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ORIGINAL ARTICLE

Magnetic controlled growth rods versus conventional growing rod systems in the treatment of early onset scoliosis: a cost comparison

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Abstract
Purpose To evaluate the cost differences between a conventional growth rod system (CGRS) and magnetic controlled growth rods (MCGR) in treating early onset scoliosis (EOS) over a projected 5 year period. We hypothesise that the high initial outlay for MCGR would be recouped from fewer admissions and surgical procedures over the lifetime of the implant.
Methods The costs of all aspects of treatment for 14 patients undergoing conversion from CGRS to MGRS were collected over a 3 year period. The costs of all aspects of each treatment including clinic visits, hospital stay, theatre and complications were calculated and projected over the lifetime of each device.
Results The initial outlay for insertion for MCGR was £12,913 more than the CGRS. There were significant cost savings for each lengthening which projected over the 5 year lifetime amounted to a cost saving of over £8,000 per patient.
Conclusions Magnetic controlled growth rods reduce the need for multiple invasive procedures in the management of EOS. The implant has a significant projected cost saving in comparison to CGRS.

Keywords Scoliosis · Cost analysis · Magnetic controlled growth rod

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Background

The introduction of a new device for treatment of a medical condition depends not only on its ability to influence the natural history of the condition but also the costs of deployment. These costs can sometimes be prohibitive and deter health commissioners from much needed investment in new infrastructure despite the potential long-term clinical benefits.

In an increasingly fragile financial climate, health economics has become the barometer for efficiency, effectiveness and value in healthcare delivery. The spectrum which constitutes this evolving discipline has been previously described by Williams [1]. The clinician is often involved in the micro-economic evaluation of new devices at treatment level to operate within financial constraints imposed by an overburdened health system. This evaluation involves comparisons of two or more alternative forms of treatment in terms of cost and effect on natural history.

Early onset scoliosis (EOS) is a complex condition with a multitude of treatment strategies. The common denominator of these treatments is the need for repeated general anaesthesia. The first centres to report on the outcomes of magnetic controlled growth rods (MCGR) have demonstrated encouraging results [2–4]. In December 2011 the Oxford Spine Unit introduced MCGR for the surgical treatment of EOS. Prior to this, a conventional growth rod system (CGRS) had been used by the senior author since 2009 to treat this condition. The perceived benefits come from fewer operations required with the new device due to lengthening being performed remotely in clinic. This removes the need for repeated surgical procedures and hospital admissions. In addition to the primary benefit to the patient population, there is a potential economic advantage to the new technique over the life span of the

implant. The initial cost outlay for the MCGR is higher than that of the CGRS. However, the lengthenings can be performed during the course of a standard outpatient clinic without the need for repeated invasive surgical procedures with lengthy in-patient admissions. The aim of this study was to perform a cost analysis comparing the MCGR with the CGRS and form a projected model based on 4 year longevity of the MCGR. We hypothesise that the higher initial outlay cost would be saved against the resources needed for repeated admissions and procedures with the conventional technique.

Methods

Data was collected from 14 children who underwent surgery for EOS from 2009 over a 3 year period to cover the whole of their spinal care pathway from pre-operative assessment clinic to post-discharge community review. Data was collected from the insertion of MCGR into 14 patients using Magec^{TM} (Ellipse Technologies). There were six primary device insertions for MCGR and 8 conversion cases from CGRS to MCGR. The eight patients who underwent insertion of CGRS prior to their conversion to MCGR acted as a cost comparison group. Information was collected on: pre-operative assessment, post-operative hospital stay, intra-operative, post-operative events, outpatient follow-up, duration of theatre episodes, personnel, implants and diagnostic imaging facilities.

The implant costs for MCGR and CGRS were obtained from the hospital procurement department. Costings for pre-operative assessment, theatres, in-patient stay, outpatient attendance, and diagnostic imaging were obtained from the Oxford University Hospitals Finance Department. Generic salary details were available from the British Medical Association, Royal College of Nursing and NHS careers [5]. Calculations were based on service costs and activity volumes. Service costs included personnel, clinics, procurement, theatre time, high dependency unit (HDU)/ward care, medication, community follow-up and revision surgery rates. Activity volumes were based on number of attendances for service input.

