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Selective posterior rhizotomy: a long-term follow-up study

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Abstract. Fifty-one spastic children who had undergone selective posterior lumbar rhizotomy between 1981 and 1984 were re-examined to determine whether the gains achieved had persisted and to look at other aspects that had not previously been explored in detail. The reduction of tone was maintained in all cases, while motor function continued to improve in 42 cases. Functional gains were greatest in children operated on under the age of 8, but pleasing results were also achieved in older children. Forty-five children continued to receive physiotherapy, particular attention being paid to building up muscle strength. Sensory disturbances were minimal, and there was no evidence of spinal instability. Post-rhizotomy orthopaedic surgery for fixed-joint contractures generally brought further improvement. Parents and older children were also questioned and almost all were enthusiastic about the outcome. Rhizotomy can be of considerable benefit to spastic children, but great care must be taken in the selection of suitable cases.

Key words: Posterior lumbar rhizotomy – Cerebral palsy – Long-term results.

Selective posterior lumbar rhizotomies have been performed in Cape Town since 1981. We reported our first 13 cases in 1982 [2] and recently published our findings on 60 cases with a follow-up period ranging from 1 to 5 years [3]. A longer-term follow-up on these cases is now presented, including aspects previously not discussed.

The primary aim of rhizotomy is to reduce spasticity. The secondary aims depend on the degree of handicap. In the case of the profoundly retarded, severely spastic child with no motor function, only easier positioning and management can be expected, while in the less handicapped child, the aim is to improve motor function. The degree of improvement depends mainly on the degree of disability pre-operatively, but factors such as intelligence, motivation and the availability of physiotherapy play a role [1, 3].

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The object of this long-term follow-up study was to determine the degree of functional improvement, how successfully the improvements had been maintained over the years, whether any disadvantages had become apparent, and whether any additional information had been obtained that would aid in the correct selection of suitable cases. To the best of our knowledge, no similar long-term study has been undertaken.

Subjects and methods

Sixty cerebral palsied children underwent selective posterior lumbar rhizotomies at the Red Cross War Memorial Children's Hospital in Cape Town between 1981 and 1984. Seven of these were lost to follow-up, 4 of whom were independent walkers. The remaining 53 (38 boys and 14 girls) were included in this study. Ages at the time of rhizotomy ranged from 20 months to 14 years (Table 1). The follow-up period ranged from 3 years to nearly 7 years.

All 53 children were hypertonic, either with mainly lower limb involvement or with severe involvement of all four limbs. Fifty-one were either purely spastic or had also some degree of athetosis while 2 were very severely affected dystonic athetoids.

All the children had had physiotherapy regularly before rhizotomy by physiotherapists experienced in treating cerebral palsy. Almost all the children over the age of 3 years attended special schools or centres where physiotherapy, occupational therapy and, where indicated, speech therapy were available as part of the daily program. The others received therapy on an out-patient basis. All were able to continue therapy post-operatively.

In our previous paper [3], we described the assessment procedure we followed pre- and post-rhizotomy. In the present study we considered the results in comparison with our previous assessments of the same children and, in addition, sought the opinions of the parents of the children themselves.

Table 1. Distribution of cases by age

Age (years)	Number
3	7
3–5	20
6–8	20
9–11	3
12–14	3
Total	53

Information for the first of these objectives was derived mainly from follow-up forms filled in 3–7 years after rhizotomy by the physiotherapists who treated the children. The therapists were asked to refer to previous notes on the child and to video recordings taken before and after rhizotomy and to consider whether there had been continued improvement, no change, or deterioration since the previous post-rhizotomy assessment. This information was sought with regard to muscle tone and muscle power and the child's functional ability, motivation and behavioural changes. Questions were asked about post-rhizotomy orthopaedic surgery, and about good postures and the wearing of orthoses. Information was requested concerning possible spinal problems relating to laminectomy, and whether there was any sensory impairment. Finally, the physiotherapists were asked whether they felt that in the long-term the results justified the surgery. Thirty-two of the children were also re-examined by one of the authors (LJA), who also studied many video recordings. There was close correlation between the physiotherapists' assessments and the author's observations.

