

# THE MATRIX SEATING SYSTEM

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**The Matrix seating system is an adaptable orthosis made of interlocking plastic components which can be shaped to fit the needs of the disabled. Twenty-five patients who had used this system for a minimum of 12 months have been assessed clinically. It was found to have several advantages over its rivals particularly in patient and guardian acceptance, versatility and on economic grounds. However, it was found not to prevent deterioration in spinal deformity nor to prevent hip dislocation.**

The provision and development of specialist seating for handicapped children is still a considerable challenge to orthopaedic surgeons and orthotists. While there are many advantages to upright sitting, no single system has been universally successful in achieving this. The conventional wheelchair provides little support to the pelvis and trunk unless some form of insert is added; these range from simple cushions or wedges, through commercially available pressure distributing devices such as Roho cushions, to more formal moulded inserts.

Many authors have graded the disability of handicapped children and attempted to match the grades to the different forms of seating available. Thus, Rang et al (1981) described three groups: group 1 (no-hands sitter) simply need a foam cushion and removable arm supports, but group 2 (hand-dependent sitter) and group 3 (the propped sitter) required more extensive chair modifications. Treffer, Tooms and Hobson (1978) also graded disability into three, minimal, moderate and severe, based on head and trunk control.

Many solutions have been advocated. Nichols (1966) and Nelham (1981) recommended adjustable supports and padded inserts for patients with moderate to severe disabilities. Dunkel and Treffer (1977) advocated the 'sleek seat' as an alternative, particularly in young patients with excessive extensor tone. Most authors, however, have recommended moulded supports. The Beaufort seating orthosis (Patrick 1980) consists of a large bag filled with thousands of polystyrene beads; this

bag is moulded to the patient's shape and the air extracted. Other workers have taken this principle further and developed moulded inserts. Many still use vacuum beads to shape a mould for the formation of contoured inserts (Hassard, Conry and Rice 1971; Nichols and Strange 1972; Bowker and Reed 1973; Germans et al 1975; Nelham 1975; Winter and Carlson 1977; Strange, Harris and Nichols 1978; Wijkmans et al 1978; Ring, Nelham and Pearson 1978; McQuilton and Johnson 1981; Pritham and Leiper 1981; Moore et al 1982). Others have used the patient directly for moulding (Kuhn 1973; Treffer et al 1978). Gibson et al (1978) recommended a specially designed spinal support system, which consisted of a fibreglass shell with seat contours, arm rests, foot rests and head rests adjustable and custom-tailored for each patient.

In the 1970s a new type of seating orthosis was developed at the Bio-engineering Centre, Roehampton. This included a shapable matrix constructed from interlocking plastic components, and became known as the Matrix seating system (Figs 1 to 5). We have evaluated our experience with this orthosis in children.

## PATIENTS AND METHODS

We studied 25 severely disabled children who had used a Matrix seating orthosis for a minimum of 12 months. The patients were reviewed personally by one author (IAT), a questionnaire was completed, and a full musculoskeletal examination carried out.

The questionnaire contained sections on the medical condition of the patient and the need for an orthosis, previous chairs and problems experienced with them, reasons for changing to a Matrix, as well as a subjective assessment of the Matrix by the guardian or physiotherapist and by the patient if possible. Alterations to the Matrix system were noted and the reasons for them, together with any problems. Examination included a critical assessment of posture, contractures, and head,

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0301-620X/90/4129 \$2.00  
*J Bone Joint Surg [Br]* 1990; 72-B:666-9.

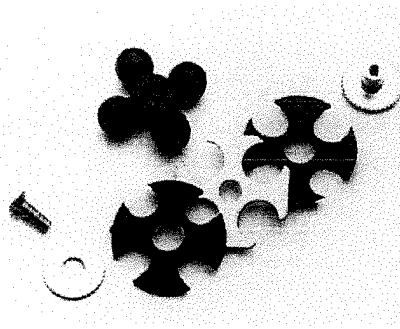


Fig. 1

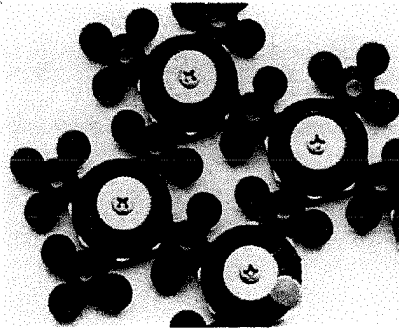


Fig. 2

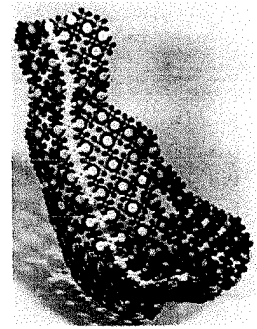


Fig. 3

The Matrix seating system, showing 1) the interlocking plastic components 2) a section of interlocked components and 3) the whole seat.