Before undergoing an initial implant insertion or lengthening, the child attends a pre-operative assessment clinic, where they are seen by a consultant, clinic nurse, physiotherapist, occupational therapist and junior doctor. Blood tests are also done. Bloods taken include clotting, urea, electrolytes and full blood count. In pre-operative assessment clinic, patients spend 15 min with the junior doctor, 30 min with the consultant, 20 min with the clinic nurse and a combined 30 min with the physiotherapist and occupational therapist. They are admitted on the day of surgery to a day ward. After surgery, they are transferred to the HDU where they remain for 24–48 h. After this period, they are transferred back to the ward. Expected length of stay in hospital is approximately 1 week. After discharge, they will attend a 10 min practice nurse appointment for wound review. At 6 weeks post-surgery, there is a 10 min follow-up review in the outpatient clinic. The MCGR group will then commence three monthly lengthenings from the next visit 6 weeks later. Imaging in the MCGR group consists of alternating fluoroscopy and plain radiographic assessment of the spine. In patients with CGRS, lengthening of the rods under general anaesthesia occurs twice a year. A hospital admission with full workup is required. This is in contrast to MCGR remote lengthening which is performed in the outpatient clinic four times per year and does not require admission to hospital. The CGRS group will attend pre-operative assessment clinic (POAC) 3 months after surgery in preparation for the next intra-operative lengthening which occurs six monthly. The CGRS group undergoes plain radiographs of the whole spine at each visit.

The cumulative financial cost to the hospital of using either treatment in the senior author's clinical practice was calculated from 2009 up to and including latest follow-up in 2012. This figure was then used to derive an average cost for each treatment modality over a 4 year period which would be the anticipated lifespan of the MCGR.

Results

Pre-operative assessment

The cost of deploying one nurse, one junior doctor, one physiotherapist, one occupational therapist, one consultant anaesthetist and one consultant spine surgeon in the POAC was calculated using average salary values. There was no difference in cost between the groups with an average cost per patient of £81.58.

Insertion of implants

Service costs in terms of personnel were greater in the CGRS group (£1,127 vs. £995) than in the MCGR group. This was due to the longer time spent in theatre in the CGRS group. Implant costs were significantly higher with MCGR (£22,050 vs. £8,562) than in the CGRS group. This is reflected in the higher cost of MCGR. The base instrument appliances were similar in both groups and, therefore, no additional costs were incurred.

Allowing for indirect costs for theatre usage and medication, the total cost for initial insertion of the MCGR was £27,036 compared to £14,123 for CGRS as illustrated in Table 1.

Table 1 Costings for initial insertion of implant based on average theatre time for CGRS of 352 min and 311 min for MCGR

	CGRS (£)	MCGR (£)
Theatre staffing	1,127.52	995.74
Total equipment costs	8,562.00	22,050.00
Theatre time	3,664.32	3,236.02
Imaging for insertion	602.50	588.07
Medication and nurse review of wound	167.26	167.04
Total cost insertion of initial system (using expedium 4.5 system)	£14,123.60	£27,036.87

Table 2 Costings of lengthenings

	CGRS (£)	MCGR (£)
Staffing costs	327.79	8.43
Theatre time	1,065.29	0.00
Imaging costs	299.62	291.71
Clinic time	106.00	106.00
Practice nurse	2.55	0
Medication	164.71	0
External remote controller	0	171.36
Total cost of lengthening	£1,965.97	£577.49

Lengthening

The unit cost for a lengthening in the MCGR group was £577 compared to £1,965 in CGRS (Table 2). The cost of the external adjustment device and depreciation factors were taken into account when calculating the unit cost. Significant savings were made by MCGR due to the ability to lengthen in the outpatient setting removing the cost of theatre and post-operative in-patient care.

Revision

Of the 14 children who have already undergone MCGR treatment, we have had four complications to date, with one broken rod, two hook revisions (both in one patient) and one wound infection. In the CGRS group, there was one patient with infection requiring revision surgery. The average cost for revision procedures in the CGRS vs. MCGR was £1,925 vs. £2,020 as shown in Table 3.

Post-operative care

There were differences in costs of post-operative care (CGRS £1,386 vs. MCGR £2,958). This was due to longer stays on Paediatric HDU and the ward by the MCGR group. The higher cost was balanced by the CGRS group requiring an additional post-operative care for each lengthening episode every 6 months. Table 4 details the individual costings for each modality.

Table 3 Revision costings based on average theatre time of 117.5 min for CGRS and 120.67 for MCGR

	CGRS (£)	MCGR (£)
Staff costs	376.38	386.52
Theatre time	1,223.18	1,256.14
Imaging	158.00	210.00
Practice nurse and medication	167.26	167.04
Total revision cost	£1,924.82	£2,019.70

Table 4 Post-operative care costings for primary and revision surgery

	CGRS (£)	MCGR (£)
Paediatric HDU	688.18	1,724.46
Paediatric ward	640.99	1,214.03
Day case ward	56.99	19.84
Total	£1,386.16	£2,958.33
Paediatric ward	916.59	472.73
Day case ward	0	68.32
Total	£916.59	£541.05

Based on the above figures, and allowing for United Kingdom inflationary pressures of 2 % per annum, 5 year projectional costings were performed (Table 5). For the purposes of forecasting, operative lengthening was estimated at twice a year for CGRS and four outpatient lengthenings per year for MCGR. During the first year, the cost of MCGR is £11,234. Projecting forwards over the next 4 years, there are annual costs of approximately £7,500 for CGRS compared to approximately £2,500 for MCGR assuming no complications. Four years after initial insertion, the MCGR group costs approximately £9,000 less than the CGRS.

