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Infantile scoliosis in Beals syndrome: the use of a non-fusion technique for surgical correction

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Abstract Beals syndrome (congenital contractural arachnodactyl) is a genetic disorder of the connective tissue phenotypically related to Marfan syndrome. It is characterised by dolichostenomelia, arachnodactyly, multiple joint contractures, crumpled ears, hypoplastic muscles and scoliosis. The latter, the most important clinical feature of this rare condition, presents in the infantile and juvenile age group and has a tendency to rapid progression. Bracing often fails to control the scoliosis and surgery is the recommended treatment. We present our

experience of two cases managed with the paediatric Isola instrumentation and a non-fusion technique.

Keywords Beals syndrome · Congenital contractural arachnodactyly · Fibrillin · Progressive infantile scoliosis · Posterior spinal instrumentation without fusion

Introduction

Beals syndrome is a genetic disorder of the connective tissue phenotypically related to Marfan syndrome. Also known as congenital contractural arachnodactyly (CCA), the features of this dominantly inherited condition are: dolichostenomelia, arachnodactyly, multiple joint contractures, crumpled ears, scoliosis and hypoplastic muscles, especially of the calf [3, 15].

Fibrillin is a structural component of microfibrils, which is found either in association with elastin or independently as an important component of the extracellular matrix of many tissues. This protein has been recently identified as the defective gene product in Marfan syndrome and related disorders such as Beals/CCA. There is evidence of at least two different fibrillin genes located on chromosomes 5 and 15, respectively. Beals/CCA syndrome is caused by mutations in the gene for *FBN2* on chromosome 5, while Marfan syndrome is

caused by mutations in the gene for *FBN1* on chromosome 15 [15, 16, 20].

Fibrillin-1, the product of the *FBN1* gene is mainly found in the eye, heart and skeleton. Fibrillin-2, the product of *FBN2* gene, seems to play a major role, as well, in the development of the skeletal system [23]. When it is absent, the joints are contracted as opposed to the hyper laxity seen in Marfan syndrome [15, 16]. It is unusual to find aortic or ophthalmologic involvement in Beals/CCA syndrome but congenital cardiac defects may occur [17]. The contractures, present at birth, tend to improve spontaneously with growth and activity. Scoliosis seems to be the most important clinical feature. Very often it presents in the infantile or juvenile age group and has a tendency to early and rapid progression [3].

We present our experience in the treatment of infantile scoliosis associated with Beals/CCA syndrome employing the Isola paediatric system (DePuy AcroMed, Raynham, MA, USA) of instrumentation without fusion.

Fig. 1 a, b Preoperative radiographs of case number 1

Case 1

The AR female, was referred to our clinic at the age of 22 months with a progressive right thoracic and left thoraco-lumbar scoliosis. A diagnosis of possible Marfan syndrome had been raised soon after birth through observation of her arachnodactyly. Our initial examination revealed a 79° right thoracic curve and a left thoraco-lumbar curve measuring 59°, height above the 97th centile and significant joint laxity. However, she lacked the aortic and ophthalmologic involvement associated with Marfan syndrome.

The Regional Genetics Service diagnosed her as suffering from Beals syndrome. This was established from DNA studies from a blood sample, which demonstrated *FBN2* gene mutation and a skin biopsy was used to culture fibrillin-2 from the fibroblasts. Clinical features of contractures to both elbows, toes, and left little finger, together with muscular hypoplasia and crumpled ears confirmed this. It is of interest to note that she was a genetic composite, her father suffering from Beals syndrome, but without scoliosis, and her mother suffering from Joint Hypermobility. This may

explain why she had a mixed pattern of joint contractures and laxity.

Initially, she was treated in a brace for 16 months; however, this failed to stop the progression of her spinal deformity. At the age of 5-year, the right thoracic curve measuring 89° and the left thoraco-lumbar curve measuring 78°. In view of the curve magnitude, a decision was taken to perform convex hemi epiphyseodesis of both curves. She underwent staged surgery in the form of right convex anterior growth arrest from T7 to T10 followed, 6 weeks later, by left convex anterior growth arrest from L1 to L3, insertion of a Harrington rod between T3 and L3, and right posterior convex fusion from T6 to T11. Following the latter intervention, the curves had improved to 52 and 54°, respectively. Unfortunately, in spite of bracing, the rod had to be removed 10 months later after recurrent disengagement of the upper hook.

