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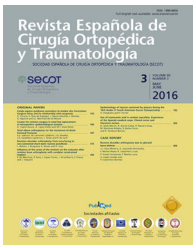

CASE REPORT

Ultrasound control of magnet growing rod distraction in early onset scoliosis☆

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KEYWORDS
Early onset scoliosis;
Growing rod technique;
Magnetic expansion control

Abstract The growing rod technique is currently one of the most common procedures used in the management of early onset scoliosis. However, in order to preserve spine growth and control the deformity it requires frequent surgeries to distract the rods.

Magnetically driven growing rods have recently been introduced with same treatment goal, but without the inconvenience of repeated surgical distractions. One of the limitations of this technical advance is an increase in radiation exposure due to the increase in distraction frequency compared to conventional growing rods.

An improvement of the original technique is presented, proposing a solution to the inconvenience of multiple radiation exposure using ultrasound technology to control the distraction process of magnetically driven growing rods.

PALABRAS CLAVE
Escoliosis de aparición precoz;
Tallos de crecimiento;
Control magnético de expansión

Control ecográfico en la distracción de los tallos de crecimiento magnéticos en la escoliosis de aparición precoz

Resumen En la actualidad, la técnica de tallos de crecimiento es uno de los métodos más empleados en el manejo de la escoliosis de aparición precoz. No obstante, requiere frecuentes intervenciones quirúrgicas para distraer los tallos, y así mantener un crecimiento adecuado de la columna y controlar la deformidad raquídea.

Recientemente se han introducido los tallos de crecimiento de distracción magnética con el mismo objetivo terapéutico pero sin el inconveniente de la distracción quirúrgica repetida. Una de las limitaciones que presenta este avance técnico es el incremento en la exposición a radiaciones ionizantes a consecuencia del aumento en la frecuencia de las distracciones, en comparación con los tallos de crecimiento convencionales.

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Presentamos una mejora de la técnica de distracción inicial, proponiendo una solución al inconveniente de la exposición múltiple a radiaciones ionizantes, empleando la ecografía para el control del proceso de elongación de los tallos de crecimiento de distracción magnética.

Introduction

Scoliosis is a spinal pathology that consists of a three-dimensional alteration of the spinal column, leading to the deviation of the same in the anteroposterior plane, together with an alteration in its sagittal profile and vertebral rotation. It can be classified using three groups: neuromuscular, congenital or idiopathic. The latter can be subdivided as infantile (0–3 years old), juvenile (4–9 years old) and adolescent (after the age of 10 years old). The infantile and juvenile types are sometimes classified together, as ''early onset scoliosis''. For a long time the most widely used therapeutic options in the treatment of this condition were orthesis and spinal fusion; nevertheless, both treatments have a series of disadvantages. Orthesis may not be effective in small children, above all in those who present swiftly progressing scoliosis or neurological pathology, as this progression will exceed the capacity of the orthesis to control the condition. On the other hand, spinal fusion involves halting the normal growth of the spinal column and may lead to a decrease in lung development and a poor appearance.

Several techniques for the treatment of early-onset scoliosis have been developed over recent decades to prevent these complications while preserving spinal column growth.[1] Skaggs et al.[2] recently classified these techniques for the preservation of growth into those based on distraction, those based on compression and those using guided growth.

Growing rods are now the most widely used method in the context of distraction-based techniques. They have the advantage of correcting spinal column deformity while allowing it to grow, and even potentially stimulating growth.

Nevertheless, this technique requires frequent surgery to distract the rods and thereby maintain suitable growth of the spinal column while also controlling spinal deformity.[3]

Bess et al.[4] analysed the complications which arose in 140 patients with implanted growing rods and who had been subjected to a total of 897 operations. They concluded that the risk of complications increased by 24% with each new operation.

The idea of a non-invasive system that makes it possible to achieve these multiple elongations without the need to subject the patient to a series of anaesthesias and surgical procedures has therefore been present for a long time. The need for this is even clearer given the evident relationship between the number of surgical operations a patient is subjected to and the number of complications.

In 2012, Cheung et al.[5] first described the use of magnetically distracted growing rods for the treatment of early-onset scoliosis.

