Long-Term Results of Modified Green Method in Sprengel's Deformity

Emel Gonen · Umit Simsek · Sukru Solak ·
Bulent Bektaser · Yalim Ates · Erbil Aydin

Received: 12 October 2009 / Accepted: 7 May 2010 / Published online: 26 May 2010
© EPOS 2010

Abstract

Aim Congenital undescended scapula (Sprengel deformity) is a rare deformity that is reported in the literature mostly as small case series with short- or medium-term follow-up periods. Here, we aimed to present the long-term results of this deformity treated with modified Green procedure.

Method The modified Green procedure was performed in 24 patients (28 shoulders) with Sprengel deformity. Clavicular osteotomy accompanied in all, and omovertebral bone excision in 13 shoulders. The mean age of the patients at the time of surgery was 4.5 years (range 1.5–17 years). Mean follow-up period was 11 years 4 months (4.3–17 years). Preoperative cosmetic appearance was noted as Cavendish III in 17 shoulders and as IV in 11 shoulders. In addition to the Cavendish scale, shoulder abduction, shoulder asymmetry, and scapular elevation and medialization were evaluated.

Results The decrease in scapular elevation and Cavendish scale, and the improvement in shoulder abduction and scapular medialization postoperatively were statistically significant ($P < 0.001$). Cosmetic improvement of at least one Cavendish grade were attained in 88.9% of shoulders. One patient (unilateral) who was Cavendish grade IV preoperatively died in the early postoperative period from unrelated causes. Of the remaining 10 preoperatively grade IV shoulders, 2 remained at the same grade, 1 improved to grade III, and 7 shoulders to grade I. Of the 17 preoperatively grade III shoulders, 1 shoulder stayed the at same grade, 7 shoulders improved to II, and 9 shoulders to grade I. Postoperative winging in 2 shoulders and hypertrophic scarring in 6 shoulders were noted.

Conclusion The modified Green procedure is a relatively safe and reliable method in the treatment of severe Sprengel deformity cases and provides highly constructive and aesthetic results in the long term.

Keywords Sprengel's deformity ·
Congenital high scapula · Modified Green procedure

E. Gonen · U. Simsek · Y. Ates
2nd Clinic of Orthopedics and Traumatology,
Ankara Diskapi Teaching and Research Hospital,
Diskapi, Ankara, Turkey

S. Solak · B. Bektaser
2nd Clinic of Orthopedics and Traumatology,
Ankara Atatürk Teaching and Research Hospital,
Bilkent, Ankara, Turkey

E. Aydin
1st Clinic of Orthopedics and Traumatology,
Ankara Diskapi Teaching and Research Hospital,
Diskapi, Ankara, Turkey

E. Gonen (✉)
Asmabahce G-30, Koru, Ankara, Turkey
e-mail: emelgonen@yahoo.com

Introduction

Sprengel deformity, or congenital undescended scapula, is the result of insufficient caudal migration of the scapula during the 9th–12th weeks of the embryologic period [1, 2]. In this pathological condition, the deformity affects not only elevation of the scapula; scapula adduction and medialization, side bending of the glenoid cavity with distal rotation, prominence of the upper corner of the scapula, abnormalities in the cervicothoracic vertebrae or thoracic rib cage, and change in clavicle position have also been detected [1, 3, 4]. Omovertebral bone is observed in

16–55% of Sprengel deformity cases [3, 5–7]. This rare deformity is always seen with either cosmetic or functional disturbances. Because of scapulothoracic stiffness and an inferiorly rotated glenoid, abduction of the shoulder is limited [8]. It may also be associated with multidirectional shoulder instability [9]. Although no improvement or worsening is reported in untreated grade I and II patients, surgery is recommended in Cavendish III and IV deformity when the superomedial angle of the scapula is above C6 [7]. The aim of surgical treatment is correction of the cosmetic deformity and improvement in extremity function, to the extent possible. There are conflicting opinions about the treatment of Sprengel deformity. The two most important considerations in the management of this deformity are decisions on whether or not to operate, and the type of surgical procedure to be performed [3, 10].

