# Comparison of functional recovery following median and/or ulnar nerve repair in children and adults

Diane Joubert MSc OT, Louise Caouette-Laberge MD FRCSC, Sharon Wood-Dauphinee PhD PT, Lynette A Jones PhD

*Division of Plastic Surgery, Hôpital Sainte-Justine, Université de Montréal, School of Physical and Occupational Therapy, McGill University, Montréal, Québec*

**D Joubert, L Caouette-Laberge, S Wood-Dauphinee, LA Jones. Comparison of functional recovery following median and/or ulnar nerve repair in children and adults. Can J Plast Surg 1993;1(3):123-127.** Functional recovery was investigated in a group of 17 children and 17 adults with a median or ulnar nerve microsurgical repair performed at least one year before the assessment. Motor and sensory function, tactile gnosis, manual dexterity, pain and perception of disability were assessed. Statistically significant differences were found between the two groups with respect to two-point discrimination, tactile gnosis, manual dexterity, pain and self-report of performance in daily activities, with the children demonstrating better functional recovery than the adults. There was little difference between the two groups when motor recovery was studied. The widely accepted belief that children recuperate better than adults after a nerve injury may not apply to all aspects of recovery.

**Key Words:** *Children, Function recovery, Nerve repair*

**Comparaison de la récupération fonctionnelle a la suite d'une réparation du nerf médian et/ou cubital chez l'enfant et l'adulte**

**RÉSUMÉ :** Nous avons étudié la récupération fonctionnelle chez un groupe de 17 enfants et 17 adultes qui ont subi une réparation microchirurgicale du nerf médian et/ou cubital au moins un an avant l'évaluation. La récupération motrice et sensitive, la gnosie tactile, la dextérité, la douleur et la perception de limitation fonctionnelle ont été documentées. Nous avons retrouvé des différences significatives entre les 2 goupes au niveau de la discrimination à deux points, le gnosie tactile, la dextérité, la perception de la douleur et de l'incapacité fonctionnelle : les enfants ont démontré une meilleure récupération fonctionnelle que les adultes. Il y a peu de différence entre les deux groupes au niveau de la récupération motrice. Bien qu'on admette généralement que les enfants récupèrent mieux que les adultes il semble que cette supériorité des enfants ne s'applique pas à tous les aspects de la récupération.

Clinical observations have led to the belief that children demonstrate a better level of functional recovery than adults after nerve repair. Although support for these observations has been provided in previous reports (1-4), few studies have used rigorous methods of evaluation and matching that would allow valid comparisons to be made between children and adults. Consequently, it was felt important to ensure comparability of the two groups with respect to initial type and level of nerve injury, include a more comprehensive battery of tests and use statistical methods to analyze the findings. The main objective of the study was to describe and compare functional recovery in children and adults who had suffered a median or ulnar nerve injury in a single upper extremity.

## MATERIALS AND METHODS

The selection criteria were as follow: unilateral median and/or ulnar nerve laceration at or above the wrist with a primary nerve microanastomosis, in a child of 13 years of age or less or an adult of 19 years of age or more, with a minimal follow-up of a year after the nerve repair. The charts were also reviewed to make sure that no other medical conditions were present in these patients that may have influenced their clinical recovery. Only adults that could fit the same strata as the children in terms of location and type of injury were selected to ensure comparability of the two groups.

Seventeen children and 17 adults were studied. Of 18 children eligible for the study, all of whom could be contacted, 17 (94%) agreed to participate. Of 84 adults eligible for the study, 19 (23%) could not be matched to any of the

*Presented at the annual meeting of the Canadian Society of Plastic Surgery, London, Ontario, May 1992, and the XVIIIth meeting of the Groupe pour l'Avancement de la Microchirurgie (GAM), St-Tropez, May 1993*

*Correspondence and reprints: Dr Louise Caouette-Laberge, Service de chirurgie plastique, Hôpital Sainte-Justine, 3175, Côte Sainte-Catherine, Montréal, Québec H3T 1C5. Telephone (514) 345-4688, Fax (514) 345-4964*