These magnetically distracted growing rods consist of titanium rods which are able to distract thanks to a magnetically controlled elongator mechanism in their central part. The distraction to be achieved is usually from 1.5 mm to 2 mm per month, according to the spinal growth data supplied by the works of Dimeglio et al.[6]

The elongation procedure may take place in the surgery with the patient in prone or lateral decubitus. The process firstly involves the positioning of a magnetic marker on the patient's skin. This makes it possible to locate the distracter mechanism inside the bar. Once the said segment has been located the distracter is applied after entering the desired elongation distance. Once the elongation process has terminated, anteroposterior and lateral X-rays are taken to check the efficacy of the distraction. These authors[5] concluded that this technique is safe and effective, reducing the risk of complications and improving patient quality of life. In terms of cost-effectiveness it is better than the elongation procedure using conventional growing rods. One limitation of magnetically distracted growing rods is the increase in exposure to ionising radiation due to the increase in the frequency of distractions compared to conventional growing rods.[5]

This limitation could be overcome if the elongation is checked by means of a technique that is free of ionising radiation, such as ultrasound scan. The aim of this work is to present an improvement in the original distraction technique described by Cheung et al., proposing a solution to the drawback of multiple exposure to ionising radiation.

Clinical case

The patient is s 36 month old male with no relevant family background, with 60° left thoracolumbar scoliosis (Fig. 1A), bilateral flexion of the knees, bilateral hip luxation and multidirectional glenohumeral instability with relapsing luxations in both shoulders, all within the context of type II spinal muscular atrophy. The patient also presented recurring respiratory infections and low weight (10 kg). Given the precarious nutritional situation of the patient (Fig. 1B) it was recommended that a gastric feeding tube be inserted prior to the implantation of the growing rods, with the aim of improving his nutritional condition. The surgery to implant the magnetically distracted growing rods took place 6 months after the first visit and 3 months after the insertion of the feeding tube.

The said procedure was undertaken without complications, and a hybrid rib-pelvic assembly was selected (Fig. 1C and D). At a distal level 2 iliac screws were implanted, proximally to 3 rib hooks (between the 2nd and 4th ribs) bilaterally. The patient evolved satisfactorily and was discharged after 5 days, with the recommendation to use a TLSO protective orthesis during one month.

The patient was examined after 3 weeks and no anomalies were detected. In the third month after the initial

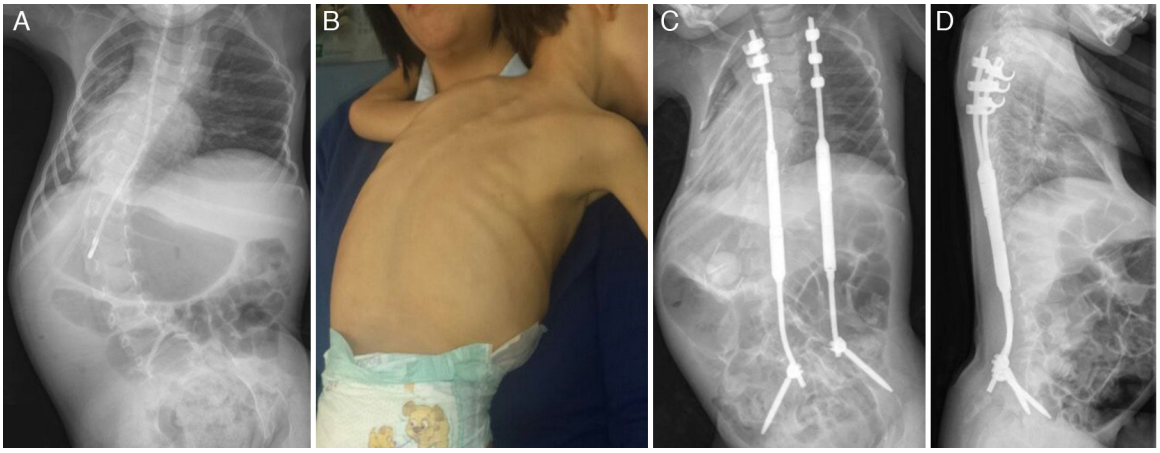

Figure 1 (A) Posteroanterior X-ray of the complete spinal column, showing a left thoracolumbar curve in a ''C'' pattern and marked pelvic obliquity. (B) Deficient nutritional condition of the patient. (C) Postoperative posteroanterior X-ray of the spinal column after the implantation of the rib-pelvis hybrid assembly. (D) Postoperative lateral X-ray of the complete spinal column.

