Our experience and early results with a complementary implant for the correction of major thoracic curves

Zoltán Csernátó · László Kiss · Sándor Manó ·
Zsolt Hunya

Received: 4 June 2012 / Revised: 23 January 2013 / Accepted: 26 January 2013 / Published online: 8 February 2013
© Springer-Verlag Berlin Heidelberg 2013

Abstract

Purpose In our article, we would like to introduce a new auxiliary implant called the CAB hook, for use in posterior approach scoliosis surgery.

Methods Since 2007, we operated 42 patients with the CAB hook with an average preoperative Cobb angle of 59.3° (28° – 92°). In three cases, the posterior approach was preceded by ventral release and Halo traction. In four cases, besides the CAB hooks, SCS hooks and pedicular screws, in three cases both CAB and SCS hooks, in nine cases CAB hooks with SCS pedicular screws, and in 23 cases, only CAB were used. The average follow-up time was 21.6 month (2–51).

Results All the patients are satisfied with the results. No reoperation was needed due to the loss of correction, pain, implant failure, or infection. The average postoperative Cobb angle decreased to 24.7° (4° – 60°). Based on this we calculated the Cincinnati Correction Index (CCI), which was 1.53 (0.7–4.8), which means that our correction exceeded the flexibility of the spine based on the lateral bending X-ray by 53 %.

Conclusion As with all new surgical techniques and implants after the short learning curve, we were able to improve the degree of correction and decrease the time of surgery. One of the advantages of the CAB hook is that besides a few implant-specific instruments, no special instrumentation is required for insertion, and image intensifier need not be used.

Keywords Scoliosis · CAB implant · Spine surgery · Spine deformity

Introduction

Over the past century, the surgical treatment of scoliosis has developed dramatically. The first major milestone for surgical treatment came in the 1960s with the introduction of the Harrington method, which was a major breakthrough [11]. As experience grew, it was later realized that this method provides correction in only one plane. Later sublamina wiring was introduced for the treatment of neuromuscular scoliosis, which after numerous modifications is still in use today [14, 15]. However, enormous research began in search of a better correction technique in idiopathic scoliosis. The second major breakthrough came in 1984 with the introduction of the Cotrel–Dubousset (CD) technique [5, 6], which by using two rods, a combination of pedicular, laminar and transverse hooks with pedicular screws and the so-called derotation technique promised a bright future for the treatment of scoliosis. In 1990, the first author had the opportunity to get acquainted with this technique first hand. However, his early positive enthusiasm about the technique soon led to confusion and criticism of the technique, as it was not providing the proper correction in all three planes as primarily intended, especially considering the rotation of the vertebra [9]. Worldwide, including our team began research on implant modification to better achieve correction in all planes. One of these implant modifications is the so-called bipedicular spinal fixation device (BSF) [3] and the Universal Clamp [16]. Although the BSF was biomechanically tested and clinical introduction was mentioned, we were not able to

Z. Csernátó (✉) · L. Kiss · S. Manó · Z. Hunya
Department of Orthopaedics, University of Debrecen Medical
Health and Science Center, Nagyterdei Krt. 98,
Debrecen 4032, Hungary
e-mail: csz@dote.hu; csz@med.unideb.hu

find clinical results in the literature, and studying it, we have our doubts about its ability to control vertebral tilt.

The first author began in-depth research trying to find the biomechanical origin of the development of a scoliotic curve. Based on his experiment the “Rotational preconstraint” theory was described as one plausible cause for idiopathic curve formation [7]. The next step was to oppose a correcting force to this curve forming force. The easiest way was to apply a force tilting the vertebrae inversely. However, it was clear that if this were achieved by a simultaneous bilateral grasp as lateral as possible this would assure the smallest charge on the instrumented vertebrae. Therefore, the hooks’ end was put in the two costotransversal spaces. This way the so-called CAB hooks (Sanatmetal, Eger, Hungary) were created, CAB being the acronym of the French *Corhet à Appui Bilatéral*, meaning Bilaterally Pushing Hooks [8].