The degree of surgical correction of the limited shoulder abduction cannot always be predicted before surgery. With mild deformities, usually no surgical treatment is necessary [3, 11]. In the event of surgical treatment, the results are not always predictable and good [3]. The most probable reason is the coexistence of this deformity with soft tissue contractures and malformations. Several surgical methods have been defined for the surgical treatment of Sprengel deformity [1, 8, 11–14]. The aim of this study was to present our treatment results with this rare deformity using a modification of the Green method described in the article by Leibovic et al. [10] accompanied with clavicular osteotomy [13].

Materials and methods

A retrospective evaluation of the modified Green procedure in congenitally high scapulae was performed in 24 patients with 28 affected shoulders with Cavendish grade III and IV deformities between January 1992 and August 2009. One of the patients died in the early postoperative period from apparently unrelated causes, leaving 23 patients with 27 affected shoulders to comprise the study group for whom we have adequate clinical follow-up. All patients gave their informed consent prior to inclusion in the study. This retrospective study was approved by the appropriate ethics committee and was therefore performed in accordance with the ethical standards set forth in the 1964 Declaration of Helsinki.

The mean age of the patients at the time of surgery was 4.5 years (range 1.5–17 years), and the mean follow-up time was 11 years, 4 months (4.3–17 years). In four patients, the deformity was bilateral. Congenital scoliosis was observed in three, Klippel-Feil syndrome in two, and renal agenesis in one case. The modification of the Green method by Ehrlich as described in an article by Leibovic

et al. [10] was performed in 24 patients (16 female, 8 male) for surgical treatment. Clavicular osteotomy was also performed in supine position just before scapular transposition in all cases as suggested [4, 5, 15] and omovertebral bone excision in 13 shoulders. In order to perform the osteotomy carefully, neurovascular structures beneath the clavicle were protected by an “S” retractor during the procedure. Drilling by Kirschner wire was performed to create several holes on the anterior part of the clavicle before applying the osteotomy. The method used by Green involves extraperiosteal detachment of the medial and superior scapular muscles, extraperiosteal excision of the supraspinous region of the scapula, caudad positioning of the scapula in a more natural position, reattachment of the muscles to the lowered scapula, and preservation of the position of the scapula with postoperative spring traction. In the modified Green’s method used in this study, the scapula was repositioned into a pocket that was created in the latissimus dorsi. The inferior angle of the scapula was placed into this pocket and rotated laterally. There was no need for wire or suture traction. The scapula was preserved in its caudad position by rejoining the muscles, in particular the serratus anterior, with care. After immobilization of the shoulder with a sling for 4 weeks, the patient began active range-of-motion exercises and then proceeded to exercises to strengthen the muscles, focusing on the abductors as suggested [10].

Cavendish classification [3] was used in order to assess cosmetic appearance and to grade deformity. Grade I (very mild)—the shoulder joints are level and the deformity is invisible when the patient is dressed; grade II (mild)—the shoulder joints are level, but the deformity is obvious when the patient is dressed, as a lump in the web of the neck; grade III (moderate)—the shoulder joint is elevated 2–5 cm with obvious deformity; grade IV (severe)—the affected shoulder is elevated, meaning that the superior angle of the scapula is near the occiput. Seventeen shoulders were classified as Cavendish III, and 11 as Cavendish IV preoperatively. Range of motion of abduction was measured to evaluate function. The distance of elevation of the scapula [16] was measured by the distance between the inferior scapular corners of each side. For bilateral deformities, each point was measured against a bony landmark on the spine. Medial displacement was calculated by measuring the distance between the medial border of the scapula and a vertical line over the C7 spinous process. In addition to the distances of elevation and medialization of the scapula, shoulder asymmetry was measured. Evaluation of postoperative shoulder asymmetry was done according to the center of the humeral head level difference that was described [17]. Objective measurement of scapular lowering is difficult and controversial due to the hypoplastic nature of the affected scapula, and it would be

unreasonable to relocate the scapula so that inferior poles are at the same level [18]. There is also controversy about measurements using the center of the humeral head, which may not reflect the rotational component [16]. In view of the above, we added the distance of elevation and medialization of the scapula as additional criteria for measuring scapular lowering and used the Cavendish scale for cosmetic improvement.

Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS) 11.5 software (SPSS, Chicago, IL). Whether the data were distributed normally or not was determined using the Shapiro Wilk test. Because one unilateral patient died in the postoperative early period, statistical analysis comparing the preoperative and postoperative results included 23 patients (27 shoulders). The differences between pre- and post-measurements were evaluated by Wilcoxon sign rank test. A *P* value less than 0.05 was considered statistically significant.

Results

The differences in pre- and post-operative abduction angles, scapular elevation, medialization and Cavendish score were statistically significant ($P < 0.001$) in 23 patients (27 shoulders) with a mean follow-up of 11 years, 4 months (4.3–17 years; Table 1).

The distribution of our cases postoperatively according to the Cavendish scale was as follows: of the 11 shoulders that were Cavendish IV preoperatively, 1 patient (1 shoulder) died postoperatively at the 3rd month; 2 shoulders remained as Cavendish IV; 1 shoulder improved to III; and 7 shoulders improved to II postoperatively. Of the 17 shoulders that were Cavendish III preoperatively, 1 shoulder remained as III, 7 shoulders improved to II and 9 shoulders to I. At the final follow-up, shoulder asymmetry was excellent or satisfactory in 85.2% of shoulders (Fig. 1), and a cosmetic improvement of at least one Cavendish grade were attained in 88.9% of shoulders postoperatively.

It was not possible to obtain a result for optimum age for surgery because almost all operations were performed

before the age of 6 years (mean age was 4.5) and we had very few older cases.

One patient died in the 3rd month after surgery from apparently unrelated causes. Of the 23 remaining patients, a girl with bilateral deformity had skin necrosis on the second shoulder following surgical intervention, but this necrosis healed uneventfully without sequelae. In 21 of the shoulders, surgical scarring was assessed as minimal while in the remaining 6 shoulders it was hypertrophic. We encountered postoperative winging in 2 shoulders, the electromyograms (EMGs) of which were interestingly assessed as normal in the follow-ups. No brachial plexus lesion was observed in any of our cases. No systemic or local complications were seen in any of the remaining patients.

Discussion

Sprengel deformity is a rare malformation, and as such, only two large case series have been reported [3, 4]. The largest included 100 patients, but only 34 were operated, with scapuloplasty in 5 cases [3]. In the other study of 37 cases, 23 patients were operated (2 Green and 6 Woodward) [4]. Nevertheless, the number of scapuloplasty (transplantation) cases in these studies was very small. The remaining literature on Sprengel deformity consists of small numbers of cases ranging between 2 and 21 patients with a mean follow-up of 2 to 12 years, with most being short–medium term [2, 3, 5, 7, 8, 12–16, 18–25] and rarely long term [4, 26, 27]. Moreover, the results are presented according to different means of evaluation, such as patient satisfaction, cosmetic appearance alone, function, or Rigault's radiologic classification, and they involve various types of surgery in a small number of patients, which also makes comparisons difficult.

This congenital structural abnormality of the shoulder girdle does not respond to conservative management. Sprengel deformity, if left untreated until adulthood, may become painful [22]. As already mentioned, several surgical methods have been defined for the surgical treatment of Sprengel deformity [2, 8, 12–14]. The most frequently

Table 1 Evaluation of the results of shoulder abduction, scapular elevation and medialization, and the Cavendish scale of patients pre- and post-operatively

	Pre-operatively		Post-operatively		<i>P</i> value
	Mean $\pm$ SD	Median (minimum–maximum)	Mean $\pm$ SD	Median (minimum–maximum)	
Shoulder abduction	101.30° $\pm$ 17.62°	105° (70°–130°)	145.93° $\pm$ 20.71°	145° (95°–175°)	$P < 0.001^*$
Scapular elevation	3.58 $\pm$ 1.84 cm	2.5 cm (2–7.6 cm)	1.19 $\pm$ 0.79 cm	1.5 cm (0–2 cm)	$P < 0.001^*$
Scapular medialization	3.20 $\pm$ 0.60 cm	3.2 cm (2.2–4 cm)	5.84 $\pm$ 0.68 cm	6.0 cm (4.5–7 cm)	$P < 0.001^*$
Cavendish scale	3.37 $\pm$ 0.49	3 (3–4)	1.89 $\pm$ 0.85	2 (1–4)	$P < 0.001^*$

