Material Choice in Custom Moulded Seating for People with Neuro-Degenerative Disorders

Nicola Aburto and Nicola Holbrook, Seating Engineers,
Contour 886, Unit 1, Paramount Industrial Estate, Sandown Road, Watford WD24 7XE

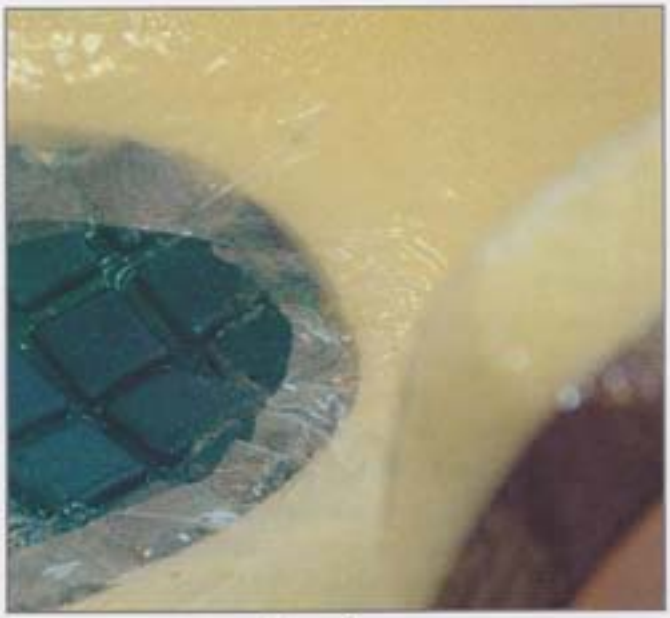
Abstract: *This article describes commonly used seating materials and goes on to propose a comparison table, which can be used as a clinical tool for choosing materials for the client. This will enable clinicians to make material decisions led by client need and consider the long-term implications of material choice. A case study will demonstrate how this can be used in practice.*

Various materials are available for custom-moulded seating: Carved Foam, Foam in Place, Matrix, New Matrix, Lynx and Thermoplastics. Each has different clinical, functional and technical attributes. The difficulty is choosing which material best meets the aims established during the assessment of the client. The material can influence how the seating works clinically and how it performs long-term. Knowledge of the materials available can assist clinicians to make an informed decision and choose the most appropriate material for the client with a neuro-degenerative disorder.

Clients with neuro-degenerative disorders present with some similar problems. These include muscle weakness, spasticity, postural deformity, contractures and the need for pressure relief (Ham R et al, 1998, pp 117). Each condition also has its own unique problems. Clients with multiple sclerosis (MS) have a "high incidence of pressure sores" (Ham R et al, 1998, pp 127) and have a tendency to overheat. With muscular dystrophy (MD) "many boys adopt a position with an exaggerated lumbar lordosis" (Ham R et al, 1998, pp 119) this is to maintain functional capabilities through building a stable sitting base. Clients with neuromuscular conditions may experience "possible shoulder girdle weakness, which may make it difficult to self propel" (Muscular Dystrophy Campaign, 2006, 46). Clients with cerebral palsy present common "complications *relating* to involuntary movements" (Ham R et al, 1998, pp 117). All of these factors will have implications on the type of material used, with consideration being given to clinical and functional needs in addition to technical considerations. These needs continually change, which means the material chosen has to be adaptable.

Carved Foam

The shape of the moulding bags is carved out of the foam. This can be done electronically or manually. Electronically, the person moulding takes a digital map of the cast, which is sent to a computer aided machine, which in turn carves the 3D cushion. Manually, the process is similar to that used in key cutting; the cutter in the profile machine follows the movements of the person tracing around the shape of the mould. During the manual process, tweaks can be made while carving if errors were made during moulding. In the electronic process this can be done on the computer prior to carving.



