Dr Peter Steadman
Orthopaedic surgeon
A/Prof University of Queensland
Australia
President Australian sarcoma group

Growing Implants

disclosures
- Travel assistance Implantcast
- Stryker Stanmore Australian advisory group- no fee
Lady Cilento Children’s Hospital
Serves total population of 6m

Invasive growers

Non invasive growers

Non invasive devices
Non-invasive growing implants

**NON INVASIVE GROWERS**

- **First implantation in 2009**
- **Based on idea by Professor Dr Baumgart**
- **In Germany**
- **Mutars, 2010**
- **Induction motor**
- **Home program**
- **Interim and convert to adult**
- **Weight limit 40kg**
- **Variable length up to 10cm**

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**History and costs**

amputation vs OPI implantation

- **Growers**
  - Invasive vs non invasive?
  - High capital cost
  - Non approved implants
  - Sepsis
  - Surgical complications
  - High Patient acceptance
  - Multiple procedures

- **Amputation**
  - Recurrent prosthetic costs
  - Prosthetic failure
  - Age of patient <4 >12

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**Non invasive growing implants**

- **Stanmore Growing Prosthesis:**
  - **Designed in 1990's invasive**
  - **By Professor John Scales**
  - **In Stanmore, North London, United Kingdom**
  - **Non invasive designed in 2009**
  - **(Stanmore, 2013)**
  - **Motor reversible**
  - **Hospital program**
  - **No adult conversion required**
  - **Length 5/7.5**

- **Repiphysis grower 2009**
  - **By Wright Medical Technology**
  - **In Tennessee, USA & Amsterdam, Netherlands**
  - **(Wright, 2013)**
  - **PEEK/spring- pogo stick**
  - **Hospital program**

- **Xpand Growing Prosthesis:**
  - **First implantation in 2009**
  - **Based on idea by Professor Dr Baumgart**
  - **In Germany**
  - **Mutars, 2010**
  - **Induction motor**
  - **Home program**
  - **Interim and convert to adult**
  - **Weight limit 40kg**
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Series

A Design and Clinical Review of 103 Non-invasive Extendible Implants

*P S Unwin1; *T W Briggs2; *S R Cannon2; *R C Pollock2; K Gokaraju2; *A T Abudu3; *S R Carter3; R J Grimer3; *R M Tillman3; G W Blunn1

1Centre for Biomedical Engineering, (UCL), Royal National Orthopaedic Hospital, Stanmore, Middlesex, United Kingdom; 2The Royal National Orthopaedic Hospital Trust, Stanmore, Middlesex, United Kingdom; 3The Royal Orthopaedic Hospital, Birmingham, United Kingdom

Summary

103 implants in 90 patients

7 completed lengthening with 39 in progress, 34 not lengthened, 1 failed to lengthen, 1 amputation for infection, 8 died of disease, 13 revised - 7 maximum extension, 4 failed mechanism, 2 for infection

Emotional Acceptance and Satisfaction Following Paediatric Limb Salvage with a Non-invasive Expandable Endoprosthesis

Eric R. Henderson1; Andrew M. Pepper1; German A. Marulanda1; Odion Binitie1; Justin Millard1; David Cheong1; G. Douglas Letson1

1Moffitt Cancer Center & Research Institute, Tampa, FL, United States; 2Department of Orthopaedics and Rehabilitation, M, United States

Summary

Overall patient/parent satisfaction following lower extremity limb salvage with Stanmore’s non-invasive lengthening prosthesis was favourable with both patients and parents reporting high acceptance of their surgery and contentment with postoperative functional capacity and body image.

Twenty-three Years of Experience with Growing Prostheses

Rainer Ingo Kotz; Martin Dominkus; Reinhard Windhager; Teresa Zettl

University Clinic of Orthopaedics, Vienna, Austria

Summary

Since 1986 68 children with malignant bone tumours in the lower extremity have been treated with growing prostheses. Complications of the prostheses were loosening in 12, bushing change in 6, screw or prosthesis breakage in 6, malfunction of the elongation mechanism in 3 and others in 3 (30 in 28 = 1.1/case). Other complications (infection 17, skin necrosis 12, hematoma 10, restriction of motion 10, nerve lesion 4, instability 4, stress shielding 3, fractures 3, thrombosis 2 (65 in 28 = 2.3/case).