For the final compilation of results, the long-term assessment forms were considered in conjunction with the pre-rhizotomy and previous post-rhizotomy forms, as well as the information from the author's assessments and the video recordings. The data were then tabulated and analysed. Parents were also asked to fill in a questionnaire. The questions for parents were less specific and directed particularly as to whether they felt the operation was worthwhile with respect to both movement and behaviour and whether they had been led to expect more from the operation and, if so, whether they had been told there would be greater benefits or had just hoped for more. They were asked whether there had been any unexpected gains and whether, over the years, there had been further improvements or deterioration. Parents of 35 children replied. One form was filled in by the father, the others by the mother or both parents. Forms were also drawn up for children who were over the age of 6 at the time of surgery. They were asked is they could remember what they were like before surgery, whether they felt that they were better or worse, and whether they felt that physiotherapy still helped them. Fifteen replies were received.

Previously [3], we divided the children into two groups consisting of the very severely handicapped and the less handicapped. In order to determine the degree of functional improvement that had occurred in the long term, the 51 spastic children were assessed first on the basis of their pre-operative motor abilities (as recorded on the forms and video recordings) and again on their post-operative status into one of seven grades (Table 2). Further subdivisions into ½ grades were found necessary in grades 4–7 and were indicated by a minus sign. A child who could crawl was graded 4 while a child who could only crawl a very short distance was classified as 4–. Children who walked well with a walking aid were graded 5 while if they could only walk a few meters with a walking aid, they were graded 5– or 6–, respectively. If they could walk alone with a poor pattern over fairly long distances, they were graded 6 but if they could only do this over a few meters, they were graded 6–. Pre-operatively, there were no children in grade 7, but post-operatively if the walking pattern had greatly improved but was not quite normal, the gradient was 7–. It must be kept in mind that the children accepted for rhizotomy had been referred because the therapists felt that a point had been reached at which physiotherapy alone was insufficient to affect improvement in useful motor function or in better patterns of movement.

Table 2. Grading of gross motor function

Grades	Function
1	No purposeful movement
2	Minimal purposeful movement
3	Sitting alone and/or creeping and/or fully supported stepping. Difficulty in assuming positions
4	Reasonably useful non-ambulant locomotion (crawling "bunny-hopping", etc) and/or walking when assisted
5	Walking with a walking aid
6	Walking alone with a poor pattern
7	Fully independent walking with good pattern

Results

Comparison with previous assessment

Reduction of tone. Tone in the lower limbs of all 51 of the spastic cases remained reduced, but where there was also some athetosis, this was unchanged or had become more obvious in the absence of spasticity. In 7 of the 18 cases where the tone had been reported low in the first post-operative assessment, there had been return to normal or near normal tone, but even where there was persistent hypotonia at rest, function was not necessarily affected. Four of the children with residual lower-limb hypotonia were independent walkers.

The two children with dystonia remained unchanged, their dystonic spasms being as severe as before, with continued minimal voluntary function. They will not be further discussed in this article.

Long-term progress. Of the 51 children, 45 were still receiving physiotherapy, mainly along neurodevelopmental (NDT) lines. Forty-two of these were still making progress while 3 remained unchanged from the previous assessment.

One of the 6 children who no longer received therapy was a 10-year-old intelligent child, previously a mild spastic diplegic, whose abnormal gait pattern had improved to normal within a year after rhizotomy in 1982 [3]. Five years after surgery the improvement has been fully maintained.

The other 5 children were all severely to profoundly mentally retarded. Physiotherapy was no longer available to 1 of these, but had been discontinued in the others because no further progress was being made. Four retained the progress they had made following rhizotomy but one, a profoundly retarded, severely affected quadriplegic with no voluntary movements pre- or post-rhizotomy, had become worse over the past year, as he had been neglected and left lying for prolonged periods in the same position and had become fixed in a "wind-swept" posture 6 years after rhizotomy.