The new implant is an auxiliary one to all systems working according to the CD principle that is using two parallel rods. Its use also resolved one of the main problems of the CD technique: the relatively modest derotation of the rotated thoracic vertebrae, one major contradiction of the CD principle [9]. One proof of the insufficient derotation achievable by the classical CD technique beside criticism was the introduction of the in situ bending technique [12].

Regarding the belief that the transverse process is fragile, the authors carried out thorough investigations confirming its mechanical reliability when charged close to its base, like it is in the case with the loaded CAB hooks [10]. Although there is no doubt about the mechanical effectiveness of pedicular screws, however, the need in high tech instrumentation [2, 17] and despite that the high rate of screw misplacement [1] underline the usefulness of an easy to use and effective implant as the CAB hook is.

Materials and methods

The CAB implants are simple in structure. They are made in two main forms, symmetrical and asymmetrical, in various sizes (Fig. 1). They are “horseshoe” shaped, and both of their hooked ends are designed in such a way that either cranially or caudally they circle around the basis of

the transverse processes and are fixed in the costotransverse space. The two rods are connected onto the CAB hook by means of two screw-fastened latches.

The patients are operated through the usual posterior approach in prone position on a spine surgical table [4]. The paravertebral muscles are detached and the transverse processes are identified. Next, the spinous processes are removed and if fusion is required, the facet joints are damaged. Only a few implant-specific instruments are required for the insertion of the hook (Fig. 2). First by using the special CAB rasp (Fig. 2a). The place of the CAB hooks is made in the costotransversal space. The use of an image intensifier is not necessary for the proper placement of the hooks. With the aid of the CAB template which is available in, symmetric, left, and right forms, the proper size of the CAB hook required is determined (Fig. 2b). If the required hook happens to fall between two available sizes then with the bending iron the smaller one could be opened or the larger one could be closed (Fig. 2c). Following this with the CAB grasp, the desired hooks are placed into the costotransversal space (Fig. 2d). Our recommendation in right convex scoliosis is placing two symmetrical hooks facing each other on the cranial and caudal end vertebral pairs and using right hooks on the remaining cranial instrumented vertebra until the apical one then switching to left hooks the rest of the way down until reaching the end vertebral pairs. This way there are opposing hooks at the apical part of the curvature. When the hooks are in place the two rods are introduced in the usual manner, and correction of the curve is done both through the rods and with the special CAB rotator (Fig. 2e). The individual left and right CAB hooks can be forced to rotate in the desired direction.

Between 2007 September and 2011 October we applied the CAB implant in 42 scoliosis cases. As it is an auxiliary implant, we used 6 mm rods from SCS (Eurosurgical, Beaurains, France). In three cases, the posterior approach was preceded by ventral release and Halo traction. In four cases besides the CAB hooks, SCS hooks and pedicular screws, in three cases both CAB and SCS hooks, and in nine cases CAB hooks were used with SCS pedicular screws. From 2009, Lumbar CAB hooks became available therefore the remaining 23 cases were instrumented only with CAB hooks (Fig. 3). In 13 cases we performed

Fig. 1 The right and left (asymmetric) and symmetric CAB hooks

Fig. 2 Implant-specific instruments. **a** The special CAB hook rasp. **b** The CAB template to determine the size of the required hook. **c** The bending iron used to open or close hooks if the desired size falls between available sizes. **d** The CAB grasp used for the proper placement of the hooks. **e** The CAB rotator used to rotate the individual hooks

Fig. 3 14-year-old girl's pre and postoperative X-rays

instrumentation without fusion (or just in the apical region on the convex side), because of the young age and expected further growth of the patient. In these cases after the cessation of growth, another surgery was or will be performed for further correction and full fusion [18]. In the rest of the cases, primary fusion was performed with autologous and heterologous bone grafting. All the operations were performed by the same team.