Carved foam

Advantages:

- Varying densities of foam can be used to increase durability and support.
- Foam is softer and more forgiving than the other materials.
- The moulded shape can be accurately reproduced in foam facilitating very acute angles and large drops in height. It can be modified for growth and some degree of postural change.
- The seat and back can be made in two separate sections to enable more adjustment.
- Pressure relieving materials such as gel, visco foam or Roho can be inserted so that they are flush with the top surface of the seat. Localised pressure relief can be given, ensuring support is retained where needed.
- Functional aids, such as swing away thoracic supports, can be added.

Disadvantages:

- Foam is an insulator and therefore can get too warm: this can be minimised by cutting holes through the foam and shell to enhance heat transfer.
- The perception of foam is that it is bulky and whilst it can be shaped to look slim-line, it is not as slim-line as other possible materials.
- Most foam seats are supplied with a protective layer to stop the ingress of fluids. However, some of these layers can deteriorate over time. Protective fabric covers can be made to stop fluids reaching the foam surface.
- Foam can deteriorate and bottom out through heavy use.

Clients who self propel find Carved Foam can be bulky under their axillae when propelling. They also find that it is quite heavy, especially when using a custom-made, lightweight wheelchair. Foam inserts without shells can be used for some clients. Foam can also provide good comfort and pressure relief. Foam can also be more forgiving for those clients who are quite thin with bony prominences. Foam has the ability to form acute angles and small radii; for example, this could be of use when making seating for clients with MD who have lumbar lordosis.

Matrix

Plastic interlocking clamping components, circular in shape with four ball and socket connecting stems. The ball-jointed connections provide the adjustment. This is made from flat sheets, which are loosened and tightened around a plaster cast of the moulded shape. It can also be formed live, suspended within a frame and tightened around the client. The finished seat is then framed using aluminium tube to keep the structure rigid.

Advantages:

- Good air flow between the components.
- Simple to adjust, as individual components can be added for growth, although it requires large areas to be loosened off to make small modifications.
- Can check the clients' conformity to the seat through the gaps in the Matrix.
- Retains shape well, due to the secure connections between the components and rigid framing.
- Fairly slim-line: components are 17mm in thickness. The framing can make the overall system more bulky when allowing for future adjustment.
- Matrix can be kept clean, by washing and scrubbing to remove any dirt from the crevices.

Matrix

Disadvantages:

- Can be heavy when made as a full seat due to material and framing, furthermore the system can be awkward to lift.
- Some clients find the material feels hard.
- Difficult to introduce localised areas of pressure relief.
- Without splitting the matrix can achieve a diameter of 40mm plus the cover thickness on top.
- Full Matrix systems are usually made as one, and, therefore, major work is needed if the backrest angle needs modification.
- Maintenance checks are required to ensure components have not loosened.

Matrix's good airflow is ideal for clients that overheat, such as those with MS. The overall system is heavy and may not be suitable for some when having to transfer it from a power chair to a manual chair on a regular basis. For clients with strong athetoid tone it is less likely to lose shape than the other materials. For MD clients with an acute angle at their lumbar curve, accurate representation of the mould at this point may not be possible. It would need to be considered at the time of assessment for the mould whether support into the lumbar curve is crucial.

New Matrix

New Matrix is similar to Matrix but thinner in profile and made of a different plastic composite, and formed from a sheet of interlocking segments, which are then loosened and tightened over a plaster cast of the moulded shape. The suggested framing method for New Matrix is to use flat aluminium cladding, although tube can be used.

Advantages:

- Good air flow between the components.
- Lighter than Carved Foam, Matrix and Lynx when framed.
- Have components, which consist of one stem and a ball joint at either end. These can be set up to allow 3D expansion of an area. This results in fewer units needing to be loosened off than Matrix when making modifications.
- Thinner in profile than Matrix, 12mm at its thickest point and is clad with flat framing, which maintains the thin profile all over the seat.
- Can check conformity through the gaps in the New Matrix.
- The flexible components can be used to make swing away anterior supports. They can also be used in areas which are susceptible to pressure.
- Cleaned using the same process as Matrix.