**TABLE 1: Sociodemographic and clinical characteristics of the sample by group (n = 34)**

| Characteristics | Children (n=17) | Adults (n=7) | Statistical analysis (two-sided) |
|---|---|---|---|
| Age at time of injury (years) | 7.4 ± 3.2 | 31.6 ± 9.3 | |
| Age at time of injury (range) | (3 - 11) | (19 - 50) | |
| Male | 14 (82%) | 13 (76%) | |
| Right-handed | 13 (76%) | 15 (88%) | |
| Right arm injury | 13 (76%) | 5 (29%) | P=0.01 |
| Delay before nerve repair (days) | 6.4 ± 17.3 | 3.6 ± 11.8 | P>0.05 |
| Time interval before evaluation (years) | 4.9 ± 1.7 | 4.1 ± 2.4 | P>0.05 |
| Associated injuries | | | |
| – tendon | 94% | 76% | P>0.05 |
| – artery | 53% | 33% | P>0.05 |
| – fracture | 12% | 6% | P>0.05 |
| Wound infection | 6% | 6% | |
| Hospital stay (days) | 2.9 ± 4.3 | 5.5 ± 7.7 | P>0.05 |
| Postoperative immobilization (weeks) | 3.4 ± 0.6 | 4.2 ± 1.3 | P=0.04 |

*When applicable, the value that accompanies the mean represents the standard deviation*

children in the sample and were, therefore, excluded. Forty-two adults (50%) could not be contacted. Among the remaining 23 subjects who were contacted, 17 adults (74%) agreed to participate.

Lacerations were caused by glass in 82% of children and 47% of adults, by knives in 6% and 35%, and by power tools in 12% and 18% of children and adults, respectively. Data relating to the sociodemographic and clinical characteristics of the sample are presented in Table 1. Injuries to the right (dominant) upper extremity were found to be much more frequent in children than adults, who tended to injure their left (nondominant) hand (P =0.01).

All subjects had a microsurgical nerve suture except for one child who had a nerve graft. Subsequent endoneurolysis was performed in one child and two adults. Sixty-five percent of subjects in each group had a partial nerve injury but, to be admissible in this study, 75% or more of the nerve trunk had to be severed. The injuries were located at or below the distal third of the forearm in 71% of children and 76% of adults.

**Data collection procedures:** A cross-sectional study of children and adults was conducted. The assessments were performed by an experienced occupational therapist, who was blind with respect to the aim and design of the study.

**Motor function:** Goniometric measurements of the affected and unaffected sides were made to assess the range of motion at the wrist, metacarpophalangeal (MCP), proximal interphalangeal (PIP) and distal interphalangeal (DIP) hand joints. To analyze the results, the method described by Swanson and his colleagues (5) was used to transpose the results into percentages of impairment in limb function.

Manual muscle testing was performed on all muscles innervated by the median and/or ulnar nerves, depending on the subject's injury. Grading was done according to a 0 to 5 scale, ranging from no palpable contraction to motion through full range against gravity and maximum force.

Grip and prehensile force measurements were taken for each hand. A Jamar dynamometer was used to measure grip strength, and a pinch gauge was used for tip, lateral and palmar pinch. The measurements were normalized in order to take into account the subject's age, gender and hand dominance (6,7).

**Sensory function:** Static and moving two-point discrimination thresholds were assessed with a two-point aesthesiometer. The analysis of the scores obtained on two-point discrimination was based on the difference in threshold between the affected and unaffected hands. A satisfactory recovery in static two-point discrimination was assigned to differences of 5 mm or less between the two hands. For moving two-point discrimination, a satisfactory recovery was attributed to differences of 3 mm or less.

A modified version of the Short-form of the McGill Pain Questionnaire (8) was used to assess pain. A visual analogue scale, quantifying the intensity of pain at the time of assessment, known as Present Pain Intensity, was taken from the standard form of the McGill Pain Questionnaire (9).