Changes in functional grading. Table 3 shows the changes in function. Of the 3 children who did not gain in function, 1 was the profoundly retarded child who had developed postural contractures and functionally remained at grade 1. Another was a totally unmotivated, severely handicapped boy who stayed at grade 3. The third child only resumed walking with a walking aid (grade 5) after a hamstring lengthening operation performed 6 years after rhizotomy.

Eight of the 13 children who gained only a ½ grade were already walking independently (grades 6– or 6) before rhizo-

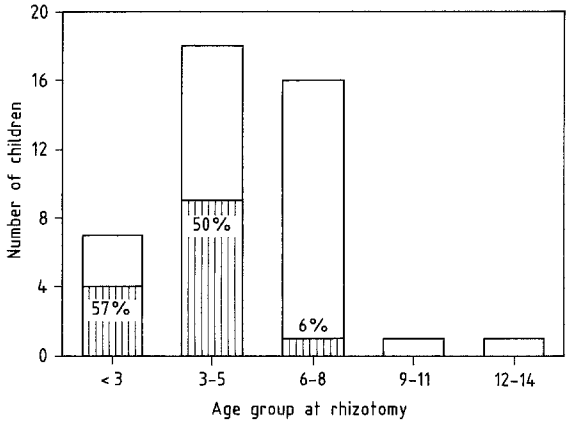

Fig. 1. Gains of 1½–2 grades according to age groups. ▥, number of children who gained 1½–2 grades

Table 3. Changes in functional grading 3–7 years post-operatively

	Number of cases
Grades gained	
0	3
½	13
1	19
1½	8
2	7
Grades lost	
½	1
Total	51

Table 4. Changes in functional grading pre-rhizotomy and 3–7 years post-rhizotomy

Grade	Pre-rhizotomy (No. of cases)	Post-rhizotomy (No. of cases)
1	1	1
2	4	1
3	14	4
4– and 4	16	11
5– and 5	6	14
6– and 6	10	16
7– and 7	0	4
Total	51	51

tomy. The improvement in walking brought them to grades 6 or 7– (two other independent walkers gained 1 grade).

The overall changes in function from pre- to post-rhizotomy can be seen in Table 4. Figure 1 shows the number of children in each age group at the time of rhizotomy who gained 1½–2 grades. All but 1 were under the age of 8 years.

Improvement in ambulation. Before rhizotomy, only 4 of the 10 independent walkers were community walkers, able to walk at least 5 min outdoors. At long-term follow-up, there were 15 such community walkers, and another 4 were fully independent indoors but were less successful over long distances or uneven terrain. One other child, previously grade 4, could walk 5 m unaided (grade 6–).

Upper limb movement. In our previous study [3], we found improvement in upper-limb function in 68% of the children who had had problems before rhizotomy. Not only was this improvement maintained in the long term, but in 11 cases there was continued improvement.

Muscle power. After reduction in tone by rhizotomy, muscle weakness, previously marked by the spasticity, became more apparent but, as pointed out previously, did improve with physiotherapy. In the long term there was further improvement in power, but weakness was still observed in some muscle groups in 46 cases. The muscle groups most commonly mentioned were the trunk and hip extensors, abdominals, the hip abductors and the muscles of the calf.

Foot postures. Pre-rhizotomy, all the children who could bear weight did so with poor foot postures, the feet being held in equinus or equinovalgus, with or without mid-tarsal "breaks" and/or clawing of the toes. After rhizotomy, only 5 of the 32 ambulant children (grades 5 and 6) had good foot postures, the remaining 26 having valgus deformity in one or both feet with persistence of the mid-tarsal "breaks" and in several cases with clawing. In 10 of the 31 ambulant cases there had been fixed contracture of the Achilles tendon, and the equinus had persisted until surgical lengthening was undertaken.