The gender ratio was 7.4:1 (37 female:5 male). The average age of the patients at the time of operation was 17 (11–46). The average follow-up time was 21.6 months (2–51). The average preoperative Cobb angle was 59.3° (28°–92°), and the average lateral bending was 35.2° (4°–78°) when the patient bent towards the convex side. We classified the curves according to King and Moe [13].

According to the relevant literature, we calculated the Cincinnati Correction Index (CCI) [19] using the following ratios:

$$\begin{aligned} \text{Preoperative Flexibility (PF) (\%)} \\ &= \frac{\text{Preoperative Erect Cobb angle} - \text{Supine bending Cobb angle}}{\text{Preoperative Erect Cobb angle}} \\ &\times 100 \end{aligned}$$

$$\begin{aligned} \text{Postoperative Correction (POC) (\%)} \\ &= \frac{\text{Preoperative Erect Cobb angle} - \text{Postoperative Erect Cobb angle}}{\text{Preoperative Erect Cobb angle}} \\ &\times 100 \end{aligned}$$

$$\begin{aligned} \text{Cincinnati Correction Index (CCI)} \\ &= \frac{\text{Postoperative Correction (POC) (\%)}}{\text{Preoperative Flexibility (PF) (\%)}} \end{aligned}$$

Results

Since 2007, we operated 42 scoliosis patients with the CAB implant. Most of the curves were King-Moe III (16 patients) and King-Moe II (15 patients). Six curves were King-Moe I, three curves were King-Moe IV and two were King-Moe V. All the patients are satisfied with the results. No reoperation was needed due to loss of correction, pain, implant failure, or infection. None of the patients operated by us was lost to follow-up.

The average postoperative Cobb angle decreased to 24.7° (4°–60°). Based on this, we calculated the CCI which was 3.12 (0.63–54.00). If we exclude two cases, the first one where the CCI was 54 because the scoliosis curve was very rigid and after ventral release major correction could be achieved and the other one where the CCI was 16 the patient had known congenital psychomotor developmental problems and we think due to this she did not perform the bending X-ray properly. Our CCI is 1.53 (0.63–4.8), which means our correction exceeded the flexibility of the spine determined by the lateral bending X-ray by 53 %.

The average surgical time was 383 min.

The main characteristics of the deformity and the corrections achieved are represented in Table 1.

Since, the CAB hook rests on the base of both transverse processes simultaneously, if well placed, when analyzing the hooks position on the postoperative X-ray it gives the

Table 1 The main characteristics of the deformities, the surgical procedure and the corrections achieved in each of the 42 operated patients with CAB hooks