After a further 20 months in a brace, during which the curves continued to progress, the right thoracic curve reached 89° and left thoraco-lumbar 72° (Fig. 1a, b). She underwent further surgery for her scoliosis with insertion of posterior, subfascial, bilateral, contoured, paediatric ISOLA implants. Proximally we positioned

Fig. 2 a, b Postoperative radiographs of case number 1 immediately after implantation of paediatric Isola

transverse process and pedicle hooks between T3 and T6. Distally we placed hooks at L1–L3 levels. We employed two sixteen inches rods over which we inserted the extended tandem connectors, and which we linked by side to side transverse connectors. The top and bottom constructs were decorticated and bone grafted. At the end of this procedure, her curves measured 65 and 53°, respectively. There was no post-operative bracing (Fig. 2a, b).

Over the following 31 months, she had four additional interventions to have the rods lengthened in order to keep pace with her growth. There were no complications of infection or prominent hardware.

Treatment was suspended at the age of 10-year, after significant correction had been achieved, right thoracic curve measuring 50° and left thoraco-lumbar curve of 45°, as the patient was not willing to continue with it. This was against our advice, as she was still pre-menarchial. At the time of the last clinic follow up, 2 years after the treatment was discontinued, the spinal deformity had not progressed. It was also noted that at the

last lengthening, the non-fused segments were found to be immobile. We believe that this may indicate a spontaneous posterior arthrodesis; however, this cannot be confirmed. In April 2002, we had correspondence with the mother of AR who informed us that her daughter had commenced menarche 1 year previously and was now the same height as mum (5ft 7) weighing 7.5 stones. She had minimal discomfort in her back but was participating fully with school activities.

Case 2

The MC female was referred to our clinic at the age of 30-month with progressive right thoracic and left thoraco-lumbar scoliosis, which at the time of her first appointment measured 21 and 14°, respectively. She had been born full term, by caesarean delivery due to failure to progress, and her developmental milestones were normal. At the age of 1-year an abnormal gait had been observed, and by the time of the referral she had been in

Fig. 3 Preoperative radiograph of case number 2

treatment for bilateral plano-valgus feet for some time requiring ankle-foot orthoses and regular physiotherapy. Examination confirmed the spinal and foot abnormalities and also that MC's weight was on the 50th centile and height above the 97th centile. She displayed rather long fingers and toes, crumpled ears, joint laxity, muscular hypoplasia, and absent tendon reflexes in the lower limbs. Examination of the cardiovascular system, an echocardiogram and ophthalmic review, were normal, making the diagnosis of Marfan syndrome unlikely. The MRI scan of the spine was normal as well. The diagnosis of Beals syndrome was again achieved through analysis of DNA from blood.

She was treated in a Boston brace for nearly 2 years with failure to stop the progression of the spinal deformity. By the time she was 5 years and 4 months the right thoracic curve had reached 55° and the left

thoraco-lumbar curve measured 53° (Fig. 3) and remained flexible on radiological assessment. Anterior growth arrest was, therefore, considered unnecessary, so posterior instrumented correction of her scoliosis was performed.

As in the previous patient, Isola paediatric instrumentation, without fusion, with dual subfascial rods and extended tandem connectors was employed between T2 and L3 levels. No post-operative bracing was employed (Fig. 4a, b).

Over a period of 5 years, she had nine additional interventions to lengthen the rods. During these procedures she required the tandem connector to be replaced once and on another occasion the transverse rod connector was replaced due to prominence but no other "hardware" problems occurred such as rod breakage or hook displacement. After the third lengthening, a superficial wound infection developed which settled initially but ultimately required exploration and excision of the chronic sinus tract that developed. This did not compromise the ongoing correction. The MC has now had her definitive fusion in November 2003 by which time she was menarchial. It was noted that the T5–L1 segments were indeed mobile. The rods and transverse rod connectors were replaced she had a T5/6 costoplasty and autograft to complete the procedure. We had achieved a significant correction of the scoliosis, right thoracic curve 25° and left thoraco-lumbar curve 32° (Fig. 5a, b). The MC was asymptomatic at her clinic visit in June 2004 and so was discharged.

Discussion

In 1971 Beals and Hecht proposed the term CCA for a condition, phenotypically similar to Marfan syndrome, characterized by dolichostenomelia (long narrow body frame), arachnodactyly, multiple joint contractures, abnormal crumpled ears, muscular hypoplasia, scoliosis, and autosomal dominant transmission. They suggested that the joint contractures, present at birth, tended to improve spontaneously with growth and activity although might result in delayed motor development, and that early onset, progressive scoliosis was the most important clinical feature of the disorder. They had observed that nearly half of the children and almost all the adults with Beals/CCA syndrome had scoliosis [3].