trunk and limb control, together with the support provided by the Matrix orthosis. Particular reference was made to the spine, pelvis and hips. Any skin problems were noted. Ten of these children were evaluated radiologically over the 12-month period to see if any scoliosis had developed or deteriorated, and also to identify any pelvic obliquity, hip subluxation or dislocation.

#### RESULTS

Of the 25 patients, 15 were male and 10 female. Their ages ranged from 2 to 24 years (mean 11.25). The underlying diagnoses were: cerebral palsy (18), spina bifida (2), Duchenne muscular dystrophy (1), craniostenosis/microcephaly (1) and Rett's syndrome (1); in two cases the diagnosis was unknown. All the children had

been in the Matrix seating system for a minimum of 12 months (range 12 to 22, mean 15).

Fourteen of the children had had previous orthotic devices. These consisted of moulded inserts (6) and Orthokinetic wheelchairs (5), Ainsbury chairs (2) a Craddock chair (1) and an Avon chair (1). Ten patients, who had not had a previous orthosis, were noted to be developing deformities of the hips and the spine. Ten patients had developed progressive spinal and hip deformity despite their modified chairs, four had outgrown their previous orthosis, and one patient could not be fitted with any other system.

In 21 cases, the subjective assessment of the guardian/physiotherapist was that the Matrix system was ~~satisfactory or good~~. Four were critical of the orthosis, three because of its appearance and one because of the many alterations required for a satisfactory fitting. Of

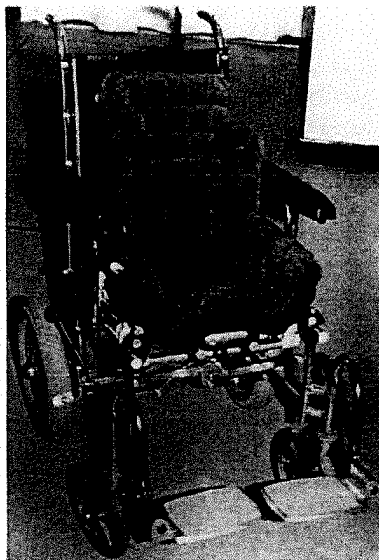


Fig. 4

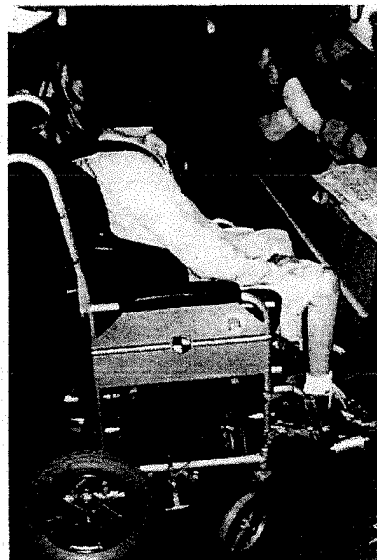


Fig. 5

The seat covered and fixed in the wheelchair 4) and in use 5).

the 10 patients who were able to give opinions, seven liked the orthosis; of the three that did not, two complained of pain when in the orthosis, the other had no reason for disliking it.

Twenty-five chairs had been altered a total of 116 times, giving a mean of 4.6 times per chair (range 0 to 15).

