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Research paper

Implementing Donor Activation Focused Rehabilitation Approach (DAFRA) following nerve transfers for children with brachial plexus birth injury: A case series

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ABSTRACT

Background: Nerve transfers are increasingly used to restore upper limb function in infants and toddlers with brachial plexus birth injuries (BPBI). However, standardized, pediatric-specific rehabilitation protocols remain lacking. Adult-focused approaches are often developmentally inappropriate, and the absence of tailored rehabilitation may contribute to high failure rates, particularly for complex transfers.
Purpose: To present a structured, milestone-based rehabilitation protocol adapted from the Donor Activation Focused Rehabilitation Approach (DAFRA) for infants and toddlers undergoing nerve transfers for BPBI and to report functional outcomes using a case-series design.
Study design: Therapeutic, case series
Methods: Following IRB approval, infants and toddlers undergoing nerve transfers for BPBI at a single institution were enrolled. Procedures included spinal accessory nerve to suprascapular nerve (SAN-SSN), medial pectoral to axillary nerve (MPN-AxN), ulnar nerve fascicle to musculocutaneous branch (Oberlin), and double fascicular nerve transfers. All pati three-phase rehabilitation protocol was implemented, emphasizing donor-recipient muscle re-education through play-based functional activities, co-activation, and caregiver participation. Outcomes were assessed using the Active Movement Scale (AMS).
Results: Fourteen patients underwent SAN-SSN transfer at a mean age of 7.0 months; 71.4% achieved full external rotation against gravity (AMS 7). Twenty-one underwent MPN-AxN transfer at a mean age of 8.9 months, demonstrating significant improvements in abduction (median AMS 5, IQR 3-6) and flexion (median AMS 6, IQR 5-6) (both $p < 0.001$). Thirteen patients underwent double fascicular nerve transfers for elbow flexion at a mean age of 10.1 months, with significant gains in elbow flexion (median AMS 6, IQR 6-7) and forearm supination (median AMS 5, IQR 3-7) (both $p = 0.002$). Biceps improved from median MRC 0 (IQR 0-1) preoperatively to MRC 4 (IQR 3-5) postoperatively ($p = 0.002$). Meaningful recovery occured in 100% for elbow flexion 62% for supination, and 70% for biceps strength.
Conclusions: A structured, milestone-based, play-integrated DAFRA protocol yields promising outcomes in infants and toddlers undergoing nerve transfers for BPBI. Developmentally appropriate rehabilitation may reduce failure rates and supports broader adoption of pediatric-specific protocols.

Introduction

The treatment landscape for brachial plexus birth injuries (BPBI) continues to rapidly evolve. Surgeons increasingly rely on nerve transfers to restore upper-limb function in children, yet the field lacks standardized pediatric rehabilitation.[1–3] Despite their popularity and promising results,[4–6] most published rehabilitation guidelines remain vague or adult-oriented, rather than tailored to early developmental stages.

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A recent scoping review by Mendiratta et al confirmed this gap: although 23 of 36 studies referenced "postoperative therapy," only a minority described their methods in detail, and few addressed distal nerve transfers despite their growing role in infants.[7–9] Persistent misconceptions—particularly the belief that children's neuroplasticity eliminates the need for structured rehabilitation—continue to undermine consistent outcomes.[10–13]

Adult Donor Activation Focused Rehabilitation Approach (DAFRA) protocols emphasize donor-target synergy and motor re-education. However, infants cannot follow verbal commands or visualize anatomy, which leaves a developmental gap that necessitates a pediatric-specific framework grounded in play-integrated functional re-education rather than volitional exercise.[14,15]

To address this gap, the authors developed a structured, milestone-based rehabilitation protocol tailored to infants and toddlers undergoing nerve transfers for BPBI. We aim to describe an integrated, developmentally appropriate protocol with caregiver engagement, and provide case examples illustrating its application.

Methods

We conducted a retrospective, consecutive case series at a single institution from 2021-2024 after obtaining Institutional Review Board approval (*Institution Blinded for Review* IRB #2022-14122) in accordance with the Declaration of Helsinki. We incorporated key CARE guideline elements into the case-report portion.[16]

The study included infants and toddlers with clinically diagnosed BPBI who underwent nerve transfer procedures. Transfers comprised the spinal accessory nerve to suprascapular nerve (SAN-SSN), medial pectoral to axillary nerve (MPN-AxN), and double fascicular nerve transfers. When indicated, the authors used imaging to confirm BPBI.