Since 2002

Age 4-12 yrs. (why this range)

25 cases with 45 operations - high maintenance space

8 Deaths from disease early 2-5 years

4 invasive and 22 non-invasive

1 unrelated death - US murder case

4 invasive and 21 non invasive

8 failed motors - 2/3 Repiphysis, 1/3 Starnow, 3/14 Xpand

Xpand - 1 with accidental MRI, 1 fall, 1 early implant jump? 2 failures of motor - no collapses.

Complications come from being a survivor

4 Revision for fully grown implant - 1 amputation infection

4 revisions for knee joint patellar stress/rapining - hips

2 adult conversions and later acetabular cup insertions for hip pain

5 grower component revisions to continue growth - 1 fully grown

1 flexion loss

Its always complicated

Queensland non-invasive series

Since 2002

Age 4-12 yrs.

25 cases with 45 operations - high maintenance space

3 Tibias, 5 proximal femurs, 1 distal femoral tenon

8 Deaths from disease early 2-5 years

4 invasive and 22 non-invasive

1 unrelated death - US murder case

8 failed motors - 2/3 Repiphysis, 1/3 Starnow, 3/14 Xpand

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Xpand Growing Prosthesis:
- First implantation in 2009
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- Mutars, 2010
- Induction motor
- Home program
- Interim and convert to adult
- Weight limit 40kg
- 2 programs - immediate/delayed
- Variable length piston up to 10cm

Different growing programs
- Home or hospital?
- Consider Economics of self manage growing vs hospital attendance
- Advantages
  - Patient performs the procedure at home, the machine is set to 9 pulses and grows at 0.03 mm per pulse equivalent to 0.27 mm per day, with no physical therapy required
  - My program is monthly observation with x-ray and checking the electric motor is working, the patients are quite vigilant about noting its function
- Cost Savings
  - No operating theatre attendance/no general anaesthetic required with lengthening
  - No risk of sepsis from invasive growth, same with all
  - No physical therapy requirements depends
  - No nursing supervision or other devices associated with transport and inpatient facilities. OT Vs large Machine Vs home
  - Xpand growth links increase to 10cm recently which generally covers a significant age group while other devices available are still limited to 5 cm.
Who might be a candidate-age 4-12yo?

Amount of growth residual (> 3-4cm)

Location and process is unique, as is age
1. Distal femur- growth rapid 5cm & outgrow
2. Tibia- lag and rehab and growth and lag vicious cycle-age
3. Proximal femur- acetabulum/lurch/not much growth in a life-

Growing tables/Bone age

Long leg films/other leg with a cm rule

Determine resection length-MRI

Admin - confirm design/cost/ sign custom sheet

Set a date for chemotherapy and a company deadline

Start manufacture

Repeat MRI at 5weeks to ensure resection is still safe
How do we calculate growth?

Calculate growth using tables

- Menelaus "rule of thumb"
- Green and Andersen tables
- Paley App

Know growth at each physis

Bone age: radiologist
Plan resection 3-4 cm margin

Planning resection and ordering prosthesis

<table>
<thead>
<tr>
<th>Menelaus Basic rules of thumb</th>
</tr>
</thead>
<tbody>
<tr>
<td>- girls stop growing at 14</td>
</tr>
<tr>
<td>- boys stop growing at 16</td>
</tr>
<tr>
<td>- distal femur 9 mm/yr</td>
</tr>
<tr>
<td>- proximal tibia 6 mm/yr</td>
</tr>
<tr>
<td>- distal tibia/proximal femur 3 mm/yr</td>
</tr>
</tbody>
</table>
Resection length
- 16cm-5cm piston
- 18.5cm -7.5cm piston
- 22cm-10cm piston
Intended use
Non-invasive lengthening of limbs
Limb salvage, bridging bone defects
Limited use of function

Indications
Limb length discrepancy or expected limb length discrepancy
in combination with bone loss or major bone defects

Limitations
- Body weight: only partial or full weight bearing
- Active hip joint activity is limited
- Prosthesis should be changed after elongation (TAM removal)
- No MRI examinations while TAM implanted

Risks
- Technical failure of the electrical devices
- Prosthesis-related complications (fracture, metallosis, loosening)
- Counter-current of the motor/telescope stress shielding