* *P* values < 0.05 were considered statistically significant

Fig. 1 Elevation and rotation of the scapula observed on the right shoulder of a five-year-old girl with Cavendish grade III deformity. **a** Preoperative posteroanterior trunk radiography. **b** Postoperative posteroanterior radiography of the thorax showing improvement in scapular elevation and medialization. **c, d** Photographic images at 17 years of age following the modified Green operation showing good cosmetic result (**c**) and excellent right arm abduction (**d**)

performed surgical procedures for depression of an abnormally elevated scapula are the techniques of Klisic [28], Schrock [2], Green [5, 10, 12, 15, 19], and Woodward [4, 14, 16, 20, 21, 23, 26, 29], vertical scapular osteotomy [13, 27], Mears inferomedial resection of the scapula [8, 18], superomedial resection of the scapula [3, 10, 25], and resection of the omovertebral bone [22], with or without partial resection—osteotomy—of the clavicle [13]. If there is a functional disturbance of the involved upper extremity, surgical choices other than excision of the upper corner of the scapula must be considered [4]. Green [12] proposed excision of the omovertebral bone and supraspinatus part of the scapula with the release of the muscles over the scapula, while Woodward [14] suggested the transportation of the origin of the trapezius muscle to the lower levels over the spinous processes. Although the Woodward technique is mentioned more frequently in the literature

[3, 4, 7, 14, 16, 20–22, 29] than Green's [5, 10, 15, 19], both scapuloplasty techniques produce similarly good results. While deciding the type of the surgery to be performed, it is also important to be aware that concomitant regional anomaly and the presence of associated spinal deformities may have an adverse effect on the outcome [7].

We agree with Andrault et al. [19], who reported Green's method as providing a good visualization of the superomedial scapular angle and better access to the acromiothoracic vasculonervous pedicle. An advantage of this method is that the lever arm relative to the scapular center of rotation is enlarged by intraoperative exposition of the scapula and by muscular reinsertion at a different site on the scapula [19].

In Green's technique, the scapula is both lowered and rotated in the frontal plane [19]. It was noted that although the original malrotation of the scapula was corrected

initially, it usually recurred after 2 years but did not affect the large increase in abduction or lowering postoperatively over time [10]. Considering the results of the current study, the authors do not agree with the idea of the deterioration of the corrected malrotation of the scapula after 2 years (Fig. 1d).

The mean increase in total shoulder abduction was 44.6° in our series of 23 patients. Similar results, with a range of 16° in 12 patients [5], 52.5° in 6 [19], 57° in 18 [10], to 77° in 7 patients [15], were reported using modified Green. With the Woodward procedure, results of 37° in 21 [23], 29–50° in 11 [16], and 51° in 21 patients; and with Mears osteotomy, abduction improvement of 60° in 8 patients [8], 64° in 14 patients [18]; and with scapular osteotomy, results of 46° in 12 [13] and 53° in 12 [27] patients were published. Excellent and good results were observed in 88.9% of our study, which was in accordance with the literature using the Green procedure [5, 10, 15, 19], the Woodward procedure [16, 20, 21, 23, 24, 26, 29], Mears partial resection technique [8, 18] and interestingly, when using partial scapulectomy [25]. Nevertheless, Cavendish et al. [3] questioned the functional impairment after scapular transplantation and warned against cosmetic deterioration in the long term. But scapular transplantation—using only the Woodward method—was performed in a very limited number (5 of 100) of their patients.

When scapular transplantation (Green or Woodward) procedures are required (Grade III and IV), it is recommended that it be performed as soon as possible after 2 years of age, but certainly by five [14], six [3, 10] or 8 years of age [22] at the latest. In children under 6–8 years of age, soft tissues will be more flexible and better correction can be obtained, and early operation allows for continued growth and development. In older children, brachial plexus injury may occur by trying to bring the scapula inferiorly because of less flexible tissues [12]. There is also some literature noting no significant difference in any of the functional or cosmetic results when compared to the age of the patients at the operation, although those observations were noted following application of the Woodward technique [4, 16, 23]. Some authors believe that while age of the patient at the time of the operation and presence of an omovertebral bone did not enhance the results, the presence of important cervical spinal deformities and Klippel-Feil syndrome had a poor prognosis [21]. As all of our patients except two were operated under the age of 6, the distribution of our patients did not allow us to draw a firm conclusion about the correlation between age at the operation and cosmetic-functional results. We agree that in patients younger than 3 years, identification of the anatomy is more difficult and the operation would be technically more demanding [14].