**Functional abilities:** In order to assess manual dexterity, the Jebsen Test of Hand Function (10) was used. Although this instrument does not include any bilateral activities, it evaluates several aspects of hand function. The scores on the Jebsen Test of Hand Function were adjusted to account for the subject's hand dominance, age and gender, based on published norms for children and adults (10,11). The difference in times for each hand was analyzed, by group.

Handedness was determined with the Hand Usage Questionnaire (12). For the purposes of the study, three questions were added to the questionnaire to ascertain the daily use made of the injured hand.

The Ayres' Manual Form Perception Test (13) was selected to assess tactile gnosis. This test has been developed for children and takes into account the developmental progression in shape recognition.

**TABLE 2: Proportion of subjects with satisfactory recovery* in static and moving two-point discrimination by group**

| Fingertip | Two-point discrimination | Children | Adults | Fisher's exact test |
|---|---|---|---|---|
| Thumb | Static | 11/12 | 3/9 | P=0.0009 |
| | Moving | 8/12 | 2/9 | P=0.06 |
| Index finger | Static | 9/12 | 3/9 | P=0.07 |
| | Moving | 6/12 | 4/9 | P=0.58 |
| Middle finger | Static | 9/12 | 4/9 | P=0.17 |
| | Moving | 8/12 | 4/9 | P=0.28 |
| Ring finger | Static | 15/15 | 15/17 | P=0.27 |
| | Moving | 16/16 | 15/17 | P=0.26 |
| Little finger | Static | 6/6 | 5/9 | P=0.09 |
| | Moving | 6/6 | 4/9 | P=0.04 |

**Defined as a difference in threshold between the affected and unaffected fingertips of 5 mm or less for static two-point discrimination and 3 mm or less for moving two-point discrimination*

**Self-appraisal of dysfunction:** A questionnaire was designed to gather the following information: subject's occupation, compensation benefits currently received, interference of pain with daily activities, sensitivity to cold and performance in daily activities. A pain thermometer (14,15) was used to assess the subjects' perception of how much pain interfered with their daily activities.

**Data analysis:** The statistical analyses were performed with the PC version of the SAS computer statistical package (16) and BMDP statistical package (17). Since the main hypothesis to be tested was that children demonstrated better functional recovery than adults, a one-sided level of probability less than 0.05 was considered to be statistically significant.

## RESULTS

**Motor function:** No statistically significant differences were found between the two groups in terms of impairment in range of motion. Nonetheless, the thumb was found to be the most impaired digit in both groups.

Muscle strength was manually tested and a score of 4 on the 0 to 5 scale was most frequently assigned. Weaknesses of grade 0 were found in three adults, but in none of the children (P=0.04). When considering the total number of weak muscles, no significant differences were found between the two groups. A description of the involved muscles revealed the following pattern of results. A weakness in the abductor digiti minimi, first palmar interosseous and third and fourth lumbricals was found in all six children with ulnar nerve injuries. Eight of nine adults with ulnar nerve injuries showed a muscle weakness in the abductor digiti minimi and first palmar and dorsal interossei. For subjects with median nerve injuries (12 children and nine adults), the main muscle weakness was found in the opponens pollicis. It remained weak in eight children and seven adults.

With respect to prehensile strength, a statistically significant difference between the two hands was found in the children only with respect to lateral pinch strength (P =0.03). In the case of adults, such a difference was found with respect to grip strength (P =0.001) and palmar pinch (P=0.03). Comparisons were made between the two groups for each type of grasp. The children displayed better recovery in palmar pinch and lateral pinch strength when compared with the adults.

**Sensory function:** The results on static and moving two-point discrimination are detailed in Table 2. Although the proportion of children who achieved satisfactory recovery in static and moving two-point discrimination was always greater than for adults, the results reached statistical significance in two instances only. In subjects with median nerve injuries, satisfactory recovery in static two-point discrimination in the thumb was present in 92% of children, as compared with 33% of adults (P=0.0009). For those with ulnar nerve injuries, satisfactory recovery on moving two-point discrimination was noted in the little finger in all children, as opposed to 44% of adults (P=0.04).