Pediatric certified hand therapists (CHTs) with more than five years of peripheral nerve and pediatric upper-limb experience delivered all rehabilitation. Each child attended weekly 60-min sessions and participated in daily caregiver-directed home exercise programs (HEP).[17–19]

The authors used the Active Movement Scale (AMS) scores to assess upper-limb function (Table 1). AMS provides validated inter- and intra-observer reliability for BPBI assessment.[20–22] We separately graded biceps function (elbow flexion in supination while palpating the biceps tendon) using the Medical Research Council (MRC) strength grading scale, which offers greater specificity than AMS for assessing true biceps activation.[23]

We instituted a two-week postoperative rest period to protect the neurorrhaphy. Surgeons communicated details of the nerve coaptation—including tension-free approximation with suture and fibrin glue—to the therapists. When surgeons noted neurorrhaphy tension or instability, we delayed motion for four weeks postoperatively to allow epineural healing.

We structured the protocol into three progressive, milestone-based phases emphasizing donor activation, co-activation, and strengthening (Fig. 1, Table 2).

Phase 1—Donor Activation and Passive Mobilization: Therapists delivered high-repetition, low-resistance activities to stimulate active donor muscle engagement. Concurrently, they introduced passive movements of the recipient muscle to preserve joint range of motion and initiate cortical mapping.

Phase 2—Co-Activation: Therapists initiated this phase once the recipient muscle demonstrated visible contraction or movement in less than half the range in a gravity-eliminated plane. Exercises began in gravity-assisted or eliminated positions and progressed to functional planes.

Table 2
Active Movement Scale (AMS) scoring system developed by the Hospital for Sick Children in Toronto, Canada. Reprinted with permission from: Clarke HM, Curtis CG. An approach to obstetrical brachial plexus injuries. Hand Clinics. 1995;11(4):563–580

Movement grade		Observation
0	Gravity-eliminated	No muscle tone or contraction
1		Muscle contraction, no motion
2		Joint motion ≤ ½ range
3		Joint motion > ½ range
4		Full joint motion
5	Against gravity	Joint motion ≤ ½ range
6		Joint motion > ½ range
7		Full joint range

Scores are assigned for the following upper extremity movements: shoulder abduction, shoulder adduction, shoulder flexion, shoulder external rotation, shoulder internal rotation, elbow flexion, elbow extension, forearm pronation, forearm supination, wrist flexion, wrist extension, finger flexion, finger extension, thumb flexion, and thumb extension.

Table 1
Milestones and checkpoints across rehabilitation phases

Phase	Clinical milestone	Home-program focus	Progression criteria
Phase 1	Visible donor contraction, maintenance of passive ROM	Daily caregiver-assisted play involving passive motion	Consistent donor contraction x 1 week
Phase 2	Partial co-activation (< 50% range, gravity-eliminated)	Bilateral play and reaching with facilitation	> 1/2 range co-activation against gravity
Phase 3	Independent activation against gravity	Functional resistance play (pushing/pulling toys)	Stable, pain-free activation with age-appropriate control

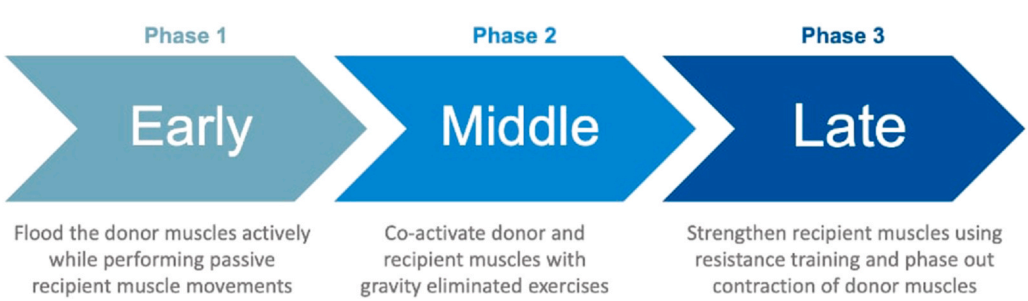

Fig. 1. General principles of the early, middle, and late phases of Donor Activation Focused Rehabilitation Approach (DAFRA).

