



# Measuring outcome in people with tetraplegia following nerve transfer surgery

Dr Jennifer Dunn

2017

October 2017

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## **Summary**

The opportunity to visit, meet with and learn from surgeons and therapists in the small field of upper limb reconstructive surgery for people with tetraplegia in Australia, Sweden and Switzerland has provided me with valuable information that can be used in New Zealand as we continue to develop and expand our services. I not only had the opportunity to brainstorm and develop a test designed to measure changes in hand function following new and innovative nerve transfer surgery in people with tetraplegia.

In February and April 2017 I travelled to Melbourne and Gotenberg respectively to meet with surgeons and therapists working with people with tetraplegia to improve hand function by providing nerve and tendon transfer surgery. Although previously known to me through interactions at conferences, this allowed time to develop collegial relationships with a group of people who have similar interests, needs and goals as myself. Due to the area of medicine in which we work, the teams often work in isolation, with only one or two teams in each country. By travelling to both of these centres, we have brought the teams together to allow true collaboration towards developing guidelines and tests for this group of people.

Following the fellowship, an International Hand Therapist Forum has been initiated with Skype meetings organised three monthly to continue development of these activities.

Attendees are currently from NZ, Australia, Sweden, Switzerland, USA, and Canada.

## **Introduction**

### **Who I am**

I initially trained as a physiotherapist and spent over 20 years rehabilitating people following spinal cord injury (SCI). For the past 15 years I have worked specifically with people with tetraplegia following upper limb reconstructive surgery. Following on from my PhD in 2012,

much of my research explores measurement of outcomes following cervical SCI, more specifically upper limb function. We have developed and implemented an International Upper Limb Surgery Registry[1] that allows clinicians from around the world to enter surgical and outcomes data on their patients who have upper limb surgical procedures performed. The aim is to gather sufficient data to provide useful information about these highly specialised, but relatively uncommon procedures to ensure that the procedures that are performed provide the function required.

### **Why do this research?**

Following a cervical SCI, loss of strength and function in their upper limb is common. This affects every aspect of an individual's daily life - from eating and drinking to return to previous life roles and employment. One option for people with tetraplegia to improve their upper limb function is surgical reconstruction involving tendon transfer surgery to provide some of the lost functions of the upper limb.[2] Tendon transfer surgery has been performed worldwide since the early 1970's and in New Zealand over 300 people with tetraplegia have had this surgery performed since the 1980's.[3] Improvements in both the ability to perform tasks, such as eating, drinking and writing, and quality of life have been reported by those who have had this surgery.[4] Recently, this concept has been advanced further with the inclusion of nerve transfers to restore functions of the arm and hand that tendon transfer surgery is unable to restore.[5] Nerve transfers are being performed by surgeons in Melbourne, Sweden and Switzerland as well as NZ. In NZ, seven people have had nerve transfer surgery performed since 2015.

Measurement of intervention is required to ensure the outcomes are relevant and meaningful not only for the clinicians but also the person with tetraplegia. There is currently no commercially available measure of hand function that can be used in this population following these procedures. Available measures of hand function use tasks or objects that are

either too difficult or irrelevant for people with tetraplegia. Therefore the options are to either develop a new measure or adapt an existing measure in order to objectively measure the results of nerve transfer surgery. The GRASSP (Graded and Redefined Assessment of Strength, Sensibility and Prehension)[6] is a test that has been developed in Canada to measure changes in upper limb function in the acute SCI population, and, with some modifications, could potentially be useful in the upper limb surgery population. However, this needs to be explored and developed.

