

## ISPO Draft Paper

Title: Structural Matrices for use in Rehabilitation: The Next Generation

Authors: Cousins SJ, May D?, Ackerley KE, Clarke R?

### Introduction

Original work on the concept of structural matrices for use in rehabilitation <sup>1, 2, 3</sup> has lead over the last 20 years to worldwide fittings of over 30,000 Matrix seating systems. The concept was to “design a universal structure, or structural matrix . . . defined as an array of small components that can be linked, shaped and locked to form a strong enclosing or supporting structure.” Additionally it was stated the “matrix approach takes advantage of mass-production techniques for producing standard components.” The vision was that the “frequency of patient visits may be reduced, as changes to the shape and strength of the orthosis can be made while the patient waits. The comfort of the patient will be increased by the provision of lightweight and cool structures that conform and respond to their needs.” The concept was later restated<sup>4</sup> “to speed production, lower costs and reduce the reliance on skilled technicians for the custom fitting processes in orthotics and prosthetics, it was proposed to divide support surfaces into load bearing, interlockable, segmented structural elements that could be mass produced.”

The vast experience (over 30,000 fittings) has shown some usefulness in this approach but, as with any mechanical system, improvements were possible. The question facing the authors four years ago was whether sufficient design improvements were possible to justify changing a working system. This paper reports on those designs changes and the results of clinical evaluations and laboratory testing.

### Method

Pre-production evaluation was conducted on 10 patients followed by post-production evaluation with 60 patients, 20 full shell and 40 back support fittings using indirect (casting) and direct (to the patient) fitting methods. In parallel destruction testing of nearly 300 structural elements before and during all stages of the design’s evaluation were undertaken. A further detailed retrospective measurement of eight casts and finished shells of the original Matrix system to determine the distribution of custom components and the orientation of all components. These evaluations lead to the complete re-design of the Matrix segmented structural approach to the manufacture of custom seating shells. Also the direct fitting method was refined to a process of taken eight ‘orthotic’ measurements to allow direct fitting to be accomplished in about 30 minutes.

### Results

For a workshop perspective the new design reduces fabrication and subsequent alterations time by about a 30 to 40% (compare to original Matrix) reduction in for a segmented structural system. Equally fitting times are reduced.

1. The re-design, in summary, has the following features (2<sup>nd</sup> Generation vs original Matrix):

1. Thinner (about 25%)
  2. Flatter (3 times surface area)
  3. Stronger (nearly 3 times)
  4. Lighter (less framing, weight decrease by 20% and lighter plastic, further weight decrease of about 19-33% depending of material used)
  5. Lower component count (6 down to 3)
  6. More corrosion resistant (stainless steel)
2. True 3D forming (new 2 ball component) by adding a translatory degree of freedom to ball and socket joint
  3. Cladding (reinforcement anywhere on Matrix shell) and interface developments

## Conclusions

1. Increased strength means
  1. Less framing: reduced weight, reduced bulk (improved cosmesis)
  2. Less framing: decreased production/adjustment time
  3. Flexible components now possible because slippage is eliminated
  4. 'Off the shelf' back supports – no custom frame
2. 3D capability allows
  1. Speeds the production process (less special threaded connectors),
  2. Strengthens the final product
  3. Allows major adjustments clinically (directly on the patient) at and post delivery
3. Cladding allows
  1. Reinforcement to be added any where and anytime during production and post delivery
  2. Thinner and more cosmetic structure where reinforcement is required

---

## References

- <sup>1</sup> Cousins SJ, Tredwell SJ, Cooper DG, Cousins SK. A Body Support System for Seating Children with Disabilities. Proceedings of the Interagency Conference on Rehabilitation Engineering. Atlanta Georgia, 1979.
- <sup>2</sup> Foort J, Hannah RE, Cousins SJ. Rehabilitation Engineering as the Crow Flies. Prosthetics & Orthotics International, April 1978, Vol. 2, No. 1
- <sup>3</sup> Cooper DG, Foort J, Hannah RE. Structural Matrices for use in Rehabilitation. Prosthetics Orthotics International, 1983 Apr;7(1):25-8
- <sup>4</sup> Cousins SJ, The Design of Segmented Structural Surfaces, Ph.D. Dissertation, University College London, January 1988.