Figure 2 (A) Ultrasound scan image before elongation of the electromagnetic rod, measuring the distracting part (arrowed). (B) The patient is placed in lateral decubitus for the elongation process. (C) Ultrasound scan image after programmed lengthening of the electromagnetic rod, measuring the distracting part (arrowed).

operation the first elongation of the rods took place in the surgery, without the need for sedation. To elongate the right rod the patient was placed in left lateral decubitus (Fig. 2A–C). The part that would be distracted later on was located using the magnetic marker and this was shown using a dermographic pencil. The marks that were to be used as controls for the distraction were then located by ultrasound scan. The ultrasound scanner used was an ESAOTE Picus (Pie Medical Equipment B.V., Maastricht, The Netherlands) with a 5–10 MHz multifrequency lineal probe at 10 MHz. The first measurement was taken (5.5 mm) and the electromagnetic distraction was performed by programming the distracter at 4 mm; after this, the measurements were repeated with the previous references, and a final measurement of 9.5 mm was detected. The same procedure was performed for the left rod, by placing the patient in right lateral decubitus and marking the skin in the area to be distracted, taking the previous length of the rod as the reference (in this case 8.5 mm), with the planned distraction of 2 mm and a final ultrasound scan check (10.5 mm).

Results

The increase in the length of the growing rods was checked during the elongation procedure in the surgery, using measurements taken over the ultrasound image and without the need to subject the patient to another dose of ionising radiation after the distraction, which is the chief drawback of the magnetic control technique.

The first measurement was taken before the elongation process, giving a distraction system length of 5.5 mm and 8.5 mm, each one of which corresponds to the initial elongation of each rod when it was implanted. A second measurement of 9.5 mm and 10.5 mm corresponds to each side after the distraction (4 mm and 2 mm of distraction, respectively). The fact that a greater distraction took place on one side than the other is justified by the patient's major pelvic obliquity, making it necessary to perform a gradual correction of the same.

Discussion

The treatment of early-onset scoliosis using the growing rods technique has two basic aims: to correct the spinal deformity and permit the growth of the spinal column, while indirectly making lung development possible.

The conventional growing rods technique is an effective therapeutic option for the management of scoliosis at early ages. Nevertheless, the manual distraction of these rods involves repeated invasive procedures under general anaesthetic. Thus although this technique gives good results, it also has a series of drawbacks that may involve 3 fields:

anaesthetic, surgical and psychological complications for the patient.[3,5]

Regarding anaesthesia, there is some evidence based on preclinical studies about the modulating potential of general anaesthesia on the development of neuronal function, more specifically on behaviour and cognitive function. Moreover, other studies have shown that this risk increases with accumulated and repeated exposure to general anaesthesia.[7]

Another important aspect that has to be taken into account is the psychological impact of repeated surgery on children. Flynn et al.[8] analysed this relationship and concluded that patients subjected to a high number of surgical operations tend to display less capacity to adapt to changes, to overcome adversities and to deal with stress. Patients who are subjected to a greater number of surgical operations are more likely to develop a negative opinion of themselves, the world and the future, with a tendency to irritability and impulsive anger.[8] The fact that repeated operations to distract the growing rods leads to an increase in psychopathological symptoms is associated with the idea that each operation and hospitalisation, regardless of how many times they occur, leads to a certain amount of psychological aggression. This aggression is increased in patients with early-onset scoliosis, as they have not developed the cognitive skills that would allow them to understand the purpose of the treatment.[8]

Regarding surgical complications, the existence of a positive correlation has been proven between the number of operations during the treatment period and an increased risk of suffering a complication (neurological problems, alignment, problems with the implant, superficial and/or deep infections, etc.).[4]

It is because of all these reasons that magnetic growing rods are considered a valid alternative to the traditional system of growing rods that require repeated surgery for distraction. Magnetic growing rods try to maintain the initial correction of spinal deformity while preserving spinal growth through non-invasive elongations that require neither sedation nor anaesthesia.