	Sex	Age at time of surgery (year)	Follow-up time on 01/01/2012 (month)	Fusion	King-Moe	Surgery time (minutes)	Surgery type	Cobb angle			CCI (POC/PF)
								Preop.	Bending	Postop.	
1	F	14.25	51	Yes	II	525	CAB + other	58	40	36	1.22
2	F	24.25	45	Yes	III	445	CAB + other	48	30	26	1.22
3	M	16	42	Yes	III	405	CAB + other	64	31	22	1.27
4	F	18	40	Yes	I	280	CAB + other	28	8	6	1.1
5	F	16	40	Yes	I	625	CAB + other	48	40	38	1.25
6	F	24.5	38	Yes	V	555	Ventralis release + CAB + other	90	78	60	2.5
7	F	12.75	37	No	IV	290	CAB + other	82	52	42	1.33
8	F	15	36	Yes	III	495	Ventralis release + CAB + other	84	65	46	2
9	F	14.75	34	No	III	370	CAB + other	72	67	48	4.8
10	F	23.25	32	Yes	III	380	CAB + other	34	20	12	1.57
11	M	25.75	31	Yes	III	335	CAB	48	29	20	1.47
12	F	46	30	Yes	III	510	CAB + other	82	46	32	1.39
13	F	17.5	29	Yes	I	350	CAB + other	38	12	4	1.31
14	F	14.5	29	Yes	II	555	CAB + other	62	46	30	2
15	F	17	29	Yes	I	445	CAB + other	50	30	20	1.5
16	F	19.25	25	Yes	III	440	CAB + other	38	24	26	0.86
17	F	14	25	No	II	310	CAB	50	20	20	1
18	F	18.5	25	Yes	II	435	CAB	42	18	12	1.25
19	F	14.5	23	Yes	I	385	CAB + other	56	30	14	1.62
20	F	16.25	20	Yes	II	480	CAB + other	58	4	24	0.63
21	F	13	20	No	V	370	CAB	88	54	42	1.35
22	F	14.5	20	No	II	300	CAB	56	36	22	1.7
23	F	12.75	19	No	III	405	Ventralis release + CAB	76	75	22	54
24	F	16.25	19	Yes	II	320	CAB + other	32	6	8	0.92
25	F	14	18	Yes	I	335	CAB	68	50	20	2.67
26	F	18.75	17	Yes	II	355	CAB	58	20	10	1.26
27	F	12	17	No	III	285	CAB	70	34	14	1.56
28	F	11.5	14	No	IV	270	CAB	56	32	34	0.92
29	F	18.5	14	Yes	III	310	CAB	52	26	16	1.38
30	M	15.75	14	Yes	III	445	CAB	92	64	36	2
31	M	14.75	13	Yes	II	495	CAB	74	20	36	0.7
32	F	19.25	12	Yes	III	385	CAB	70	38	14	1.75
33	M	18.75	9	Yes	III	445	CAB	70	58	40	2.5
34	F	13.75	9	No	II	285	CAB	52	20	12	1.25
35	F	15.5	7	Yes	III	280	CAB	38	8	8	1
36	F	16	7	Yes	IV	320	CAB	70	28	10	1.43
37	F	18.25	5	Yes	III	219	CAB	40	8	8	1
38	F	19.75	5	Yes	II	360	CAB	52	34	30	1.22
39	F	12.25	2	Apical	II	335	CAB	72	50	38	1.55
40	F	13.25	2	Apical	II	310	CAB	70	52	26	2.44
41	F	13.25	2	Apical	II	330	CAB	58	30	24	1.21
42	F	13.5	2	Apical	II	295	CAB	46	45	30	16
Average		17.08	21.62			382.6		59.33	35.19	24.71	3.12

position of the vertebra it is on, that is, the tilt and rotation of the hook represent the tilt and rotation of the vertebra.

Conclusions

In our present article, we are reporting on the results of the first clinical series obtained with the auxiliary use of the CAB hooks, results should be considered accordingly.

With the introduction of a new implant, even if it works according to pre-existing principles there are often slight technical difficulties at the beginning. This is the so-called learning curve effect. The task is even more difficult when the new implant demands new surgical maneuvers. With the clinical introduction of the CAB, we had to resolve this double task.

Our results reflect these difficulties, as it can be seen from Table 1, where we were able to achieve better correction in the later operations. However, we are satisfied with the results obtained, also with the handling manageability of the implant, which fulfills all our intention regarding effectiveness, easy handling and surgical safety.

Based on our early promising results, we can conclude that the CAB hook fulfilled our expectations. It is easy to introduce into the costotransversal space even in scoliotic curves with large vertebral rotation, without the need for a C or O-arm. Only a few special instruments are required. The correction index achieved by it is more than satisfactory. Although we did not experience transverse process fracture in our series, since it is an auxiliary implant for CD principle instrumentation if for some reason required it can be easily substituted by pedicular hooks or screws.

Because of mismanaging reasons, the CAB hook's patent expired therefore it fell into the public domain; hereby, there is no commercial interest in its scientific promotion.

Acknowledgments No funds were received in support of this study.

Conflict of interest None.

