on 12 patients from the duPont Institute. They achieved an average increase of 45 degrees in shoulder abduction, with two cases of postoperative winging of the scapula and one transient brachial plexus palsy. Carson *et al.* (1981) reviewed 11 patients who achieved an increase in abduction of 29 degrees and an average lowering of the scapula of 1.6 centimetres.

The present series represents our experience with 21 Woodward procedures in 20 patients over the past 18 years.

MATERIALS AND METHODS

The records of the 20 patients who had undergone operative correction of a congenitally undescended scapula by the Woodward procedure between 1964 and 1982 at The Hospital for Sick Children in Toronto were reviewed: 13 patients were available for follow-up (Table I). Of the other seven patients, one had recently died (the cause of death was unrelated to the operation) while six were studied from their clinical records and, where possible, also from a questionnaire.

The follow-up evaluation consisted of: clinical photographs; radiographic examination of both scapulae, the cervical spine, and the thoracolumbar spine (when indicated); examination of the shoulder, including measurement of the range of active movement, particularly combined abduction; grading of the cosmetic result

Fig. 1

Fig. 2

Fig. 3

Figure 1—Patient 17. Clinical photograph of the omovertebral bone and two smaller fragments. Figure 2—Patient 16. Postero-anterior radiograph showing a left undescended scapula with an omovertebral connection. Figure 3—Patient 10. Postero-anterior radiograph showing a right undescended scapula and an omovertebral connection. (With routine views the omovertebral connection is seldom as visible as this and oblique views are necessary.)

Table I. Clinical details and results of treatment of the 13 patients personally evaluated at follow-up

Patient number	Age at operation	Sex	Side	Follow-up interval	Abduction		Scapular lowering (centimetres)	Grade*
					Before	After		
1	3 yrs 10 mths	F	Both	7 yrs 6 mths	R 120 L 90	R 160 L 120	1.5 3.5	R 2 L 3
2	8 yrs 10 mths	F	R	3 yrs 7 mths	120	160	1.3	1
3	5 yrs 1 mth	M	L	7 yrs 3 mths	180	180	1.7	1
4	7 yrs 8 mths	F	R	6 yrs 7 mths	110	120	1.9	2
5	8 yrs	F	L	15 yrs 7 mths	95	100	†	2
7	15 yrs 10 mths	M	R	6 yrs 7 mths	90	120	0.8	2
10	4 yrs 6 mths	F	R	9 yrs 2 mths	110	150	0	4
11	3 yrs 5 mths	F	L	3 yrs 9 mths	90	175	2.5	1
13	4 yrs 6 mths	F	L	15 yrs 6 mths	110	160	2.1	1
15	5 yrs 5 mths	M	R	7 yrs 4 mths	90	165	3.4	1
18	9 yrs 4 mths	F	L	17 yrs 6 mths	135	180	1.9	1
19	3 yrs	F	R	13 yrs 3 mths	90	110	†	2
20	12 yrs 10 mths	F	R	3 mths	160	170	3.7	1

* Cavendish grading (Cavendish 1972)

† Radiographs not adequate for accurate measurement

using a subjective scale and the Cavendish (1972) grading system; and questioning regarding satisfaction with the operative results. In most cases radiographs and clinical photographs taken before operation were available for comparison.

Surgical technique (after Woodward 1961). With the patient in the prone position and the head resting on a neurosurgical headrest with the neck slightly flexed, a midline skin incision is made extending from just below the occiput to the tenth thoracic vertebra. The plane between the subcutaneous tissues and the muscular layer is then developed to display the orientation of the muscle fibres of trapezius. At its inferior end the lateral border of trapezius is easily identified, and the deeper muscular layer of latissimus dorsi is separated from the trapezius at this point. The midline fascial origin of trapezius is then detached from the spinous processes with a scalpel, in an inferior to superior direction. The origins of the rhomboids and the levator scapulae are consecutively released as part of this continuous fascial sheet.

At this point access is gained to an omovertebral bone or other binding fibrous band between the scapula and underlying structures. These are removed to allow free movement of the scapula on the chest. The omovertebral bone is completely resected extraperiosteally from its attachment to the superior angle of the scapula and to the cervical spine. Care must be taken to protect the spinal accessory nerve, which descends on the anterior surface of the trapezius in line with the medial border of the scapula. The transverse cervical artery, a branch of the thyrocervical trunk of the

subclavian artery, passes posterior to the levator scapulae muscle at its insertion into the superior angle of the scapula and should be avoided during dissection.