Pain descriptors on the adapted short-form of the McGill Pain Questionnaire were reported by a similar proportion of children and adults, except for tenderness, which was reported by 65% of adults, as compared to 29% of children (P=0.04). In both groups, the pain descriptor most frequently reported and with the greatest intensity was tingling (71% of children and 94% of adults). On the visual analogue scale quantifying pain, the children reported experiencing less pain at the time of assessment than the adults (P=0.001). Neuromas, defined as an area where pain is experienced upon the application of pressure, were reported by 88% of children and adults. The majority of subjects perceived their pain as being in deeper structures (53% of children and 82% of adults), as opposed to the surface of the skin (P=0.03). The two groups showed no statistically significant difference in their perception of how much pain interfered with their daily activities, as assessed by the pain thermometer.

**Functional activities:** On the Jebsen Test of Hand Function, significant differences were found between the hands of the adults on four out of seven subtests (writing, card turning, manipulating small objects and handling light large objects) and on one subtest in the children (handling checkers). When overall scores based on six subtests were examined, only the adults showed an impairment in performance between the hands (P=0.04).

Ninety-four percent of children and 82% of adults did not

change hand dominance following the injury (P>0.05). Forty-one percent of children and 65% of adults reported the compensatory use of their unaffected hand to accomplish most of their activities (P>0.05). Eighty-two percent of children and 59% of adults perceived that they were using their affected hand as frequently now as before their injury (P>0.05).

On the Ayres' Manual Form Perception Test, both groups took a longer time to recognize a form with the affected hand, as compared with the unaffected hand. The average difference in recognition time was 4.3 s in the adults (P=0.001) and 1.3 s in the children (P=0.03). The children were faster than the adults in recognizing forms with their affected hand (4.7 s in the children versus 8.1 s in the adults) (P=0.02). Both groups were, however, similar when using their unaffected hand (3.5 s in the children and 3.8 s in the adults) (P>0.05). The accuracy in response was found to be similar in the two groups, with the children averaging 1.2 errors compared with 1.7 errors in the adults (P>0.05).

**Self-appraisal of disability:** At the time of assessment, all adults had resumed work and all children were in school. Ten adults reported having resumed their former position or holding a job requiring similar work skills. The remaining subjects could not do so because of the sequelae from the injury. Ninety-four percent of children and 82% of adults were not currently receiving any compensation or insurance benefits.

The ability to feel differences in temperature with the affected hand was reported by 53% of children, as compared with 65% of adults (P>0.05). A reduced tolerance to cold was reported by 59% of children and 88% of adults (P>0.05). Fifty-nine percent of children and 82% of adults reported diminished hand function in comparison to before their injury (P>0.05).

The above information indicates that deficits were found to persist in the injured hand in both groups. The children and adults were found to diverge, however, in their perception of how these deficits affected their performance of daily activities. Difficulties in the areas of work, leisure and self-care were a major complaint in more than half of the adults, while this was much less common in the children. Moreover, the results obtained on the visual analogue scale were found to substantiate the above finding: children felt that their injury resulted in a lesser impairment than the adults (P=0.0006).

**Multivariate analyses:** In spite of the small sample size, it was decided to carry out logistic regression analyses to determine the factors that best differentiated the two groups with respect to functional recovery. The summary scores from seven tests were examined. The tests were: range of motion as defined by the percentage of upper extremity impairment, prehensile strength (the mean palmar pinch strength of the affected hand), static two-point discrimination (difference threshold on the thumb or little finger, depending on the subject's injury), manual dexterity (normalized time score on the Jebsen Test of Hand Function for the affected hand), tactile gnosis (difference between the hands in recognition time on the Ayres' Manual Form Perception Test), self-appraisal of disability on the visual analogue scale, pain score on the Present Pain Intensity scale, and activities of daily living (number of categories in which difficulties were reported). The involvement of the dominant versus nondominant hand was also investigated.

The number of categories of daily activities in which difficulties were experienced was found to be the strongest factor in quantifying the differential extent of functional recovery in children and adults. The estimated odds ratio for activities of daily living was 0.1, with a 95% confidence interval of [0.03, 0.5]. In clinical terms, this means that a child was extremely less likely than an adult to report experiencing difficulties in performing daily tasks. Two-point discrimination, especially when examined in conjunction with tactile gnosis, was found to be the second most important factor in differentiating the extent of functional recovery in children and adults. The third most important factor was found to be the subject's self-appraisal of disability.