Phase 3—Recipient Muscle Strengthening: After children achieved antigravity control, therapists advanced therapy to active, resistance-based play.

Caregivers reinforced each phase through structured in-clinic sessions and daily HEP, reinforced by caregiver education and feedback loops. We advanced patients based on functional milestones rather than time.

We expressed descriptive statistics as median ± interquartile ranges (IQRs) and performed paired comparisons using the Wilcoxon signed-rank test with statistical significance set at $p < 0.05$.

Results

Spinal accessory nerve (SAN) to suprascapular nerve (SSN) transfer

Fourteen patients (8 males and 6 females) underwent SAN-SSN transfers at a mean age of 7 months (SD ± 3.7) (Table 3). At a mean follow-up of 16 months (SD ± 2.5), they demonstrated significant gains in shoulder external rotation (ER) (preoperative AMS 3 [IQR 2-5] to AMS 7 [IQR 6-7]), $p < 0.001$. Ten patients (71.4%) achieved full functional ER recovery (AMS 7), three patients (21.4%) achieved partial recovery (AMS 4-5), and one demonstrated complete failure of re-innervation in ER at 12 months post-op, requiring surgical revision.

Medial pectoral nerve (MPN) to axillary nerve (AxN) transfer

Twenty-one infants underwent MPN-AxN transfer at a mean age of 8.9 months (SD ± 2.9) with follow-up of 17.7 months (SD ± 6.1). They achieved statistically significant improvements in abduction (AMS 2 [IQR 1-3] to AMS 5 [IQR 3-6]) and flexion (AMS 2 [IQR 1-3] to AMS 6 [IQR 5-6]), $p < 0.001$ (Table 4). Functional abduction (AMS ≥ 5) occurred in 15 patients (71.4%), and functional flexion in 17 (81%).

Double fascicular nerve transfer for elbow flexion

Thirteen patients (7 males and 6 females) underwent double fascicular nerve transfers (median fascicle to biceps, ulnar fascicle to brachialis) for elbow flexion. Their mean age was 10.1 months (SD ± 9), with a mean follow-up of 19 months (SD ± 6). They demonstrated significant gains in elbow flexion (AMS 2 [IQR 0-4] to AMS 6 [IQR 6-7]), supination (AMS 1 [IQR 0-2] to AMS 5 [IQR 3-7]), and biceps strength (MRC 0 [IQR 0-1] to MRC 4 [IQR 3-5]), $p = 0.002$ (Table 5). All patients regained meaningful elbow flexion (AMS ≥ 5), 62% regained meaningful supination (AMS ≥ 5), and 70% regained meaningful biceps function (MRC ≥ 4).

Table 3
Spinal accessory nerve (SAN) to suprascapular nerve (SSN) transfer cohort outcomes

Movement	Pre-op AMS (median, IQR)	Post-op AMS (median, IQR)	*p* value
SA	3 (2-5)	7 (6-7)	< 0.001
ER	2 (0-4)	7 (6-7)	< 0.001

Table 4
Medial pectoral nerve (MPN) to axillary nerve (AxN) transfer cohort outcomes

Movement	Pre-op AMS (median, IQR)	Post-op AMS (median, IQR)	*p* value
SA	2 (1-3)	5 (3-6)	< 0.001
SF	2 (1-3)	6 (5-6)	< 0.001

Table 5
Double fascicular nerve transfer cohort outcomes

Movement	Pre-op (median, IQR)	Post-op (median, IQR)	*p* value
Elbow flexion	2 (0-4) AMS	6 (6-7) AMS	0.002
Supination	1 (0-2) AMS	5 (3-7) AMS	0.002
Biceps	0 (0-1) MRC	4 (3-5) MRC	0.002

Case series

Case 1

A 4-week-old male presented with an extended upper trunk palsy. After two months of therapy, he continued to demonstrate abnormal shoulder function, especially in external rotation, and point-of-care ultrasound revealed glenohumeral dysplasia refractory to supination external rotation bracing. His AMS scores for abduction, flexion, and ER at this point were 2, 2, and 1, respectively. Because the dysplasia progressed despite appropriate nonoperative treatment, we recommended surgery to prevent abnormal joint mechanics, muscle vector imbalance, and bony motion blocks such as a hypertrophic coracoid. We performed an SAN-SSN nerve transfer at 3.6 months of age.