The problems experienced by the patients and their guardians are listed in Table I. The principal difficulty in six patients was that they tended to fall out of the chair; this was solved by adding a pommel together with buckles and a belt. In three other patients, a head rest was found to be loose and offered little support; this has been a continuing problem. The other problems related to the

**Radiography.** Eight of the 10 patients who had serial radiography had scoliosis; of these, six had not deteriorated during their period in the Matrix chair. However, one had a segmental spinal stabilisation and another wore a thoracolumbar spinal orthosis in the Matrix system. In two patients the curve had progressed; in one, with a T3 to L3 scoliosis, the Cobb angle had increased from 20° to 46°, and in the other with a T5 to L4 curve, it had increased from 5° to 24°. Eight patients had pelvic obliquity which, in six had not deteriorated. Of the eight patients whose radiographs showed subluxed or dislocated hips, six had not deteriorated; the other two deteriorated from subluxation to dislocation during their period in the Matrix chair.

## DISCUSSION

The improvement of orthoses in recent years has led to an improvement in the quality of life of many severely handicapped people. The ideal orthosis should provide support over a large area, thus minimising local pressure, with enough postural support to allow the patient to utilise his or her resources to the utmost. In addition the orthosis should correct established deformity, or at least prevent any deterioration.

The Matrix seating system satisfies at least two of these criteria. None of our patients developed significant pressure sores and its functional success was such that only three patients and three parents/guardians did not like the Matrix, the principal cause of dislike being the appearance. Another advantage of the Matrix system is its versatility. In our series alterations were required an average of 4.6 times per chair; this facility for change contrasts sharply with other forms of orthoses, notably the moulded insert. Although the Matrix system initially is dearer than a moulded insert (£524 fully fitted as against £368) it proved its value when the number of changes required was considered. Furthermore, an alteration to the Matrix system took an average of five man-hours, whereas a fitting for a new moulded insert averaged 10 man-hours.

However, there were problems. This orthosis provided little correction of deformity. Two of eight patients with scoliosis deteriorated, and hips dislocated in a further two patients. Upper limb and head and neck control were poor. Other problems concerned principally the vehicle in which the Matrix was installed. It tended to be fitted too upright or too anterior thus altering the centre of gravity and causing problems mounting steps. Also, several guardians were concerned that their charges found it quite easy to extricate themselves from the orthosis despite pommel and belts.

Previous work on the Matrix seating system by Aparisi and Lindh (1984) has, like ours, showed encouraging results. They looked at 115 chairs prescribed and found that 105 were still in use. They also noticed a reduction in the number of pressure sores and an

Table I. Problems with the Matrix seating system in 25 patients

	Number
Does not restrain patient	6
Head-rest weak	3
Difficult to stabilise in ambulance*	2
Too upright	1
Top heavy	1
Hard to manoeuvre*	1
Superficial pressure sore	1

\*due to wheelchair faults

fitting of the Matrix system into a standard wheelchair, one difficulty being that the Matrix and consequently the patient were often too anterior in the chair, thus causing difficulty in tipping and in ascending steps.

**Clinical findings.** In five patients the head and neck were poorly supported by the Matrix system, but in all patients the shoulders were well supported. Fifteen patients had scoliosis which was well-supported in the Matrix chair, as was the spine in the 10 non-scoliotic patients. Eight patients had significant pelvic obliquity; this was also well supported in the Matrix.

Ten patients (11 hips) had abnormalities of the hips: seven were dislocated and four were subluxed; in all these patients, the limbs were well supported. Fourteen patients had fixed flexion contractures of both knees, and a further six had equinovarus deformities of the feet; none of these deformities caused problems with the Matrix system.

No patient had a pressure sore over the buttocks or spine during the period spent in a Matrix system, despite the fact that only two were totally continent of urine and faeces. One patient developed a superficial sore over the scapula which healed after modifying the chair.

improvement in motor function of the upper limbs with less spasticity in some cases, and a reduction in the scoliotic curvature in a number of patients. Despite the initial expense, they found that over a five-year period costs with the Matrix system were appreciably lower than for vacuum or plastic moulded orthoses. The only drawback they found with the Matrix system was its weight.

However, good results have been reported for other orthoses. The successful use of moulded inserts has been reported by Hassard et al (1971) in four patients with pressure sores, by Germans et al (1975) in 15 patients and by Ring et al (1978) in 53 patients. In Ring's series the insert was popular with 39 out of 44 medical officers and 40 out of 42 patients. Medhat and Redford (1985) reviewed 100 patients in a seating clinic over a three-year period. They recommended the DESMO custom-moulded support system. Moore et al (1982) evaluated this system in 51 patients. They found that it was

enthusiastically received by their patients and therapists, although of 265 supports reviewed 51 were not in use. Of these, eight had been outgrown and 10 were discontinued because of inadequate fit or discomfort. Finally, Seeger and Sutherland (1981) reported the results of another modular seating system and found preliminary results to be encouraging.