As previously stated, injuries to the dominant (right) hand were found to be much more frequent in children than adults. Although injuring one's dominant hand may appear to increase the likelihood of using it following an injury, evidence for this was not obtained in the regression analyses.

## DISCUSSION

There appears to be a difference between the recovery of the sensory function and that of motor function when children are compared with adults.

In this study, the children were not remarkedly superior to the adults when detailed muscle strength was considered. We have not found similar studies comparing the motor function in these two age groups. Lindsay et al (1) reported weak adduction of the little finger as the most common motor dysfunction in nine of 11 children with ulnar nerve injuries. Vahvanen (3) reported a similar impairment in five of eight children with ulnar nerve injury. Stevenson (2) reported reinnervation of the intrinsic muscles responsible for thumb adduction and opposition to be present in five of eight children with proximal nerve injury, and mentioned that it is not usually the case in adults. Unfortunately, no adult control groups were included in these studies.

It is surprising to find that children are not recovering better motor function. Experimental data has shown a faster motor nerve recovery in younger animals (18). The distance between the nerve lesion and the target is shorter in children, therefore, the muscles should be denervated for a shorter period. These two factors do not seem to affect significantly the ultimate motor function recovery.

In this study, sensory recovery (two point discrimination and tactile gnosis) was found to be better in children than in adults, as previously mentioned in other reports (19,20). Better sensation in the thumb was also pointed out by other authors (3,19). Laboratory investigations have yet to explain why the sensory recovery is better since the sensory nerve conduction velocity is not different after a nerve repair in the young or in the older primate.

The possibility of a better adaptability of the central nervous system in the young subject is believed to be responsible for the better recovery (21-23).

Manual dexterity was found to be better in children than in adults. This could be related to the fact that the children displayed better sensory recuperation than the adults. Also, the children injured their dominant hand more frequently. Although not statistically significant, this may have favoured more use of the injured hand during the rehabilitation period.

A reduced tolerance to cold was reported by a large proportion of children and adults, which is contrary to the findings of Stevenson and Zuker (2). In a follow-up study of five children who had sustained multiple proximal nerve injuries, they reported that none of the children had complaints relating to the presence of pain or cold intolerance. There is no description of the method used to assess this aspect. It may be that the differences between the studies reflect the assessment method used and the limited sample size.

A high proportion (88%) of subjects in our study were found to have an area of local tenderness when pressure was applied over the repair site. This was defined as a neuroma. Many authors use a more restrictive definition of neuromas and include only painful neuromas. Painful neuromas often require further intervention to correct the pain. None of our subjects required treatment for their neuromas. McEwan (4) reported the presence of neuromas in two of 54 children and three of 43 adults with median and/or ulnar nerve sutures. This difference may lie in the distinction made between the terms neuroma and painful neuroma.

In the present study, the extent of sensory and motor impairment did not correlate with the subjects' perceptions of their disability. This finding is in agreement with that reported by Onne (19) who found that for the majority of his subjects (59 of 69) there was no direct relation between the assessment of subjective symptoms and the results on tests of two-point discrimination and tactile gnosis. In contrast, Boswick et al (24) reported that in subjects with peripheral nerve injuries below the elbow, the subjective evaluations of their hands were an extremely useful and reliable index of hand function. No statistical tests were performed on these results.

## CONCLUSION

In this study the children showed better results on two-point discrimination, tactile gnosis and manual dexterity than the adults. They also presented fewer difficulties in performing daily tasks and reported experiencing less pain than adults. No major differences were found between the two groups with respect to motor recovery.