Disadvantages:

- Can be quite hard in comparison to foam.
- Individually the components are stronger than Matrix, but care needs to be taken when framing as there can be flex in the overall system.
- Does not conform closely to shapes with tight angles or radius under 38mm.
- Longer to adjust than Matrix due to cladding strips used for framing.

New Matrix

Consideration of the appropriate framing technique should be made when using this material for strong athetoid clients, or those who exert a lot of force through one particular area. The cladding has been found to bend away in some cases. For those with postural deformity such as scoliosis and corresponding rib prominence, the flexible components are good for accommodating and relieving pressure. Where there is expected to be postural change the two ball units can be used compressed initially and then gradually extended out to allow for change. This material also lends itself to clients who self propel, as it is slim-line, lightweight and can be easily modified and adjusted unlike thermoplastics.

Lynx

Interlocking plastic cross shaped components, which have been slotted to facilitate extension or compression. Formed from a sheet of interlocking segments, which are then loosened and tightened over a plaster cast of the mould. The final seat is then framed using aluminium tube to give it rigidity.

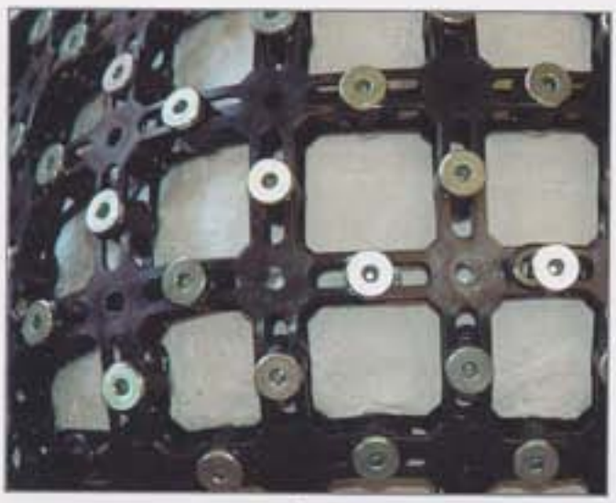
Advantages

- Good air flow between the components.
- Reasonably thin in profile, but can be bulky due to framing.
- Can check conformity through the gaps in the Lynx.
- Easy to modify: small areas can be loosened and adjusted by sliding the components over each other.
- Can be pulled out and expanded to create more room within the mould. Whereas with Matrix, additional components would need to be added.
- Cleaned using the same process as Matrix.

Disadvantages:

- Reasonably strong, but due to their flexibility and clamping Lynx components can loosen and give, especially if the client has strong athetoid tone.
- Both the material and framing can be heavy.
- Can be hard if the components are fully extended. Can get localised pressure areas on the components themselves due to large gaps between them.
- Difficult to introduce localised areas of pressure relief.

For clients expecting weight gain or where there are likely to be postural changes Lynx offers the most adjustment. This is due to its ability to grow in width and length within each component. It is also simpler to modify than Matrix and New Matrix as a smaller area can be loosened off. However over time the plastic work hardens, which makes adjustments more difficult. Lynx has more flex within the components than Matrix, but less flex in the overall structure than New Matrix due to the framing method used. This can be an advantage for clients where some give in the seating would be of benefit, but not as suitable for those clients with strong



Lynx

tonal patterns, as the Lynx gradually loosens and gives with the movements.

Thermoplastics

The shape is created by vacuum-forming plastic, generally ABS, around the mould of the client.

Advantages:

- The most lightweight in comparison to the other materials.
- Slim line, 6mm or 8mm plastic shell and then one or two 10mm inner foam linings.
- High strength in thin sections and rigid with no loss of shape over time.

Disadvantages

- Difficult to modify either for postural change or growth, large areas of the mould have to be heated to make small corrections. This process can be inaccurate.
- The final seat is made with the seat and back as one. The angle of the backrest section is therefore unable to be altered. It can however be manufactured as two separate parts with a hinge point between the two.
- The manufacturing process will not allow for the material to have a large drop in height and contour: instead it may hammock across. This will vary depending on the manufacturer. Also, with each forming process, the contours are smoothed, thereby losing definition.
- Limited airflow as the plastic shell and foam lining insulates. Holes can be drilled in the shell but this should be done with caution as it weakens the material.
- High rigidity, although pressure relieving material can be added flush to the seat surface.