**Conclusions.** From our analysis of 25 Matrix seating orthoses we can recommend its use for severely disabled children. The system was superior to its rivals, particularly the moulded insert, in patient and guardian acceptance, versatility and on economic grounds. However, it did not regularly prevent deterioration in patients with spinal deformity or prevent hip dislocation.

We are grateful to Miss L. Morris for typing the manuscript and to the Department of Medical Illustration, Royal Manchester Children's Hospital for preparing the illustrations.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

## REFERENCES

- Aparisi T, Lindh L. Matrix - ett nytt sittersystem. *Ortopediskt* 1984; Aug:6-8.
- Bowker JH, Reed BA. A vacuum-formed plastic insert seat for neurologically handicapped wheelchair patients. *Inter-Clinic Information Bulletin* 1973; 12(10):7-17.
- Dunkel RH, Trefler E. Seating for cerebral palsied children - the sleek seat. *Phys Ther* 1977; 57:524-6.
- Germans FH, Koster MW, Kwee HH, vd Mey N, Soerjanto R, Wijkmans DW. Vacuum dilatancy casting for the construction of individually molded seats. *Inter-Clinic Information Bulletin* 1975; 14(5):1-9.
- Gibson DA, Koreska J, Robertson D, Kahn A, Albisser AM. The management of spinal deformity in Duchenne's muscular dystrophy. *Orthop Clin North Am* 1978; 9:437-50.
- Hassard GH, Conry J, Rice W. Bucket seat for control of decubitus ulcers. *Arch Phys Med Rehabil* 1971; 52:481-4.
- Kuhn GG. Individual moulded seat-shells for severely handicapped persons. *Acta Orthop Scand* 1973; 44:366-71.
- McQuilton G, Johnson GR. Cost-effective moulded seating for the handicapped child. *Prosthet Orthot Int* 1981; 5:37-41.
- Medhat MA, Redford JB. Experience of a seating clinic. *Int Orthop* 1985; 9:279-85.
- Moore S, Bergman JS, Edwards G, Cowsar D, Echols SD, Forbes J. The DESMO customized seating support - custom-moulded seating for severely disabled persons. *Phys Ther* 1982; 62:460-3.
- Nelham RL. The manufacture of moulded supportive seating for the handicapped. *Biomed Eng* 1975; 10:379-81.
- Nelham RL. Seating for the chairbound disabled person - a survey of seating equipment in the United Kingdom. *J Biomed Eng* 1981; 3:267-74.
- Nichols PJ. Adjustable wheel-chair supports for paralytic collapsing spine. *Ann Phys Med* 1966; 8:266.
- Nichols PJ, Strange TV. A method of casting severely deformed and disabled patients. *Rheum Phys Med* 1972; 11:356.
- Patrick JH. Seating orthoses for severely paralysed patients. *Physiotherapy* 1980; 66:195.
- Pritham CH, Leiper CI. A method for custom seating of the severely disabled. *Orth Pros* 1981; 34:19-26.
- Rang M, Douglas G, Bennet GC, Koreska J. Seating for children with cerebral palsy. *J Pediatr Orthop* 1981; 1:279-87.
- Ring ND, Nelham RL, Pearson FA. Moulded supportive seating for the disabled. *Prosthet Orthot Int* 1978; 2:30-4.
- Seeger BR, Sutherland AD. Modular seating for paralytic scoliosis: design and initial experience. *Prosthet Orthot Int* 1981; 5:121-8.
- Strange TV, Harris JD, Nichols PJ. Individually contoured seating for the disabled. *Rheumatol Rehabil* 1978; 17:86-8.
- Trefler E, Tooms RE, Hobson DA. Seating for cerebral-palsied children. *Inter-Clinic Information Bulletin* 1978; 17:1-8.
- Wijkmans DW, Germans FH, van der Mey N, Soerjanto R, de Soete HW. Individually moulded seats. *AAOT* 1978; 25(3):15-20.
- Winter RB, Carlson JM. Modern orthotics for spinal deformities. *Clin Orthop* 1977; 126:74-86.