As this type of surgery is uncommon, there are usually only single centres in each country with the expertise to perform these procedures. Thus for clinicians, difficulty lies in improving and sharing knowledge and collaborating with other clinicians with expertise in the area. Due to the small number of therapists worldwide who have expertise in this field, travel is needed to allow all the ‘experts’ to work together to ensure an effective and timely collaboration. Previous experience with collaborating with this group of therapists has resulted in firstly a consensus of outcome measures to use for people with tetraplegia, secondly the development of the International Upper Limb surgery Registry (based in NZ), and now it aims to develop an acceptable and useful tool to measure the outcomes of nerve transfer surgery. This need has recently been highlighted in a published series in the Archives of Physical Medicine and Rehabilitation Journal by the International Therapists group for Upper Limb Surgery for Tetraplegia.[7]

### **Personal and organisational benefit**

Firstly the personal benefits of meeting with like-minded colleagues from other centres in Australia, Sweden and Switzerland has opened up different ways of managing people who have upper limb surgery. It has shown me that even though we provide a quality service in New Zealand for people with tetraplegia, we often get stuck with offering the same

procedures to all people, irrespective of their specific goals and plans. Until recently, this surgery was only performed in Christchurch therefore I have been working in isolation in this area for many years. Being able to visit other centres who also perform these surgeries has provided me with experience in other surgical procedures, different rehabilitation strategies as well as perspective on how the differences and similarities between our centres. Being able to discuss thoughts, opinions and observations with other therapists and surgeons skilled in this area has broadened my outlook about upper limb surgery and will improve in my ability to provide the best treatment and education for people with tetraplegia. Travelling to some of the leading centres in Europe has built networks that will allow collaboration for future projects, which as an emerging researcher for the University of Otago, Christchurch will assist with my career development.

Secondly for the field of upper limb reconstructive surgery, development of a measure of hand function that can be used following nerve transfer surgery will 1) provide therapists working in the field with a measure of interventions 2) enable comparison of results with other centres, countries, surgical procedures and 3) establish a network that will allow for research collaborations in this area where each centre only typically performs between 10 – 20 procedures each year.

### **Wider benefits and significance**

By developing an outcome measure for these new and emerging techniques in Upper Limb Reconstructive Surgery will continue to maintain New Zealand's strong international reputation within this field. It will also assist in ensuring that the surgical procedures that are performed in NZ are effective – both cost-wise for the NZ Health System and for the individual having the procedure. Visiting other centres that provide these surgical services will also enable me to see their care delivery and ensure the NZ model of care is effective and efficient compared to international centres.

## **Key Issues to be addressed:**

- 1) Is there a measure of hand function currently available that could be used to measure outcome in the tetraplegic population following nerve transfer surgery?
- 2) If there is not a measure of hand function, what would a newly developed measure need to have in it to measure outcome following nerve transfer surgery?

## **Key Learnings**

### **Current measures being used**

Christchurch and Notwill currently use the Graded and Redefined Assessment of Strength, Sensibility and Prehension (GRASSP) and the Grasp Release Test (GRT). Melbourne currently use the Action Research Arm Test (ARAT) and the GRT. Gothenburg currently use the GRT.

### **Graded Assessment of Strength, Sensibility and Prehension (GRASSP)**

The GRASSP was developed to measure change in tetraplegic hand function in the early acute phases of spinal cord injury. [6] Clinical impairment measure that measures strength sensation and prehension. For prehension subjects need to be able to generate three grasps 1) cylindrical grasp, 2) lateral key pinch and 3) tip to tip pinch. Performance of prehension is scored 0 – 5 on ability to perform six tasks using correct grasp pattern. Tasks are: 1) pour water from a bottle, 2) open jars, 3) pick up and turn a key, 4) transfer 9 pegs from board to board, 5) pick up four coins and place in slots, 6) screw four nuts onto bolts. It is commercially available for purchase for CAD\$1250 plus shipping and handling (<http://grassptest.com/Purchase.aspx>) .



Figure 1: Graded Assessment for Strength, Sensibility and Prehension

### **Grasp Release Test (GRT)**

The GRT was designed for people with tetraplegia to assess basic unilateral hand performance with manipulating six objects: peg, weight, fork, block, can and video tape.[8, 9] Objects are moved as many times as possible in 30 seconds. While it was initially developed for people with tetraplegia using a neuroprosthesis, it has been validated in the upper limb surgery population. This test is no longer commercially available, therefore only centres that were involved in an international clinical study for implanted neuroprosthesis have this test.

Therefore new centres and those not involved in the clinical study do not have access to this test.