The scapula itself is often deformed. The supraspinous portion is commonly curved anteriorly over the superior aspect of the chest wall and may be enlarged. If such bony deformity is present, it is removed using bone cutters, avoiding subperiosteal stripping. This will allow a more normal gliding of the scapula on the chest wall after it has been moved downward. The remaining tether preventing scapular relocation is the narrow proximal portion of the trapezius above the level of the fourth cervical vertebra; this is transected horizontally.

Now the scapula is free to be pulled downward by traction on the muscular aponeurosis. While held in its lowered position by an assistant, the fibrous origin is re-attached to the midline, proceeding from proximal to distal and using heavy sutures. A redundant portion of trapezius aponeurosis may develop in the distal segment and is dealt with by transverse release and imbrication.

The subcutaneous tissue and skin are then closed. Meticulous attention to achieving a snug anatomical closure will be rewarded by a cosmetically pleasing scar. Subcuticular closure with a fine synthetic suture has given the best results. A stockinette Velpeau bandage is applied and maintained for 10 to 14 days, until shoulder movement is comfortable. The patient is allowed to walk immediately.

RESULTS

Twenty-one surgical procedures were performed on 20 patients: 12 for right-sided deformities, nine for left; one

patient had bilateral deformities corrected. A clavicular osteotomy was performed in only one patient (Patient 11). Fifteen patients were girls and five boys. The age at operation ranged from 2 years 11 months to 15 years 10 months, with an average of six years six months. On average the patients were seen for follow-up 8 years 9 months after operation. The average age at follow-up was 15 years 3 months.

Associated congenital abnormalities were seen in all patients (Table II). The most common were Klippel-Feil deformities (as evidenced by incomplete segmentation of cervical vertebrae) in nine patients and scoliosis in nine. The most significant abnormalities included congenital heart disease (one patient), diastematomyelia (two patients), tethered cord (two patients), and a unilateral kidney (one patient). An omovertebral bone was found in nine of the 21 shoulders (43 per cent). Fourteen patients (70 per cent) had more than one associated abnormality.

Before operation, the average combined scapulo-humeral abduction in the 19 shoulders in which it was recorded was 110 degrees. After operation, 15 shoulders had an average of 147 degrees of combined abduction—an average improvement of 37 degrees.

Thirteen of the 14 patients questioned (93 per cent) expressed satisfaction with the result (Table III); these patients and their parents were grateful for the marked cosmetic improvement. The one dissatisfied patient had a severe deformity with significant spinal anomalies and scoliosis before operation and was left with a significant deformity at follow-up. This appeared to be due in part to the partial regeneration of the superior pole and the omovertebral bone as evidenced by serial radiographs.

The patients were given two ratings for their cosmetic appearance after operation (Table III). The first was a subjective evaluation (excellent, good, fair or poor) based on the patient's overall clinical appearance as judged by the examiner. Eleven of the 14 patients (79 per cent) were rated excellent or good, and three were rated fair or poor by this method. The second rating was an objective evaluation using the Cavendish (1972) grading: Grade 1, very mild (the shoulder joints are level and the deformity is invisible, or almost so, when the patient is dressed); Grade 2, mild (the shoulder joints are level, or almost level, but the deformity is visible when the patient is dressed showing as a lump in the web of the neck); Grade 3, moderate (the shoulder joint is elevated two to five centimetres and the deformity is easily visible). Grade 4, severe (the shoulder is much elevated, so that the superior angle of the scapula is near the occiput, with or without neck webbing or brevicollis). Twelve of the 14 patients (86 per cent) were rated Grade 1 or 2 after operation. There was one Grade 3 (Patient 1, the left side) and one Grade 4 (Patient 10).

An important index of the objective evaluation of these patients is the amount of scapular lowering obtained by surgical correction. However, it is also a difficult and

somewhat controversial measurement. Several authors (Jeannopoulos 1952; Woodward 1961) have pointed out that due to the hypoplastic nature of the affected scapula it is not reasonable to attempt to relocate the scapula so that the inferior poles are level. This would constitute an overcorrection and would put the neurovascular structures at particular risk of compression. Ross and Cruess (1977) recommended using the centre of the humeral heads as reference points to measure the amount of scapular lowering. This method, however, does not

Table II. Associated congenital abnormalities

	Number
Klippel-Feil syndrome	9
Scoliosis congenital	8
idiopathic	1
Omovertebral bone	9
Spinal column and rib abnormalities (other than congenital scoliosis)	8
Cleft palate	3
Diastematomyelia	2
Tethered cord	2
Congenital dislocation of the hips	2
Congenital heart disease	1
Lumbosacral lipoma	1
Myelomeningocele (sacral)	1
Unilateral kidney	1
Hypoplastic thenar eminence with reduction defects in thumb and index finger	1
Hearing loss	1
Accessory nipple	1
Bifid clavicle	1

Table III. Cosmetic results of the operation in 14 patients

	Number
<i>Opinion of patient or parent</i>	
Satisfied	13
Dissatisfied	1
<i>Subjective cosmetic grade</i>	
Excellent or good	11
Fair or poor	3
<i>Objective cosmetic grade*</i>	
Grade 1	7
Grade 2	5
Grade 3 or 4	2

* Cavendish grading (Cavendish 1972)

provide an accurate measurement in every case because it fails to consider the rotational component of the deformity; it can be shown that a significant deformity can still exist when the humeral heads are nearly level. Carson *et al.* (1981) suggested that the inferior angle of the scapula be used as the point of reference.