Postoperative rehabilitation phases included:

Phase 1

Therapists facilitated active scapular shrugging and retraction using vibrotactile input and performed passive shoulder external rotation and abduction during seated or supine play.

We recommend two options:

1. place the patient in supported sitting position and apply vibration along the spine between the scapulae to facilitate scapular retraction while the therapist performs passive ER and abduction (Fig. 2A), or
2. position the patient supine with the shoulder abducted and a toy suspended overhead; the therapist massages the upper trapezius to elicit a reflexive shrug while performing passive abduction and ER.

Phase 2

Once the infraspinatus and supraspinatus demonstrate motion through less than half the range in a gravity-eliminated plane, therapists began co-activation of donor and recipient muscles through toy-reaching in side-lying, progressing to inclined and prone positioning.

Recommended activities include:

1. place the child supine and assist them with proper positioning for abduction and ER active range of motion while encouraging bilateral toy-reaching paired with shoulder shrugging (facilitated by stroking along the muscle belly); therapists may progress this using an incline wedge or prone positioning (Fig. 2B), or
2. position the child side-lying on the unaffected side, support the affected arm in abduction, and guide the child to retrieve a colorful scarf from a box using ER AROM; this can also be performed in supported sitting position with back support to prevent trunk hyperextension.

Phase 3

Once the child demonstrated antigravity function, therapists initiated strengthening via isometric resistance-based ER tasks during seated and/or prone play.

Recommended activities include:

1. place the child in a seated position with the affected arm abducted to facilitate pushing into a toy while the therapist applies

Fig. 2. Demonstration of patients with a spinal accessory to suprascapular nerve transfer during different phases of the DAFRA protocol. **(A)** Demonstration of an infant during the first phase of the DAFRA protocol actively contracting the donor muscles (upper and middle trapezius) while a provider is passively externally rotating and abducting the shoulder (recipient muscles: infraspinatus and supraspinatus). **(B)** Demonstration of an infant during the second phase of the DAFRA protocol co-activating the upper and middle trapezius (donor) muscles with the infraspinatus and supraspinatus (recipient) muscles. **(C)** Demonstration of a child during the third phase of the DAFRA protocol. The provider is assisting in strengthening the recipient muscles (infraspinatus and supraspinatus muscles) by helping the child to perform shoulder external rotation while the provider applies manual resistance.

manual resistance into internal rotation for strengthening (Fig. 2C), or

2. prone play with alternating hands pulling colorful tissues from a slot using ER.

At 13 months postoperatively, the patient demonstrated AMS 7 (full range of motion against gravity) in shoulder abduction, flexion, and external rotation, without evidence of compensatory scapulothoracic motion.

Case 2

A 5-month-old female presented with an extended upper trunk palsy and suboptimal shoulder function, including abduction (AMS 3), flexion (AMS 3), and ER (AMS 0). To optimize function, we performed combined SAN-SSN and MPN-AxN nerve transfers at 7 months of age. The following phases highlight the MPN-AxN-specific rehabilitation.

Phase 1

Therapists paired passive shoulder flexion with active internal rotation and horizontal adduction using toy-reach activities in seated or side-lying positions. We recommend encouraging the child to reach across midline with the forearm pronated to grasp toys while the therapist passively elevates the shoulder (Fig. 3A).

Phase 2

Therapists introduced co-activation of donor and recipient muscles in gravity-assisted o r eliminated planes. Suggested activities include bilateral active and active-assisted range of motion reaching tasks in seated or prone play (Fig. 3B).

Phase 3

Once the child could co-activate the pectoralis major/minor with the deltoid against gravity, therapists advanced to functional strengthening via gravity-resisted reaching, weight-bearing, and manual resistance.

We recommend placing the child prone (optimally on a wedge to increase weight-bearing tolerance) and guiding them to reach against gravity for toys with manual assistance (Fig. 3C).

At 14 months postoperatively, the child achieved full active shoulder motion against gravity in all planes (AMS 7).

Case 3

A 7-month-old male with an upper trunk BPBI demonstrated inadequate recovery after nonoperative management. His preoperative AMS scores were elbow flexion 3, supination 3, and biceps strength MRC 1. We performed an Oberlin transfer (fascicle of the ulnar nerve to the nerve to the biceps).

Phase 1

Therapists encouraged active wrist flexion and ulnar deviation while providing passive elbow flexion and supination.