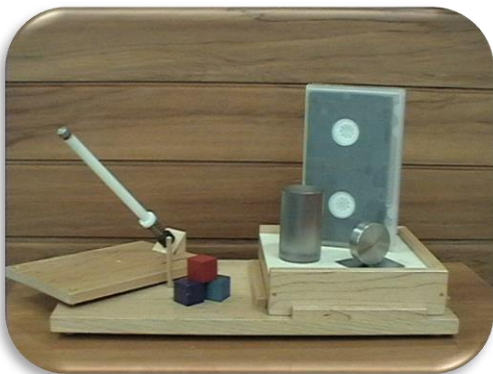


Figure 2: Grasp Release Test



### **Action Research Arm Test (ARAT)**

The ARAT is a 19 item measure that was designed for the stroke population to test grasp, grip, pinch and gross arm movement. Items tested include wood blocks (various size), cricket ball, stone, jug and glass, tube, washer and bolt, ball bearing and a marble.[10, 11]

Performance of each item is rated on a 4-point ordinal scale. The ARAT is available for purchase for USD\$750 + USD\$250 shipping outside the US (<http://www.aratkits.com/buy/>).



Figure 3: Action Research Arm Test

Table 1: Advantages and disadvantages of current measures

Measure	Advantages	Disadvantages
GRASSP	<ul style="list-style-type: none"> <li>• Designed and validated for a tetraplegic population</li> <li>• Commercially available</li> <li>• Items relevant for people with tetraplegia</li> <li>• Can use the subscales separately</li> <li>• Only assesses hand function</li> </ul>	<ul style="list-style-type: none"> <li>• Not tested on upper limb surgery population</li> <li>• Surgery patients cannot generate all three grasps</li> <li>• If not performed using correct grasp will always score the same score irrespective of change in function</li> <li>• Timed – must perform task in specific time</li> <li>• Assessment of prehension subjective.</li> </ul>
GRT	<ul style="list-style-type: none"> <li>• Designed and validated for tetraplegics following upper limb surgery</li> <li>• Fast and easy to administer in clinical setting</li> <li>• Pre-test means only those objects able to be manipulated are used in the test</li> <li>• Only assesses hand function</li> </ul>	<ul style="list-style-type: none"> <li>• Not commercially available</li> <li>• Some of the lighter objects (peg and block) show no change before and after surgery</li> </ul>
ARAT	<ul style="list-style-type: none"> <li>• Uses a number of objects relevant to people with tetraplegia</li> <li>• Commercially available</li> <li>• Don't need to test all 19 objects, items tested in order of difficulty so stop once you cannot perform a task.</li> </ul>	<ul style="list-style-type: none"> <li>• Designed for people with stroke</li> <li>• Not validated in SCI population</li> <li>• Assesses upper limb function and balance as well as hand function as includes tasks in which people have to lift items up to shoulder height</li> </ul>

All centres were using the GRT and liked the measure for the upper limb surgery for

tetraplegia population. The main problem with the GRT was that it was not commercially available thus limiting the utility of the measure for centres that did not have access to it.

While all therapists thought the range of objects used in the GRT was good for the tetraplegic population, there were some lighter objects that were able to be performed before and after surgery to the same degree and therefore this was an issue. The therapists liked the fast administration time of the GRT, especially within a clinical environment. The therapists felt

that some larger objects in the GRT would demonstrate differences between those who have nerve and tendon transfer surgery and those who only have tendon transfer surgery. It was felt the 30 second pick and place test provided a quantitative measurement of hand function. The therapists felt that the GRASSP, while validated in the tetraplegic population, would need extensive changes to the scoring system to be able to demonstrate change in the upper limb surgery population. They felt that some of the objects such as picking up coins from a table top (without sliding to the edge) were not relevant for people with tetraplegia and would be impossible to achieve. Thus both the scoring and some of the objects would need to be reviewed if this were to be used in the upper limb surgery population.

The ARAT contained a number of objects that were able to demonstrate changes following nerve transfer surgery that the other tests could not. However, some of the objects (such as the large block) it was noted that those with small hands (such as some women and people of Asian descent) would never be able to pick up these objects. In addition, the test included tasks that had to be lifted up onto a shelf, which tests not only hand function but also shoulder and upper limb strength, trunk stability and balance. The therapists who were using this test felt that scoring was very subjective and it would be difficult to get consistency between therapists and countries.