We recommend using the centrum of the scapula as the reference point. We feel that this allows a more accurate measurement of scapular position than the above alternatives because it considers both the vertical and rotational components of the deformity (Figs 4 to 7). The most superior and the most inferior borders of the scapula are marked and the distance between them measured. The midpoint of this line is the centrum. The

vertical distance between the centrum of the normal and the affected scapula is compared before and after operation. For bilateral deformities, each centrum is determined as above, but must be measured against a bony landmark on the spine. In the 14 patients for whom adequate radiographs before and after operation were available the average scapular lowering was two centimetres and the range was 0 to 3.7 centimetres (Table I).

The recommended age for operative correction of this deformity is three to five years according to Woodward (1961) and under six years according to Jeannopoulos (1961) and Cavendish (1972). It has been suggested that in patients younger than three years the

Fig. 4

Fig. 5

Patient 15 at the age of five years five months. Figure 4—Showing the right undescended scapula and the associated Grade 3 deformity. Figure 5—Pre-operative postero-anterior radiograph demonstrating the method of measurement of the relative scapular positions using the centrum of each scapula; there is a difference of 5.7 centimetres.

Fig. 6

Fig. 7

Patient 15 at the age of 12 years nine months (seven years four months after operation). Figure 6—A Cavendish Grade 1 deformity is seen. The surgical scar is acceptable. The lower lumbar scar is from the resection of his diastematomyelia (see Fig. 9). Figure 7—Postoperative postero-anterior radiograph demonstrating a residual difference of 2.3 centimetres, but the scapula has been lowered by 3.4 centimetres.

anatomy is more difficult to identify and the procedure therefore becomes technically more challenging. Older patients present with less plastic soft and hard tissues which are less adaptable to positional changes. In addition, older children may have become socially and psychologically maladjusted.

From our series it was difficult to specify criteria to define the optimal age for operative correction. No significant differences were found in any of the indices evaluated when we compared our patients over seven years of age with those under seven years of age at the time of operation.

The superior pole of the scapula was resected as part of the Woodward procedure in four patients. In three other patients the superior pole had been resected previously, usually several years before, as an initial attempt to achieve cosmetic improvement. One patient subsequently had the lower pole excised because it remained prominent (Patient 5). One young man had a Harrington instrumentation and fusion for scoliosis seven years after his scapular correction (Patient 3).

Complications. Surgical complications were few. One patient had a partial palsy of the brachial plexus; this was, however, temporary and was completely resolved two months after the operation. (This patient had not had a clavicular osteotomy.) One patient was felt to have had an exaggeration of the scapular winging that had been present before operation; no specific information could be gleaned from the notes as to any injury during operation. This complication has also been noted by Carson *et al.* (1981) who recommended that scapular winging before operation should be considered a relative contra-indication to this procedure. There were no wound infections.

The young lady with the worst cosmetic result (Patient 10) appeared to have reconstitution of the superior pole of the scapula and possibly of an omovertebral bar. According to the operation note, both structures had been resected extraperiosteally at the time of operation. However, over the years bone had again become visible in this area of the radiograph. This patient also has a significant scoliosis and webbing of the neck. The combination of these deformities makes for a poor cosmetic result. However, she does have 150 degrees of abduction and no complaints regarding function.

The reappearance of excised bone is an unusual occurrence in recent series. Jeannopoulos (1952) observed that resection of an omovertebral bar or the superior pole of the scapula by subperiosteal resection was associated with a high incidence of bony regrowth in the periosteal sleeve, but that extraperiosteal dissection and resection to include the periosteum could avoid this problem. We must assume that, in the patient described above, the periosteum was not completely excised.

The significant problem of spreading of the surgical scars that has been noted in other series (Jeannopoulos 1952; Cavendish 1972; Carson *et al.* 1981) was again

evident in our patients, but to a lesser degree. All scars were subjectively graded good, apart from one which was graded fair. The scar always tended to spread more in the proximal half of the incision; this portion is subject to more movement, and therefore more stress, than the midthoracic portion. The scars of those patients operated on more recently using a subcuticular closure of absorbable synthetic suture were better than those of older operations in which standard skin closures and non-absorbable sutures were used.