Although brachial plexus lesion is the most important complication cited in the literature [16], this complication due to scapular transfer and also to the close vicinity of the clavicle to the neurovascular structure was not observed in any of our cases. Clavicular osteotomy was recommended by Andrault et al. [19] as a “must” systematically if intraoperative monitoring is not available. As we performed clavicular osteotomy in all cases, we did not encounter this neurovascular impairment using the modified Green method, even in older patients.

Unfortunately, we found postoperative winging of the scapula in two cases. We think that this may be the result of muscle imbalance or of failure to reattach the serratus anterior to the scapula, as no neurologic impairment was noted in postoperative EMG evaluations. The etiology of this winging is not described in the literature [10].

In terms of keloid formation risk and postoperative scarring, better results were reported using the Woodward method than Green [4]. However, a rate of up to 60% of unsightly scar formation using the Woodward technique was reported in some series [16], while this was observed in 22.2% of shoulders with the modified Green technique in the present study. Some authors [10, 16, 20, 21, 23] also reported 57–86% excellent–good cosmetic results, which is similar to our results.

Although the number of cases in the present study is limited compared to some larger series [3, 4], and despite the newer methods that have been defined recently in the literature [8], our good results of functional and cosmetic improvement in addition to patient satisfaction encourage us to continue to use the modified Green technique at least into the near future.

In conclusion, Cavendish et al. [3] emphasized improvement in appearance as the primary aim of treatment and reported that improvement in function is uncertain and that cosmetic appearance often deteriorates during a period of rapid growth of the neck. However, we believe that a properly applied modified Green procedure in severe cases is a safe and predictable method in the treatment of this complex deformity. Furthermore, it provides highly favorable functional and cosmetic results in the long term.

Acknowledgments No funds were received in support of the study.

References

1. Beaty JH (2003) Congenital anomalies of trunk and upper extremity. In: Canale ST (ed) *Campbell's operative orthopaedics*, 10th edn. CV Mosby, St. Louis, pp 1125–1140
2. Schrock RD (1926) Congenital elevation of the scapula. *J Bone Joint Surg Am* 8:207–215 (reprinted in: Brand RA (2008) *The Classic. Congenital elevation of the scapula: Robert D. Schrock MD (1884–1960). The 9th president of the AAOS 1940. Clin Orthop Relat Res* 466(1):74–80. doi:10.1007/s11999-007-0025-2)