## **Conclusions**

The consensus from the panel discussion was that the GRT, with some modifications to the objects used, was the best option to measure hand function following both nerve and tendon transfer surgery. However as this was no longer commercially available, we would need to look at developing a test that included selected objects of the GRT as well as some new objects to increase the difficulty of the test so it was relevant for people undergoing nerve transfer as well as tendon transfer.

## **Recommendations:**

### **Building the measure**

From the testing of people with tetraplegia and panel discussion we decided that any test of hand function following nerve and tendon transfer surgery needed to have the following attributes:

Format: that the format of the GRT i.e. a 30 second pick and place test, was ideal for both clinical and research purposes. This allows a quantitative test of hand function.

Objects: The consensus was that the test needed to contain at least six objects; three that used key pinch and three that used a grasp/release of the fingers. These objects need to replicate everyday items/tasks.

Key pinch objects: card in slot, pocketbook, weight

Grasp/release objects: tennis ball, can, jar

Standardised testing board: A testing board will be required to provide the subject with a barrier to pick the object up and place over/on top of the board to standardise the testing positions. An upright will be required to house the 'slot' for the card to be placed in/pulled out from.

### **Future direction**

#### **Development of new outcome measure**

We have applied for further research funding to allow us to manufacture prototypes of the proposed measure – a collaboration between New Zealand and Sweden. If this funding is successful then we will distribute the prototypes to centres in Sweden, New Zealand, Switzerland, Canada and Australia initially and to further refine and validate the measure in this population.

### **Collaboration with other international sites**

Following on from my travelling fellowship, we have had surgeons from Melbourne (Natasha Van Zyl and Steve Flood) and therapists from Notwill (Sabrina Koch-Borner) all come to Christchurch to visit our centre and observe our unique bilateral simultaneous surgeries. Both centres have now started offering bilateral options for surgery to their patients. In addition, Melbourne, Gotenburg and Notwill have started entering their outcomes data on the International Upper Limb Surgery Registry.

There is a planned therapists workshop at International Conference for Upper Limb Surgery in Tetraplegia – Notwill Switzerland 2018. It is hoped that we will be able to present some preliminary findings of both this fellowship and further development of the measure at this conference.

## Appendix 1: Travel Diary

### Melbourne, Australia

10 – 12 February 2017



Figure 4: Royal Talbot Rehabilitation Centre, Melbourne.

I visited the Upper Limb Surgery Team, based at Royal Talbot Rehabilitation Centre, Kew, Melbourne. Dr Natasha van Zyl (Plastic and Reconstructive Surgeon) has been performing nerve transfers on people with tetraplegia since 2012 [5, 12, 13]. She has nearly completed a three year study on the assessment, timing and outcome of over 20 people with tetraplegia in Australia.

#### Observation of assessment

During my two-day visit in Melbourne, I observed a number of follow-up assessments for people who had nerve and tendon transfer procedures performed at least 9 months earlier.



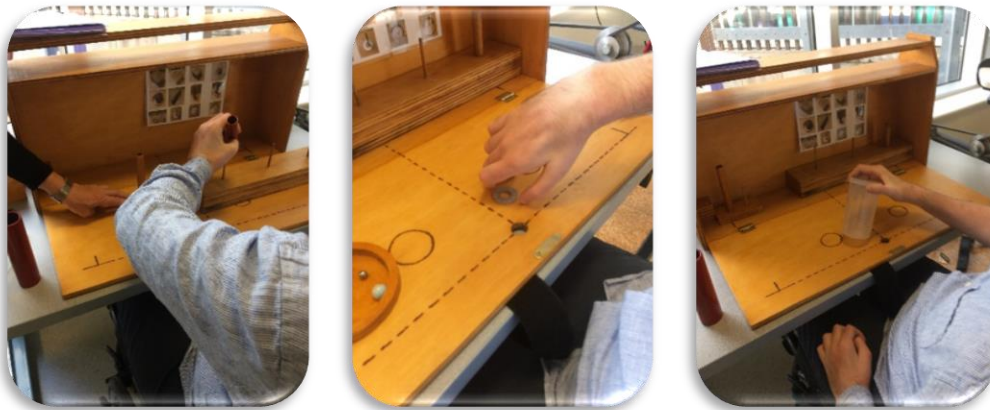


Figure 5: Objects in the ARAT

### **Discussion with therapists**

Extensive discussions were held with both Cathy Cooper (Occupational Therapist) and Bridget Hill (Physiotherapist) on the advantages and disadvantages of the outcome measures used in the nerve transfer and tendon transfer study they are currently involved with.