DISCUSSION

Congenital undescended scapula is the most common congenital abnormality of the shoulder (Pinsky *et al.* 1980). It should, for accuracy, be regarded as a "general disturbance" of development in which the scapula participates (Horwitz 1908). Associated congenital abnormalities are identified in nearly all reported patients, and must be searched for in each new patient seen with a congenital undescended scapula. Indeed, the associated abnormalities may be more significant to the child's well-being than the obvious scapular deformity. Von Bazan (1979) has recently reported on the association between this deformity and diastematomyelia of which he found nine cases in 46 patients with undescended scapulae. In our series two patients were identified with a documented diastematomyelia (Figs 8 and 9). There were also two patients with a tethered cord and one with a lumbosacral lipoma, all of whom presented with neurological findings. These patients are also at greater risk of having significant renal abnormalities (Hensinger, Lang and MacEwen

Fig. 8

Fig. 9

Figure 8—Patient 16. A pre-operative anteroposterior myelogram demonstrating a defect at L3. Figure 9—Patient 15. An anteroposterior view of the lumbar spine demonstrating the diastematomyelia at the L4 level. There are also posterior arch defects visible at L3 and L5 levels.

Fig. 10

Fig. 11

Patient 7. Figure 10—A pre-operative anterior view at the age of 15 years 10 months showing a Grade 3 deformity. Figure 11—A posterior view six years seven months after operation. There is now a Grade 1 deformity. Although the proximal scapula is still prominent posteriorly, the neck contour is markedly improved. The patient was very satisfied with the postoperative cosmetic improvement. (Note, Figures 10 and 11 also demonstrate the decreased lateral width of the right shoulder compared to the normal left shoulder. This decrease is due to the involvement of the entire shoulder girdle in the pathological process.)

1974; Pinsky *et al.* 1980); Hensinger *et al.* (1974) have suggested that intravenous pyelography should be an integral part of their assessment.

Once the general assessment has been completed, then the treatment of the scapula itself must be considered. Both the cosmetic and the functional aspects of the deformity are important, although "appearance is the usual indication for treatment and the yardstick of its success" (Cavendish 1972). Not every patient who presents with an undescended scapula warrants operative treatment; those with a minor cosmetic deformity or minimal functional impairment will not benefit appreciably from operation. Our operative goals are to improve the appearance of the scapula and the neck to the point where the deformity is not noticeable when the patient is dressed; and to increase the combined shoulder abduction where there is significant limitation.

The optimal age for operative correction was not proven in the present series. It was shown, however, that age is no longer a specific contra-indication. Scapular transplantation was performed successfully with good long-term results in children up to 15 years old (Figs 10 and 11). Other authors have stated that children over six years of age are unsuitable for such procedures (Jeannopoulos 1952; Cavendish 1972). We recommend, however, that the correction be performed between the ages of three and eight years; at this age the anatomy is sufficiently developed and yet a state of biological plasticity is still available to accommodate the changes induced by operation.

No single procedure can be expected to produce a perfect appearance in many of these children whose deformity is often due to several factors. The short, webbed neck of Klippel-Feil's syndrome, the rib and chest wall anomalies, and the scoliosis all add to the clinical deformity but are not ameliorated by any

procedure that primarily aims to correct only the position of the scapula.

The previous reports of Schrock (1926), Jeannopoulos (1952; 1961), Cavendish (1972) and Ross and Cruess (1977) document an unacceptable rate of incomplete correction or of recurrent deformity following simple excision of the superomedial part of the scapula and the omovertebral bone, or when the scapula was transplanted distally using a proximal (scapular) muscle release. The information available on those patients corrected using the Woodward procedure (Woodward 1961; Cavendish 1972; Pinsky *et al.* 1980; Carson *et al.* 1981) shows that it is a more reliable means of obtaining and maintaining significant clinical improvement. It also offers several practical advantages over previously described procedures: the approach is midline; the scapular dissection is less extensive; and the scapula is held in its new position by a more physiological transplantation of the muscular aponeurosis which is sutured in place without the need for wires or springs that may later require removal (Cavendish 1972).

We do not recommend a clavicular osteotomy as a routine part of the procedure. Although the clavicle is a component of the deformity, it is usually not necessary to osteotomise it in order to achieve significant improvement. Our series shows that as long as the attempted correction is not overvigorous, operation is quite safe. We use clavicular osteotomy in those patients where more correction is desired, and an extra step is indicated to diminish the risk of neurovascular compression that may occur between the clavicle and the deformed chest wall (Robinson *et al.* 1967).

Based on the review of the literature and the results of this series, the Woodward procedure appears to be the best surgical procedure available for the correction of congenital undescended scapula.

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