Where weight is an issue, for instance those who self propel and have a lightweight chair, thermoplastics offer best strength to weight ratio. But this benefit has to be weighed up against the disadvantages. The client will ideally have been stable in weight for the past couple of years and not likely to change significantly in posture. Clients with MS may find thermoplastics too hot. If holes are drilled in the plastic for airflow, their spasms may cause the plastic to crack around the holes. For clients with fixed deformities such as very limited flexion in one hip, the material may not form properly due to the drop in height from one leg to another.

Foam in Place

This consists of a bag divided up into compartments, each containing a different chemical. These are mixed together and the solution poured out into a bag. The chemicals then start to react with the air and expand. The shape is moulded directly to the client. The client will need to be covered to protect them from the expanding foam and the heat generated during the reaction. The foam is then trimmed and then sent off to have a cover made. Another technique is to use moulding bags, from which a plaster cast is taken and then the foam is formed around the cast.

Advantages:

- Relatively quick in manufacturing time compared to the other materials.
- Fairly inexpensive compared to the other materials.
- No loss of accuracy between mould and final product.
- Good for providing basic support

Disadvantages:

- Not able to form stable lateral support to the torso or pelvis. This limits the degree of support that can be achieved and its ability to arrest the progression of deformity.
- The client has to remain completely still in the desired position while the seat sets, which is difficult to achieve.
- The process can be very messy and hot, which may distress the client.
- The results are not always accurate due to limited moulding time.

When looking at which material is suitable for the client the following areas should be addressed:

Clinical – comfort, pressure relief, posture, tone.

Functional – weight of the system, cleaning, size of the system, transport and manoeuvrability.

Aesthetics – is the proposed solution acceptable to the client?
Technical – growth, adaptability, strength.

The clinical and functional aims are established following the initial assessment. The aesthetics can be discussed if the clinician has examples of moulded seating, or using examples given at the moulding by the engineer. The importance of a good mould cannot be underestimated, but the material and technique in which the mould is then reproduced can add to the success of the final mould. Technical considerations should be discussed with the engineer prior to moulding.

Case Study

The following case study will show the areas considered when comparing materials. A comparison table, as described by Stuart Pugh (Pugh, 1991), is used as a tool to assist the clinician when making the final decision.

In this case study the client is a 15 yr old male with muscular dystrophy with severe postural deformities. Due to muscle weakness head control is maintained by precise balance of the body segments over the base of support.

The key issues affecting the material choice were identified to be:

- Tendency to overheat.
- A scoliosis that is likely to progress and therefore ability to modify the support would be beneficial.
- Need for adjustment within the backrest area behind the left shoulder to facilitate movement, which is used to relieve pain.
- Thin profile around the axilla to facilitate arm function.
- Strength to ensure the material holds the moulded shape, in order to limit deterioration of posture.
- Low profile and rigid material needed at the transition of the backrest to the seat, where the back cups under the ribs.
- Allowance for future modification around rib fullness where change in shape may be expected.

The materials considered were New Matrix, Matrix, Lynx, Carved Foam and Thermoplastics. A material selection chart was used to assess the importance of the key criteria against how well each material meets that need.

Material requirements to meet the key issues were defined and given a weighting specific to this client.