Although in principle there seems to be little evidence of cardiovascular involvement or ophthalmologic problems of the sort seen in Marfan syndrome in CCA, mild, non-progressive aortic root dilatation and mitral regurgitation secondary to mitral valve prolapse have been reported as well established features of the disorder by some authors [1, 2, 7, 17].

Fig. 4 a, b Initial post-operative radiographs case 2

It was not until 1991 when fibrillin was finally implicated as the defective gene product in Marfan syndrome and in a series of phenotypically related disorders that included Beals/CCA. The same studies revealed genetic heterogeneity of the fibrillin proteins with at least two different fibrillin genes, *FBN1* and 2, located on chromosome 15 and 5, respectively. Genetic linkage was established between Marfan syndrome and only the fibrillin gene on chromosome 15, whereas CCA was linked to the fibrillin gene on chromosome 5. These studies failed to show any linkage of mitral valve prolapse or ectopia lentis to *FBN2* gene [15–17].

It is known that in Marfan syndrome and related disorders, such as Beals/CCA, scoliosis is often seen in the infantile and juvenile age groups [3, 8, 18, 19, 22]. Curve types, although resembling those seen in idiopathic scoliosis, tend to progress early and rapidly [19, 22]. Many authors believe that bracing treatment is generally ineffective in managing these curves but in the younger child it might have a place in preventing or retarding curve progression until a spinal instrumentation can be performed at an older age [22]. When radiological measurement documents progression, and particularly if the curve reaches a magnitude greater than 40°, surgical treatment should be considered. Posterior distraction spinal instrumentation is the recommended treatment for these patients [5, 6, 8, 10, 12, 14, 18, 19, 21, 22].

The issue of whether the instrumented spine should be fused, or not, is somewhat controversial. Sponseller, based on his experience in managing infantile scoliosis in Marfan syndrome, suggested that posterior instrumentation without fusion should only be considered for those patients where no significant kyphosis exists [18]. He felt that attempts to lengthen the spine through the posterior column might increase the kyphosis. Because of the increased height of these patients, he did not feel that loss of growth would be significant and the use of anterior fusion should overcome the crankshaft phenomena.

Other authors have recommended posterior instrumentation without fusion in the belief that this allows for spinal growth while providing correction of the deformity. Definitive arthrodesis can be delayed until the end of the adolescent growth spurt [5, 6, 8, 10, 11, 12, 14, 19].

Harrington [6] first described the use of instrumentation without fusion in 1962 [5, 6, 8, 19]. He reported that subperiosteal exposition of the spine could lead to spontaneous fusion over the length of the instrumentation [5]. In order to minimize the chances of this complication occurring Moe et al. [12] recommended a subfascial positioning of the Harrington rods [8, 12, 19]. With this technique the only portion of the spine exposed were the sites of the hook insertion, whilst the rest of the spine, undisturbed, would be less likely to fuse [5, 8].

Fig. 5 a, b Final radiographs of case number 2

Subsequent generations of posterior spinal instrumentation from Luque's segmental spinal instrumentation [8, 10, 14] to the Cotrel and Dubousset's system [8, 13, 19] have been used, without arthrodesis, in the surgical treatment of progressive and severe infantile and juvenile scoliosis. A number of the current systems designed for paediatric work utilise some type of lengthening device. The authors feel that in the case of AR there is likely to have been a degree of spontaneous fusion given the clinical findings at the last lengthening procedure in December 1998. Blakemore et al noted that an unintentional fusion around the placement of the submuscular rod claw construct occurred in his series of 17 patients. To our knowledge, there are no reports of spontaneous fusion throughout the entire length of a non-fused segment where the rod is inserted using a subcutaneous technique.

We experienced only one complication of wound infection over the duration of sequential rod lengthenings. This occurred to MC initially as a suspected superficial infection, which failed to completely settle

on intravenous antibiotics and so underwent definitive sinus tract excision. Infection rates for posterior instrumentation in the literature vary from 2 to 10% [4, 9]; however, in none of these papers was the paediatric ISOLA system employed.

Conclusions

We have used the Isola paediatric system, with limited end fusions to successfully treat two cases of progressive infantile scoliosis resulting from Beals/CCA. The incorporation of the tandem rod connectors linking the sub-fascial rods implanted to each side of the construct greatly facilitates and simplifies the regular lengthening of the implants until skeletal maturity and definitive fusion is achieved. Only one complication occurred requiring a small surgical procedure to be corrected. The treatment is technically demanding for the surgeon, family and child alike. However, the rewards of progressive correction and increased spinal growth justify this treatment regime.

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