Orthopaedic surgery. Twenty-four children had orthopaedic operations after rhizotomy with a total of 34 procedures. There were 28 muscle releases or tendon lengthenings for fixed contractures (all present pre-operatively), mainly hip adductors, hamstrings and triceps surae. There were 3 derotation osteotomies, 1 open hip reduction and 1 Grice procedure. Further functional improvement was noted after these procedures in most cases. Nine children were still awaiting surgery. On the other hand, in a number of cases joint range was considerably increased after rhizotomy and some children who pre-operatively were considered to have fixed contractures did not need contracture releases following rhizotomy. No case of subluxation or threatening subluxation of the hips present pre-operatively progressed further towards dislocation once the spasticity had been reduced.

Lumbar pain or instability. In only three children (an 8-year-old boy and two 14-year-old girls) was lumbar pain experienced after the immediate post-operative period. In two cases the pain was intermittent and lessened over the years, and in the third case there was severe pain in the lumbar region for 8 months after surgery, but this disappeared completely after 1 year. There was no clinical evidence of lumbar instability. Lordosis present pre-operatively in 16 cases improved in 9. In the two cases where kyphosis was noted pre-operatively improvement occurred after surgery.

Sensory changes. Despite the dividing of the posterior rootlets there has been minimal sensory loss and no sensory problems such as trophic sores. Three cases of limited diminution of sensation were noted. A boy, 10 years old at rhizotomy, had bilateral diminution of touch and pressure sensation in the S 2 distribution; a 14-year-old girl had bilateral diminution of touch in the L 2, 3 and 4 distribution, and a 6-year-old girl had a patchy diminution of touch in the L 4 and 5 dermatomes on the right and a slight loss of position sense in the toes of the right foot, which did not result in any functional disability. In all 3 cases the children were initially aware of their sensory disturbances, but this awareness lessened in time.

Intelligence and motivation. Forty children were receiving formal education and one had completed high school. Five children were classified as moderately retarded or "trainable", while 5 were severely to profoundly retarded. Of the latter 10 retarded children, 1 had not achieved any function, 2 gained a ½ grade, 6 gained 1 grade and 1 gained 1½ grades. None became independent walkers.

In 18 cases, the physiotherapists commented on improvement in motivation or self-confidence since rhizotomy; in some cases this was almost immediate and in others there was a slow improvement over the years. Four of these had already been independent walkers and gained a ½ grade while 6 were among those who had gained 1½ to 2 grades (Table 3). One other child, grade 3 pre-rhizotomy, improved rapidly to grade 4 and then lost motivation when progress slowed.

Final summation. The operation was judged to have been worthwhile in 49 cases, and in 24 of these the benefits to the child were considered to be great. In only 1 case was the operation of no benefit in the long term (the profoundly retarded child) and in 1 further case very little was gained.

Parents' responses

The parents of all 35 children noted that the children were less stiff. Thirty-two felt that rhizotomy had been worthwhile, 11 of these expressing their satisfaction in very positive terms, such as that the results had been "amazing" or that there was a vast improvement. Ten parents commented on behavioural improvement, stating that the child was less irritable and frustrated, or had a better self-image, etc. Two remarked on improvement in sleeping habits. Three parents were less definite (in all 3 cases the children had made only small gains). One felt that there had been neither progress nor deterioration, the second wondered whether improvement would have occurred without surgery, and the third mother, while acknowledging some improvements, said she was not satisfied that the goals had been met.

Replies to the question whether there had been unexpected gains was answered in the affirmative in 9 cases, the parents expressing pleasure at improvement in upper-limb function, in balance or in the ability to walk, etc.

Four parents said they had been led to expect more from the operation, two from seeing other children; two said doctors had predicted greater improvement. Nine others said that they had just hoped for more gains.

Children's responses

Two of the 15 completed questionnaires were discarded as the children no longer remembered what they were like before rhizotomy. The remainder either said that they had felt stiff prior to surgery and less stiff after, or they enumerated the things that they could not previously do, but were able to do after surgery. All thought the operation had been worthwhile. However, 2 commented on the sensory loss in their legs. One thought there had been improvement but was not sure whether physiotherapy still helped him, but the others all felt that physiotherapy did still help, and 5 made very definite statements that it helped greatly, 1 child saying that she would like to have even more physiotherapy.