Table 5 projected cost of MCGR vs. CGRS over a 5 year period based on the initial costings from the first year of experience with the MCGR.

Discussion

The introduction of any new medical device comes with cost implications from not only the implant itself but adaptation around change in practice both in theatre and in outpatients. This work has been performed as part of a due diligence process to assess the cost burden imposed by the senior author on departmental resources in deploying new technology and forms part of an ongoing constructive debate with health authorities.

Table 5 Projected cost of MCGR vs. CGRS over a 5 year period based on the initial costings from the first year of experience with the MCGR

	Year 1	Year 2	Year 3	Year 4	Year 5	Totals
CGRS						
Pre-operative asessment clinic	245	166	170	173	177	931
Insertion of initial system	14,124	0	0	0	0	14,124
Lengthening	1,966	4,011	4,091	4,173	4,256	18,496
Revision	1,925	0	0	0	0	1,925
Post-operative care	2,772	2,828	2,884	2,942	3,001	14,427
Post-complication operative care	917	0	0	0	0	917
Total cost outpatient first clinic appointment	168	0	0	0	0	168
Total cost outpatient follow-up appointment	343	233	238	243	248	1,305
Total CGRS	22,460	7,238	7,383	7,531	7,681	52,293
MCGR						
Pre-operative asessment clinic	163	0	0	0	0	163
Insertion of initial system	27,037	0	0	0	0	27,037
Lengthening in clinic	577	2,356	2,403	2,451	2,500	10,289
Revision	2,020	0	0	0	0	2,020
Post-operative care	2,958	0	0	0	0	2,958
Post-complication operative care	541	0	0	0	0	541
Total cost outpatient first clinic appointment	168	0	0	0	0	168
Total cost outpatient follow-up appointment	229	0	0	0	0	229
Total MCGR	33,694	2,356	2,403	2,451	2,500	43,405
Total difference	−11,234	4,882	4,980	5,079	5,181	8,888
Inflation		2 %	2 %	2 %	2 %	

The data was collated as accurately as possible using patient notes, computer record systems for X-rays, duration and location of stay in hospital along with operation times. However, data was unavailable for anaesthetic induction agent costs, which are likely to be the same for each system and, therefore, have no bearing on final estimations. The data collection was limited by the quality of information available through the hospital records. Other drawbacks of this analysis include the retrospective nature of the review; some of the information such as time spent with individual professionals in clinic was based on estimates and may not truly reflect actual timescales. There is also the senior author's learning curve in that the new device may have required longer to insert in the early stages; hence, the additional cost but still relevant to new centres looking to adopt this technique. The numbers reviewed are small and a much larger series is required with an all encompassing model which takes account of complication rates in real time. The projectional data is based on the assumption that no further complications will occur during the five year period. In our institution, the lengthening of CGR is performed as an inpatient procedure with an associated cost from the hospital stay. Some centres perform this as a day case procedure and will incur a lower cost from the repeated lengthenings. The high complication rate with conventional growing rod technology is well documented, and we would hope that with less surgical events, the MCGR rate of untoward events will be lower [6].

This cost analysis indicates that there is an initial high capital investment for primary insertion of MCGR. The costs of initial insertion and post-operative care were more expensive in MCGR. The higher initial post-operative costs may reflect the use of new technique and the need for closer monitor of the patients post-operatively. The cost of lengthening in MCGR is significantly cheaper than CGRS which in the medium- to long-term outweighs the initial expenditure. These savings are at least sufficient to pay for the yearly maintenance of the new system. Although the focus of this paper is made around the economic savings, the real advantage to this technique comes from the health and psychosocial benefits of reducing invasive procedures in a paediatric population. The advantages of minimising repeated surgical procedures in the children has been recognised since single multilevel surgery was introduced in cerebral palsy patients to reduce the development of 'birthday syndrome' [7]. The EOS population often have other comorbidities requiring repeated visits to hospital. The ability to significantly reduce surgical admissions will have a substantial effect on their social development. There is a significant health benefit to be gained from reducing operative events in relation to hospital acquired infections, toxicity from anaesthesia and operative complications.

Anecdotally, the families and children who appear to have approached the new technique with most enthusiasm are the cohort that has converted from other conventional instrumentation to MCGR. They themselves have seen the true cost to their child of numerous surgical events throughout the early years of life.

Conflict of interest None.

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