Procedures and protocols
Precise planning step: indication based on scaled X-rays and detailed case description
- Decision if one-stage or two-stage procedure
- Surgery with TAM or dummy
- One-stage
- Elongation in small increments to keep the system running
  maximum lengthening 1mm/day until equal limb length,
  overlengthening or reaching the maximum capacity of TAM
- Two-stage
  Implantation of the TAM after limb length discrepancy 3-8cm
  lengthening 1mm/day until equal limb length or
  overlengthening if more growing expected
- After lengthening change of the prosthesis into an adult
  implant or a new Xpand
### Implantations since 2005

<table>
<thead>
<tr>
<th>Total</th>
<th>Distal Femur</th>
<th>Proximal Tibia</th>
<th>Proximal Femur</th>
<th>Distal Tibia</th>
<th>Total Tibia</th>
<th>Total Femur</th>
<th>Total Knee</th>
</tr>
</thead>
<tbody>
<tr>
<td>505</td>
<td>354</td>
<td>87</td>
<td>42</td>
<td>1</td>
<td>1</td>
<td>39</td>
<td>2</td>
</tr>
<tr>
<td>79</td>
<td>3</td>
<td>6</td>
<td>2</td>
<td>1</td>
<td>7</td>
<td>1</td>
<td>12</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

### PROBLEMS AND SOLUTIONS

<table>
<thead>
<tr>
<th>PROBLEM</th>
<th>CAUSE</th>
<th>ACTION DONE</th>
<th>ACTION PLANNED</th>
<th>STATUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor failure</td>
<td>Handling problems, connector</td>
<td>Design change connector</td>
<td>No</td>
<td>solved</td>
</tr>
<tr>
<td>Receiver misplacement</td>
<td>Better Description (IFU)</td>
<td>No</td>
<td>solved</td>
<td></td>
</tr>
<tr>
<td>Transport damage</td>
<td>Better packaging</td>
<td>No</td>
<td>unchanged</td>
<td></td>
</tr>
<tr>
<td>Tissue ingrowth or scar</td>
<td>Better description (IFU), lengthening process</td>
<td>No</td>
<td>Under observation</td>
<td></td>
</tr>
<tr>
<td>Cable rupture</td>
<td>Trauma</td>
<td>No</td>
<td>Activity warning (IFU)</td>
<td>In progress</td>
</tr>
<tr>
<td>Receiver misplacement</td>
<td>Training</td>
<td>Better Description (IFU)</td>
<td>In progress</td>
<td></td>
</tr>
<tr>
<td>Cable</td>
<td>Design change (distal Femur, cable outlet)</td>
<td>Design change cable</td>
<td>Cable outlet</td>
<td>In progress</td>
</tr>
</tbody>
</table>

*Note: IFU = Instruction for Use*
## PROBLEMS AND SOLUTIONS

<table>
<thead>
<tr>
<th>PROBLEM</th>
<th>CAUSE</th>
<th>ACTION DONE</th>
<th>ACTION PLANNED</th>
<th>STATUS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Telescope</td>
<td>Overlengthening of TAM</td>
<td>Better description (IFU)</td>
<td>Biomech. tests to proof mechanical stability again for 70kg BW</td>
<td>In progress</td>
</tr>
<tr>
<td></td>
<td>Trauma</td>
<td>Activity warning (IFU)</td>
<td></td>
<td>In progress</td>
</tr>
<tr>
<td>Implant too bulky</td>
<td>Patient too small</td>
<td>Custom made implants No</td>
<td>Custom made implants</td>
<td>In progress</td>
</tr>
<tr>
<td>Metastasis</td>
<td>Abrasive wear TiNM axle and telescope</td>
<td>TiN coating Bushing PEEK</td>
<td>Bushing PEEK</td>
<td>In progress</td>
</tr>
<tr>
<td>Expensive implants</td>
<td>Expensive racket</td>
<td>No</td>
<td>Silver coating on demand</td>
<td>In progress</td>
</tr>
<tr>
<td>Infection</td>
<td>Stiff leg, fully lengthened</td>
<td>Silver coating on demand No</td>
<td>No further action</td>
<td>No further action</td>
</tr>
</tbody>
</table>

## Options for the future

- CF certificate for standard sizes
- Active length-bearing module to reduce costs
- Actively TAM (one similar axis shortening TAM with integrated receiver)

## INTERESTING CASE

**Osteosarcoma**

Stiff leg, fully lengthened
Bibliography


Thank you