Discussion

This study has shown that the reduction of spasticity by selective posterior rhizotomy has persisted for nearly 7 years and is presumably permanent. A very pleasing aspect of the study was the progressive improvement in function over the years in 42 out of 51 cases (82%). In addition, the ambulant child whose walking pattern had become normal within a year of surgery had completely maintained his improvement. Gains in function, as might be expected, were most marked in the younger child. Maturation certainly played a part here. However, pre-operatively the children were either not progressing functionally or progressing at a very slow rate despite regular physiotherapy, so the large gains must be ascribed to the increased ease of movement due to the reduction of spasticity. Also, older children and even teenagers in whom improvement was no longer expected continued to show improvement over the years. Improvement was less marked and leveled off sooner in the more retarded children, although even here the progress justified the surgery in most cases. The exception, the profoundly retarded, neglected and immobile child who developed postural deformities despite the reduction in tone, would almost surely have developed earlier joint contractures without the rhizotomy.

Once again, we noted the improvement in self-confidence and motivation in many children who had become more outgoing and eager to work towards improving their function. Lack of motivation had a negative influence on progress.

The importance of muscle weakness as a retarding factor in the achievement of good motor function after rhizotomy needs to be stressed. The roles played by muscle tone (an involuntary muscle response) and power (a voluntary muscle action) are extremely difficult to separate in the presence of spasticity, as spasticity can mask underlying weakness. In

the presence of spasticity, little-used antagonist muscles become weakened, while it is common to find both hypotonia and weakness in neck and trunk muscles in association with spastic limbs. Once the spasticity is reduced, underlying muscle weakness becomes more obvious and physiotherapy must be directed towards improving strength. Stable standing balance and good weight-bearing postures are dependent on strong hip and trunk extensors and strong quadriceps muscles, while the trunk sway, so common in ambulant spastic children as a result of weak hip abductors, can be difficult to eradicate. Attention must be paid to strengthening these weak muscles. The feet carry the entire weight of the body in the upright posture, and muscle weakness and imbalance appear to be largely responsible for the persistence of poor foot postures.

In our previous paper [3], we showed that joints which had been judged before rhizotomy to have fixed contractures had greater range of movement after rhizotomy. However, surgical correction of fixed contractures was still necessary in a considerable number of children and, provided this was undertaken only after a period of rehabilitative therapy, was generally very successfull, the children gaining further function thereafter. We feel that orthopaedic surgery should, if possible, be deferred until after rhizotomy rather than before rhizotomy in most cases.

The laminectomy in this procedure is a limited one, the facet joints being left intact. A study from the Mayo Clinic in 1982 [4] showed no spinal deformities following multiple level lumbar laminectomies without facetectomies. Despite this, doubts are frequently expressed as to whether the operation would not lead to spinal instability. This study has shown no evidence of this and of the three cases with back pain after rhizotomy, one no longer had pain, and the other two experienced it less with the passage of time.

On the whole, the response of the parents was very similar to that of the physiotherapists. Every effort must be made to see that the parents do not have unrealistic aims as to the degree of improvement to be expected, but there will always be parents who hope for a "miracle". Of interest in the children's replies was the fact that they were aware of the change in their movements and that they appreciated the importance of prolonged physiotherapy.

This study served to reinforce previous accounts of the beneficial results of selective posterior lumbar rhizotomy on spastic children, even in the long term, and has not brought to light any major disadvantages. Important facts are that not only is improvement maintained, but in most cases it is ongoing and prolonged physiotherapy is necessary in most cases. Careful selection of suitable children is clearly of the utmost importance, and the ideal case is the intelligent child with spasticity mainly confined to the lower limbs, and without much accompanying muscle weakness.

While no new absolute contraindications to rhizotomy have emerged from this study, we must once again stress that it is of no value to the dystonic athetoid. Also, it would seem wise before deciding on a rhizotomy for the profoundly retarded spastic quadriplegic to give consideration to the quality of home care that would be available for the child in the long term. It will be interesting to watch the further progress of these 51 children.

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