We recommend seated or side-lying positioning while the child reaches for a toy positioned above the wrist to encourage wrist flexion as the therapist passively flexes the elbow (Fig. 4A).

Phase 2

Therapists facilitated functional co-activation using midline reaching and grasping tasks in side-lying or seated positions.

Recommended activities include placing the child side-lying and guiding them to pull clothespins off their shirt at mid-chest level or reach for a toy at mid-chest level, focusing on active and active-assisted elbow flexion with wrist flexion (Fig. 4B).

Phase 3

Therapists introduced progressive strengthening using manual resistance and gravity-based play as the child transitioned from side-lying to seated postures.

We recommend side-lying reaching tasks at chest level with manual forearm resistance, progressing to seated/supported-seated activities performed against gravity (Fig. 4C).

Fig. 3. Demonstration of patients with a medial pectoral nerve to axillary nerve transfer during different phases of the DAFRA protocol. **(A)** Demonstration of an infant during phase one of the DAFRA protocol. In this image, the child is in a seated position, reaching across the chest to perform horizontal adduction, with the forearm in pronation to reach for a toy, while the therapist passively abducts the shoulder to contract recipient muscles (anterior, middle, and lateral deltoids). **(B)** Demonstration of an infant during phase two of the DAFRA protocol. In this image, the child is positioned on their side, reaching for a toy with both hands at midline and holding it overhead to engage both the donor and recipient muscles. **(C)** Demonstration of an infant during phase three of the DAFRA protocol. In this image, the child is positioned on a wedge in a prone stance, reaching for a toy against gravity and manual resistance to strengthen the recipient muscles.

At 7 months follow-up, the child achieved AMS 6 in supination, AMS 7 in elbow flexion, and MRC 4 biceps strength.

Case 4

A 19-month-old female presented with an upper trunk palsy and significant deficits: elbow flexion AMS 2, supination AMS 1, and biceps MRC 0. We performed a double fascicular nerve transfer (median fascicle to biceps and ulnar fascicle to brachialis).

Phase 1

Therapists paired wrist and finger flexion-based play with passive elbow flexion and supination in seated or supported-seated positions.

We recommend seating the child while the provider passively positions the forearm in supination and holds a ball above the hand to encourage wrist/finger flexion as the therapist passively flexes the elbow (Fig. 5A).

Fig. 4. Demonstration of patients with an ulnar nerve fascicle to the musculocutaneous branch to the biceps nerve transfer during different phases of the DAFRA protocol. **(A)** Demonstration of an infant during phase one of the DAFRA protocol. In this image, the child is in a side-lying position while having the child reach for a toy above the wrist to encourage wrist flexion, while the provider passively flexes the elbow. **(B)** Demonstration of an infant during phase two of the DAFRA protocol. In this image, the child is in a side-lying position while having the child reach for a toy at mid-chest level while focusing on active or active-assisted elbow flexion with wrist flexion. **(C)** Demonstration of a child during phase three of the DAFRA protocol. In this image, the child is in a seated position while grabbing toys, to strengthen active elbow flexion and forearm supination.

Fig. 5. Demonstration of a child with a double fascicular nerve transfer during different phases of the DAFRA protocol. **(A)** Demonstration of a child during phase one of the DAFRA protocol. In this image, the child is in a seated position while the provider passively positions the forearm in supination and flexes the elbow while positioning a toy above the patient's hand to enable wrist flexion. **(B)** Demonstration of a child during phase two of the DAFRA protocol. In this image, the child is in a seated position while bringing toys toward the chest and co-activating wrist flexion and elbow flexion and forearm supination. **(C)** Demonstration of a child during phase three of the DAFRA protocol. In this image, the child is in a seated position while lifting and holding objects with varying weight and providing manual resistance using elbow flexion with forearms in supination.

Phase 2

Therapists promoted active wrist flexion and elbow flexion in supination through bilateral toy-scooping and pulling activities.

Recommended activities include seated or standing play in which the child scoops toys toward the chest using bilateral grasp and wrist flexion while performing active or active-assisted elbow flexion (Fig. 5B).

Phase 3

Therapists advanced to strengthening with progressive resistance and functional toy-lifting tasks in seated or standing positions.

We recommend guiding the child to lift and hold objects of increasing weight or applying manual resistance during elbow flexion with forearm in supination (Fig. 5C).