**ACKNOWLEDGEMENTS:** The authors wish to thank the personnel from the following medical centres for their contribution: Hôpital Ste-Justine, Montreal General Hospital, Hôpital Notre-Dame and the Royal Victoria Hospital. Financial assistance was received from the Quebec March of Dimes (October 1987). This article is based on a thesis submitted in partial fulfillment of the requirements for the degree of Master of Science (Rehabilitation Science), McGill University

**REFERENCES**

1. Lindsay WK, Walker FG, Farmer AW. Traumatic peripheral nerve injuries in children. Plast Reconstr Surg 1962;30:462-7.
2. Stevenson JH, Zuker RM. Upper limb motor and sensory recovery after multiple proximal nerve injury in children: a long term review in five patients. Br J Plast Surg 1986;39:109-13.
3. Vahvanen V, Gripenberg L, Nuutinen P. Peripheral nerve injuries of the hand in children. Scand J Plast Reconstr Surg 1981;15:49-51.
4. McEwan LE. Median and ulnar nerve injuries. Aust N Z J Surg 1962;32:89-104.
5. Swanson AB, Goran-Hagert C, DeGroot Swanson G. Evaluation of impairment of hand function. In: Hunter JM, Schneider LH, Mackin EJ, Callahan AD, eds. Rehabilitation of the Hand, 2nd ed. St-Louis: The CV Mosby Co, 1984:101-32.
6. Mathiowetz V, Kashman N, Volland G, Weber K, Dowe M, Rogers S. Grip and pinch strength: normative data for adults. Arch Phys Med Rehabil 1985;66:69-74.
7. Mathiowetz V, Wiemer DM, Federman SM. Grip and pinch strength: Norms for 6 to 19-year olds. Am J Occ Occup Ther 1986;40:705-11.
8. Melzack R. The short-form McGill Pain Questionnaire. Pain 1987;30:193-7.
9. Melzack R. The McGill pain questionnaire: major properties and scoring methods. Pain 1975;1:277-99.
10. Jebsen RH, Taylor N, Trieschmann RB, Trotter MJ, Howard LA. An objective and standardized test of hand function. Arch Phys Med Rehabil 1969;50:311-9.
11. Taylor N, Sand PL, Jebsen RH. Evaluation of hand function in children. Arch Phys Med Rehabil 1973;54:318-24.
12. Chapman LJ, Chapman JP. The measurement of handedness. Brain Cogn 1987;6:175-83.
13. Ayres AJ. Southern California Kinesthesia and Tactile Perception Tests Manual. Los Angeles: Western Psychological Services, 1966.
14. Jay SM, Ozolins M, Elliott CH, Caldwell S. Assessment of children's distress during painful medical procedures. Health Psychol 1983;2:133-47.
15. Thompson KL, Varni JW. A developmental cognitive-biobehavioral approach to pediatric pain assessment. Pain 1986;25:283-96.
16. SAS Institute Inc., Release 6.03 Edition. Cary, NC: SAS Institute Inc, 1988.
17. Dixon WJ, ed. BMDP Statistical Software. Berkeley: University of California Press, 1985.
18. Whittaker Vaughan D. Effects of advancing age on peripheral nerve regeneration. J Comp Neurol 1992;323:219-37.
19. Onne L. Recovery of sensibility and sudomotor activity in the hand after nerve suture. Acta Chir Scand Suppl 1962;300:1-69.
20. Almquist E, Eeg-Olofsson E. Sensory-nerve-conduction velocity and two-point discrimination in sutured nerves. J Bone Joint Surg 1970;52A:791-96.
21. Almquist EE, Smith OA, Fry L. Nerve conduction velocity, microscopic and electron microscopy studies comparing repaired adult and baby monkey median nerves. J Hand Surg 1983;8:406-10.
22. McKinley PA, Jenkins WT, Smith JL, Merzenich MM. Age-dependent capacity for somatosensory cortex reorganization in chronic spinal cats. Dev Brain Res 1987:1-4.
23. Kaas JH, Merzenich MM, Killackey HP. The reorganization of somatosensory cortex following peripheral nerve damage in adults and developing mammals. Annu Rev Neurosc 1983;6:325-56.
24. Boswick JA, Schneewind J, Stromberg W. Evaluation of peripheral nerve repairs below elbow. Arch Surg 1965;90:50-1.