They also presumably minimise the psychological impact on the patient, so that it is possible to lengthen the rods more often, seeking a more physiological growth for the column than is the case with conventional distraction technique.

The time between distractions when the conventional technique is used is from 6 to 9 months.

An important aspect that has to be taken into account is the economic cost. Armoiry et al. found a significant difference in cost between magnetic rods and conventional ones. Nevertheless, magnetic distraction growing rods reduce the costs associated with hospitalisation and additional procedures (surgery, check-ups and X-rays, etc.). In treatment lasting for 53 months these stand at around €40,000 per patient with conventional rods, while with magnetically controlled rods these costs are no higher than €35,000.[9]

Conclusions

To improve techniques it is suggested that ultrasound scan be used as the method to control the distraction of growing rods. This technique is innocuous for the patient and is also fast and reliable. This technique is easy to perform in the surgery and makes it possible to monitor progress before distraction and the subsequent planned elongation, without having to subject the patient to repeated exposures to radiation.

This technique is in an early stage in which results are being analysed, as may be seen in the paper by Stokes et al.,[10] which was published recently.

It also has the advantage of making it possible to take measurements before and after distraction, permitting detailed quantification of the growing rods elongation sequence from the start of the process to its end, without this leading to any prejudice or discomfort for the patient.

The main restriction in the use of ultrasound scan to control the growing rod distraction process is the fact that it requires a doctor who is familiar with the ultrasound scan technique, as well as an ultrasound scanner in the surgery.

Ethical responsibilities

Protection of persons and animals. The authors declare that no experiments were performed in human being or animals for this research.

Data confidentiality. The authors declare that they followed the protocols of their centre of work on the publication of patient data.

Right to privacy and informed consent. The authors obtained the informed consent of the patients and/or subjects referred to in the paper. This document is held by the corresponding author.

Conflict of interests

The authors have no conflict of interests to declare in this work.

References

1. Farrington DM, Tatay-Díaz A. Escoliosis de aparición precoz. ¿Qué opciones tengo? Rev Esp Cir Ortop Traumatol. 2013;57:359–70.
2. Skaggs DL, Akbarnia B, Flynn J, Myung K, Sponseller P, Vitale M. A classification of growth friendly spine implants. J Pediatr Orthop. 2014;34:260–74.
3. Akbarnia BA, Mundis GM, Salari P, Yaszay B, Pawelek J. Innovation in growing rod technique. A study of safety and efficacy of a magnetically controlled growing rod in a porcine model. Spine. 2012;37:1109–14.
4. Bess S, Akbarnia BA, Thompson GH, Sponseller PD, Shah SA, El Sebaie H, et al. Complications of growing-rod treatment for early-onset scoliosis: analysis of one hundred and forty patients. J Bone Joint Surg Am. 2010;92:2533–43.
5. Cheung KM, Cheung JP, Samartzis D, Mak KC, Wong YW, Cheung W, et al. Magnetically controlled growing rods for severe spinal curvature in young children: a prospective case series. Lancet. 2012;379:1967–74.
6. Dimeglio A, Bonnel F, Canavese F. Normal growth of the spine and thorax. In: Akbarnia BA, Yazici M, Thompson GH, editors.

The growing spine: management of spinal disorders in young children. New York: Springer; 2010. p. 13–42.
7. Sanders RD, Hassell J, Davidson AJ, Robertson NJ. Impact of anaesthetics and surgery on neurodevelopment: An update. Br J Anaesth. 2013;110 Suppl. 1:i53–72.
8. Flynn JM, Matsumoto H, Frances Torres MA, Ramirez N, Vitale MG. Psychological dysfunction in children who require repetitive surgery for early onset scoliosis. J Pediatr Orthop. 2012;32:594–9.
9. Armoiry X, Abelin-Genevois K, Charroin C, Aulagner G, Cunin V. Magnetically controlled growing rods for scoliosis in children. Author's reply. Lancet. 2012;380.
10. Stokes OM, ÓDonovan EJ, Samartzis D, Bow CH, Luk KD, Cheung KM. Reducing radiation exposure in early-onset scoliosis surgery patients: novel use of ultrasonography to measure lengthening in magnetically-controlled growing rods. Spine J. 2014;14:2397–404.