3. Cavendish ME (1972) Congenital elevation of the scapula. *J Bone Joint Surg* 54B(3):395–408
4. Greitemann B, Rondhuis JJ, Karbowski A (1993) Treatment of congenital elevation of the scapula. 10 (2–18) year follow-up of 37 cases of Sprengel's deformity. *Acta Orthop Scan* 64(3):365–368. doi:[10.3109/17453679308993646](https://doi.org/10.3109/17453679308993646)
5. Aydinli U, Ozturk C, Akesen B, Ozer O (2005) Surgical treatment of Sprengel's deformity: a modified Green procedure. *Acta Orthop Belg* 71(3):264–268
6. Cho TJ, Choi IH, Chung CY, Hwang JK (2000) The Sprengel deformity. Morphometric analysis using 3D-CT and its clinical relevance. *J Bone Joint Surg Br* 82(5):711–718. doi:[0301-620X/00/510389](https://doi.org/10.1055/b-000510389)
7. Farsetti P, Weinstein SL, Caterini R, De Maio F, Ippolito E (2003) Sprengel's deformity: long-term follow-up study of 22 cases. *J Pediatr Orthop B* 12(3):202–210. doi:[10.1097/01.bpb.0000049568.52224.1e](https://doi.org/10.1097/01.bpb.0000049568.52224.1e)
8. Mears DC (2001) Partial resection of the scapula and a release of the long head of triceps for the management of Sprengel's deformity. *J Pediatr Orthop* 21(2):242–245
9. Hamner DL, Hall JE (1995) Sprengel's deformity associated with multidirectional shoulder instability. *J Pediatr Orthop* 15(5):641–643
10. Leibovic SJ, Erlich MG, Zaleske DJ (1990) Sprengel deformity. *J Bone Joint Surg* 72A:192–197
11. Tachdjian MO (1990) Congenital deformities. In: Tachdjian MO (ed) *Tachdjian's pediatric orthopedics*, 2nd edn. Saunders, Philadelphia, pp 136–168
12. Green WT (1957) The surgical correction of congenital elevation of the scapula (Sprengel's deformity). *J Bone Joint Surg* 39A:1439–1448
13. Robinson R, Braun R, Mack P, Zadek R (1967) The surgical importance of the clavicular component of Sprengel's deformity. *J Bone Joint Surg Am* 49-A:1481
14. Woodward JW (1961) Congenital elevation of the scapula. Correction by release and transplantation of muscle origins. A preliminary report. *J Bone Joint Surg* 43A:219–228
15. Bellemans M, Lamoureaux J (1999) Results of surgical treatment of Sprengel deformity by a modified Green's procedure. *J Pediatr Orthop B* 8(3):194–196
16. Carson WG, Lowell WW, Whiteside TE (1981) Congenital elevation of the scapula. Surgical correction by the Woodward procedure. *J Bone Joint Surg* 63A:1199–1207
17. Ross MD, Cruess RL (1977) The surgical correction of congenital elevation of the scapula. *Clin Orthop* 125:17–23
18. Masquijo JJ, Bassini O, Paganini F, Goyeneche R, Miscione H (2009) Congenital elevation of the scapula: surgical treatment with Mears technique. *J Pediatr Orthop* 29(3):269–274
19. Andrault G, Salmeron F, Laville JM (2009) Green's surgical procedure in Sprengel's deformity: cosmetic and functional results. *Orthop Traumatol Surg Res* 95(5):330–335. doi:[10.1016/j.otsr.2009.04.015](https://doi.org/10.1016/j.otsr.2009.04.015)
20. Borges JL, Shah A, Torres BC, Bowen JR (1996) Modified Woodward procedure for Sprengel deformity of the shoulder: long-term results. *J Pediatr Orthop* 16(4):508–513
21. Ciaudo O, Bensahel H, Desgrippes Y, Csukonyi Z (1984) Therapeutic remarks on the congenital elevation of the scapula. Apropos of 16 cases (in French). *Chir Pediatr* 25(1):58–63
22. Doita M, Iio H, Mizuno K (2000) Surgical management of Sprengel's deformity in adults. *Clin Orthop* 371:119–124
23. Grogan DP, Stanley EA, Bobechko WP (1983) Congenital undescended scapula. Surgical correction by the Woodward procedure. *J Bone Joint Surg* 65B(5):598–605
24. Khairouni A, Bensahel H, Csukonyi Z, Desgrippes Y, Pennecot GF (2002) Congenital high scapula. *J Pediatr Orthop B* 11(1):85–88
25. Zhang ZM, Zhang J, Lu ML, Cao GL, Dai LY (2007) Partial scapulectomy for congenital elevation of the scapula. *Clin Orthop Relat Res* 457:171–175. doi:[10.1097/BLO.0b013e31802db115](https://doi.org/10.1097/BLO.0b013e31802db115)
26. Le Saout J, Lefevre C, Kerboul B, Fenoll B, Miroux D, Courtois B (1987) Congenital elevation of the scapula (in French). *J Chir (Paris)* 124(3):181–183
27. McMurtry I, Bennet GC, Bradish C (2005) Osteotomy for congenital elevation of the scapula (Sprengel's deformity). *J Bone Joint Surg* 87B:986–989. doi:[10.1302/0301-620X.87B7.16148](https://doi.org/10.1302/0301-620X.87B7.16148)
28. Klisić P, Filipović M, Uzelac O, Milinković Z (1981) Relocation of congenitally elevated scapula. *J Pediatr Orthop* 1(1):43–45
29. Langlais J, Rigault P, Pouliquen JC, Padovani JP, Janklevicz P (1989) Long-term results of surgical treatment of congenital elevation of the scapula (in French). *Rev Chir Orthop Reparatrice Appar Mot* 75(5):318–328