Additive Manufacture for Orthotics and Prosthetics

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Peacocks Medical Group

Established in 1903, Peacocks Medical Group has been supplying medical equipment and services for over 100 years.

A family-run group based in the North East of England with clinics across the UK.

Peacocks delivers both services and orthotic equipment to the NHS and the private sector.
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Introduction – O&P
Introduction – O&P

**Orthotics** – *External devices that support the body, realign it or redistribute pressure.*
Introduction – O&P

**Prosthetics** – Replacements for a part of the anatomy

- **External**
- **Internal**

![Prosthetics Diagram](image)
Manufacturing processes

1. Pour plaster in the negative
2. Remove negative and finish
3. Vacuum form thermoplastics on positive
4. Cut from positive and finish
5. Remove plaster from body
6. Issue to patient
Why Additive Manufacturing
The industry needs change

*Working methods have to be brought to the 21st century*

- Current technology base limits innovation and improvement
- Quality of (bespoke) products and the amount of remakes and corrections
- Speed and quality of service
- Efficiency in general
- Traceability
- Standards
Main advantages of Additive Manufacturing over traditional methods

- Easy to manufacture bespoke parts
- Good fit and comfort easy to achieve – good design still needed
- Automatic manufacturing

- Digital design environment
- Engineering not craft

Functional integration

Functional integration

- *Imitating the functionality of separate parts/materials in a single part through “clever” design*
- *Making complex parts is not an issue...*  
  ...*designing complex parts is*
Why is functional integration important?

**A digital design environment:**
- It can be controlled very precisely
- It can be optimised
- It can be automated and repeated

**Precise placement of external components.**
- Reinforcements, hinges, sensors, activity monitors...

**All of this adds value and differentiates products**
Go crazy with the form but keep the function

State of additive manufacturing in O&P
History of additive manufacturing in the O&P

*O&P applications as old as the technology itself – in research*

- **Tfem socket**
  - Manufacturing 1990

- **FO’s & outsoles**
  - 2000-2003

- **Knee braces**
  - 2004

- **AFO’s**
  - 2006 (?)
History of additive manufacturing in the O&P

- **Main focus in transtibial socket manufacturing, AFO design and manufacturing and in foot orthoses/soles**

- **Processes SLA, SLS, FDM**

- **Only one directly manufactured end-user device in the market at this time**
State of the art today – Orthotics and Additive Manufacturing

The process

CAD design**

Additive Manufacturing

State of the art today – Orthotics and Additive Manufacturing

Early steps towards functional integration

And some beyond
State of the art - Prosthetics and Additive Manufacturing

Variable impedance prosthetic socket:

- Multimaterial socket made with Objet Connex from MRI images
- Contact pressures recorded during the stance stage of the gait cycle was measured to be 15% and 17% reduced on the fibular head when compared to a "traditional" socket.
- A 7% and 8% reduction was observed along the tibia.

http://www.deskeng.com/articles/aabjpe.htm
State of the art – Prosthetics and Additive Manufacturing

Craniomaxillofacial reconstruction

State of the art – Prosthetics and Additive Manufacturing

Cosmesis

http://web.ncsu.edu/abstract/technology/3d-printing/
AM vs traditional methods – main issues

Geoffrey Moore’s ‘Crossing the Chasm’ diagram
circa 1991
• Started SEP 2009
• 11 Partners
  – 5 universities,
  – 1 industrial organisation
  – 6 SME’s
• 3.7M Euro EC contribution
Objectives:

• To improve the accuracy of clinical prescriptions for customised foot and ankle orthoses
• To improve the fit and functionality
• To significantly decrease manufacture time to 48 hours
• To develop a cost-effective, fully integrated orthotic solution
• To disseminate and demonstrate the results

• To utilise the potential of manufacturing
Integrated process (plan)

- Clinical assessment
- Biomechanical analysis
- 3D Surface scan (leg/foot)
- CAD
- Design Optimisation
- Rapid manufactured
- Supply fit and review
Integrated process (result)

3D scan of plantar Surface

Plantar pressure measurement

Plantar pressure driven insole design

3D CAD of variable hardness insoles (UNEW)
Selected results

- Full sized insoles printed by Objet Connex with variable hardnesses ranging from Shore 25 to 95 (UNEW)
• **Selected results - New orthotic concepts**

- 3D CAD design of ¾ length foot orthotics designed with variable thickness and arch support (PCK)
- SLS-made ¾ length foot orthotics in ETX Nylon powder and textured surface (PCK)
- FDM-Made orthotics in PLA with CF reinforcement. a) Top carbon-fibre surface b) lower honey-comb built-time optimized structure
- SLS-made AFO in Duraform PA with foot-plate and calf connected by a carbon fibre 7 spring (PCK-UNEW)
Summary

Additive manufacturing has a huge potential to change the lives of many disabled people

So far the potential is largely untapped because of the nature of the industry and costs of manufacturing

Engineering principles and methods are making their way to the O&P industry and the major change will happen through functional integration
Thank you for your attention

Any questions?

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