	Weighting	Matrix	New Matrix	Lynx	Carved Foam	Moulded Seat Insert
Heat	1 Client tends to overheat however low area of contact therefore heat retention low	3 Increased air flow	3 Increased air flow	3 Increased air flow	1 Insulative	1 Limited air flow
Future modification of concavity	3 Shape likely to change in this area with increase in rib fullness, likely need to pull out	2 Requires large area to be loosened and disconnected to make adjustments pulling out an area	3 Use of 2-ball components to pull out easily	2 Pulled out easily providing radius is not very small	1 Area can be scraped out, must be done with user out of seat and difficult to push in an area	0 Limited adjustment for pulling out
Modification around shoulder	3 May need to adjust to compromise support with ability to perform stretch	3 Easy to reshape relatively flat areas	3 Easy to reshape relatively flat areas	3 Easy to reshape relatively flat areas	2 Easy to scrape back relatively flat areas but adding foam less accurate	1 Adjustments can be made to flat areas but low accuracy and difficult to achieve in clinic
Thin profile	3 Thin around axilla for arm function	2 High strength and rigidity with thin profile but thicker than other materials	3 As Matrix, but slightly thinner	2 As Matrix	2 Difficult to give firm support to thin areas	3 High strength and rigidity at thin sections
Strength	3 Losing shape over time is likely to lead to conforming to that shape and potential deterioration of posture	3 Holds shape well and rigid	3 Holds shape well and rigid	3 Holds shape well and rigid problems with slippage resolved with framing	2 Compression of foam over time	3 Rigid with no loss of shape over time
Transition	3 Needs to flow onto seat cushion under ribs	2 Thicker than New Matrix and no modifications to thin edges	3 Thinner than Lynx and Matrix	3 Can be made thinner with edging	3 Can be tapered to a thin edge	3 Thinnest of all materials whilst maintaining strength

Fig 1

Each material was assessed as to how well it meets each material requirement and given a rating. Comments were documented to justify these ratings. Multiplying the ratings by the weightings and summing for each material, a numerical indication of how well each material meets the requirements can be identified. The higher the number, the better the material meets the stated requirements. This can be used to aid the decision of which material to use along with the expertise of the clinician and engineer involved.

The most appropriate material for this client was found to be New Matrix. The case study demonstrates a method used for a particular client, however in general practice the process can be utilised informally with full documentation not necessary.

The conclusions raised in this article may vary dependent on the engineer involved in the moulding of the seating and the specific circumstances of the clients. Each contractor has their own method of moulding and production and their own experiences of each material. With new technologies being developed, there are going to be more advances in the materials and technology available in this field. Each new development will have its own pros and cons which are evaluated when assessing a client for moulded seating. By maintaining their knowledge of the materials available, the therapist will be able to assess which is best for their client.

References:

Ham R et al, 1998. Wheelchair Users and Postural Seating – A Clinical Approach, Churchill Livingstone, pp 117.

Muscular Dystrophy Campaign. 2006. Wheelchair Provision for Children and Adults with Muscular Dystrophy and other Neuromuscular Conditions, pp 46.

Pugh S, 1991, Total Design: Integrated Methods for Successful Product Engineering, Addison-Wesley Publishers Ltd.

Pope PM, 2007, Severe and Complex Neurological Disability, Elsevier Ltd.

Edwards S, 1996, Neurological Physiotherapy, Churchill Livingstone.

Contact details for Nicola Aburto:
Email: nicky@contour886.co.uk
Tel: 0870 3500 886

Key for Figs 1 & 2: **Weighting:** 0 – negligible benefit, 1 – some benefit, 2 – significant benefit, 3 – essential.
Rating: 0 – does not meet requirements, 1 – meets some aspects of requirements, 2 – meets most aspects of requirements, 3 – meets all aspects of requirements.

	Weighting	Matrix	New Matrix	Lynx	Carved Foam	Moulded Seat Insert
Heat	1	3 x 1	3 x 1	3 x 1	1 x 1	1 x 1
Future modification of concavity	3	2 x 3	3 x 3	2 x 3	1 x 3	0 x 3
Modification around shoulder	3	3 x 3	3 x 3	3 x 3	2 x 3	1 x 3
Thin profile	3	2 x 3	3 x 3	2 x 3	2 x 3	3 x 3
Strength	3	3 x 3	3 x 3	3 x 3	2 x 3	3 x 3
Transition	3	2 x 3	3 x 3	3 x 3	3 x 3	3 x 3
Totals		39	48	39	31	31

Fig 2