References

1. Abul-Kasim K, Ohlin A (2011) The rate of screw misplacement in segmental pedicle screw fixation in adolescent idiopathic scoliosis. *Acta Orthop* 82(1):50–55
2. Amiot LP, Lang K, Putzier M, Zippel H, Labelle H (2000) Comparative results between conventional and computer-assisted

pedicle screw installation in the thoracic, lumbar, and sacral spine. *Spine* 25(5):606–614

3. Balabaud L, Gallard E, Skalli W, Dupas B, Roger R, Lavaste F et al (2003) Biomechanical evaluation of a bipedicular spinal fixation device: three different strength tests. *Eur Spine J* 12:480–486
4. Bauer R, Kerschbaumer F, Poisel S (1993) *Atlas of spinal operations*, 1st edn. Georg Thieme Verlag, Stuttgart
5. Cotrel Y, Dubousset J (1984) A new technic for segmental spinal osteosynthesis using the posterior approach. *Rev Chir Orthop Reparatrice Appar Mot* 70(6):489–494
6. Cotrel Y, Dubousset J, Guillaumat M (1988) New universal instrumentation in spinal surgery. *Clin Orthop Relat Res* 227: 10–23
7. Csernátó Z, Szepesi K, Gáspár L, Dezső Z, Jónás Z (2000) “The rotational preconstraint”. A kinetic model of a possible new mechanism in the ethiopathogenesis of scoliosis. *Med Hypotheses* 54(2):203–206
8. Csernátó Z, Goodship A, Szepesi K, Jónás Z, Gáspár L, Benkő K et al (2001) A complementary thoracic implant for the surgical correction of the scoliotic curve. A preliminary report. *Eur J Orthop Traumatol* 11:85–89
9. Csernátó Z, Szepesi K, Gáspár L, Kiss L (2002) Contradictions of derotation in scoliosis surgery using the CD principle. *Med Hypotheses* 58(6):498–502
10. Csernátó Z, Molnar S, Zs Hunya, Manó S, Kiss L (2011) Biomechanical examination of the thoracic spine—the axial rotation moment and vertical loading capacity of the transverse process. *J Orthop Res* 29(12):1904–1909
11. Harrington PR (1962) Treatment of scoliosis. Correction and internal fixation by spine instrumentation. *J Bone Joint Surg Am* 44:591–610
12. Karger C, Steib JP, Roussouly P, Chopin D, Roy C, Dimnet J et al (1995) Les ‘nouveaux’ systèmes d’ instrumentation rachidienne postérieure. Expansion Scientifique Française Cahiers d’ Enseignements de la SOFCOT. Paris, pp 121–35
13. King HA, Moe JH, Bradford DS et al (1983) The selection of fusion levels in thoracic idiopathic scoliosis. *J Bone Joint Surg Am* 65:1302–1313
14. La Rosa G, Giglio G, Oggiano L (2011) Surgical treatment of neurological scoliosis using hybrid construct (lumbar transpedicular screws plus thoracic sublaminar acrylic loops). *Eur Spine J* 20:90–94 (Suppl. 1)
15. Luque ER (1989) Segmental spinal instrumentation in neuromuscular scoliosis. *Orthopade* 18:128–133
16. Mazda K, Ilharreborde B, Even J, Lefevre Y, Fitoussi F, Pennecot GF (2009) Efficacy and safety of posteromedial translation for correction of thoracic curves in adolescent idiopathic scoliosis using a new connection to the spine: the Universal Clamp. *Eur Spine J* 18:158–169
17. Ovadia D, Korn A, Fishkin M, Steinberg DM, Wientroub S, Ofiram E (2011) The contribution of an electronic conductivity device to the safety of pedicle screw insertion in scoliosis surgery. *Spine* 36(20):1314–1321
18. Sanders J (2011) Scoliosis “nonfusion”—a reality check. *J Pediatr Orthop* 31(1 Suppl):114–118
19. Vora VCA, Babekhir N, Boachie-Adjei O, Lenke L, Peskin M, Charles G, Kim Y (2007) A pedicle screw construct gives an enhanced posterior correction of adolescent idiopathic scoliosis when compared with other constructs: myth or reality. *Spine* 32(17):1869–1874