### **Gothenburg, Sweden 8 – 29 April 2017**

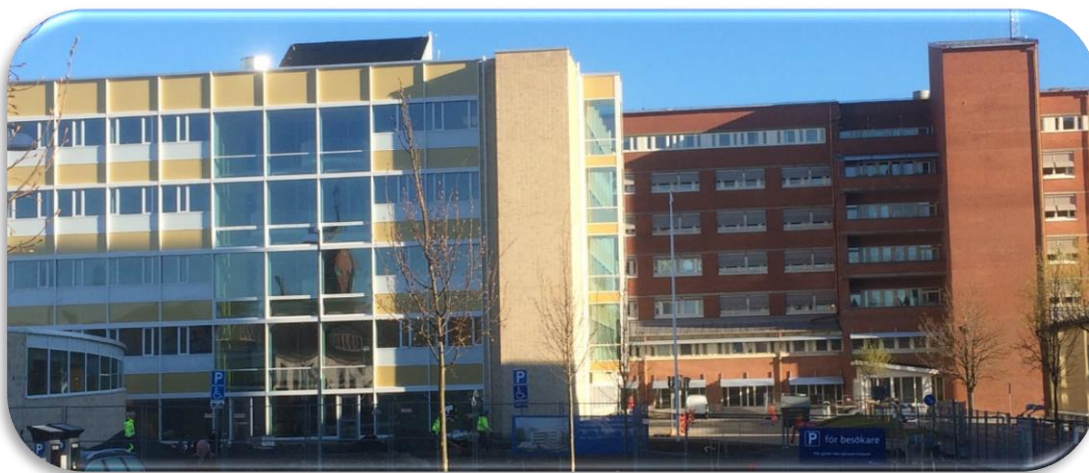


Figure 6: Sahlgrenska University Hospital, Gothenburg.

### **Observation of assessment**

Following the visit to Melbourne, I then visited the Centre for Advanced Reconstruction of Extremities (C.A.R.E.), Sahlgrenska University Hospital, Gothenburg, Sweden. Dr Carina Reinholdt (Plastic Surgeon) and Prof Jan Friden (Plastic Surgeon) have also been performing nerve transfer surgery on people with tetraplegia since 2012. Prof Friden splits his time

between centres in both Sweden and Switzerland and was fortuitously in Sweden during my visit. The Swedish team includes Dr Johanna Wangdell (Occupational Therapist), Therese Ramstrom (Occupational Therapist) and Dr Lina Bunketorp Kall (Physiotherapist).



Figure 7: Assessment of a person with tetraplegia before surgery

During my visit to Gothenburg, I observed a number of pre- and post-surgery assessments of people with tetraplegia. These were both for nerve transfer and tendon transfer surgery.

Additionally I was able to observe a tendon transfer surgery and compare surgical techniques between Sweden and NZ.

### **Outcome measure panel discussion**

Following the observation of the assessment, a multi-disciplinary forum (surgeons, occupational therapists, physiotherapists and people with tetraplegia who have had surgery) was assembled to discuss current measures of hand function used in Melbourne, Christchurch, Notwill and Gothenburg with particular regard to assessing efficacy and outcomes following combined nerve/tendon transfers. A teleconference to Dr Sukhvinder Kalsi-Ryan (developer of the GRASSP) with myself and Dr Wangdell was made following this panel discussion.

### **Testing of proposed objects on people with tetraplegia**

Next we tested some of the current measures of function on people with tetraplegia before and after surgery, as well as developing additional objects that warranted further exploration following the panel discussion.



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