At 19 months follow-up, the child achieved AMS 7 in elbow flexion and supination and biceps strength of MRC 4.

Discussion

This study presents a structured, play-integrated, milestone-based rehabilitation framework for infants and toddlers undergoing nerve transfers for BPBI. By adapting DAFRA principles to early developmental capacities, the protocol emphasizes donor-recipient synergy through guided functional play and yields improved AMS outcomes across a diverse cohort.

Our findings directly counter the misconception that infant rehabilitation occurs intuitively. Infants cannot visualize anatomy or follow complex verbal instruction; instead, they depend on therapist-guided, play-based activation strategies. Pediatric therapists routinely adjust to developmental capacity, but formalizing these strategies enhances reproducibility and rigor.[24]

Every patient in our series received specialized therapy from pediatric CHTs using our adapted DAFRA protocol, supplemented by caregiver-directed HEPs. Despite significant preoperative deficits, all four exemplar cases demonstrated substantial postoperative gains and achieved age-appropriate strength and antigravity movement in targeted muscles.

SAN-SSN transfers remain challenging because the donor (trapezius) and recipient (infraspinatus/supraspinatus) muscles are not naturally synergistic. Reported failure rates in adults and children range from 41-87%.[4,25,26] Using our protocol, 92% of patients achieved meaningful recovery (AMS ≥ 5). The single failure occurred in a revision case with prolonged denervation (15 months) after a failed outside-hospital reconstruction. While there are cases of recovery in delayed and late transfer cases, they rely on maintenance of muscle motor end-plates via tropism due to misdirected innervation and developmental dyspraxia.[27] Our failure may be attributed due to the prior failed allograft reconstruction that resulted in a complete denervation of the infraspinatus. With regard to our overall difference in successful recovery rates compared with the literature, this may be explained by a lack of specialized therapy for children in literature studies.

Outcomes after MPN-AxN transfers vary widely in adults, with up to 50% failure rates.[28,29] Pediatric data are absent. In our cohort, 71% achieved functional abduction and 81% achieved functional flexion. Because the MPN innervates pectoralis major and minor, its synergy with anterior deltoid during forward elevation likely enhances the success of this “in-phase” transfer.[30]

The Oberlin transfers are well-established in adult literature: meta-analyses report success rates of up to 64% achieving MRC ≥ 4 strength,[31] while pediatric studies show a wide range of favorable outcomes, with recovery rates ranging from 54%-100%.[32–35] For double fascicular nerve transfers, adult outcomes demonstrate MRC ≥ 4 recoveries in 80-90% of cases.[36–39] However, pediatric data remain limited and no BPBI-specific analysis of the double fascicular nerve transfer exist. Our cohort demonstrated 100% meaningful elbow flexion recovery, along with robust supination and biceps strength outcomes.

Although surgeons have refined nerve transfer techniques, the major gap lies in postoperative rehabilitation. In the BPBI nerve transfer population play-based, developmentally appropriate therapy remains under-represented and described in the literature.

Our findings support the critical role of structured rehabilitation and highlight the need for broader dissemination, caregiver-centered adaptability, and multicenter validation. Qualitative studies of hand therapists validate this gap in nerve rehabilitation.[40]

This study carries limitations, including single-institution design, absence of a control cohort, variability in surgical timing, potential interrater AMS differences, and reliance on highly specialized therapists. Furthermore, AMS does not necessarily reflect the quality of movement and possible compensatory patterns. Socioeconomic variation, orthotic use, and family engagement may also influence outcomes. Nonetheless, by detailing the protocol, we aim to disseminate knowledge and enhance reproducibility across centers.

Additional modalities—such as constraint-induced movement therapy—supplemented activation in select cases, but these techniques do not diminish the central role of the structured protocol.[41]

Timing of nerve transfer remains controversial. We agree that surgeons must allow time for spontaneous recovery, but excessive delay, especially in the presence of glenohumeral dysplasia, can compromise joint mechanics and functional potential.[42,43] When dysplasia progresses despite bracing, we advocate early surgical intervention regardless of chronological age.

Conclusions

Nerve transfer surgery offers infants and toddlers with BPBI meaningful opportunities for functional recovery. Optimal outcomes depend not only on surgical technique but also on timely, developmentally appropriate rehabilitation. Our structured, milestone-based rehabilitation protocol—rooted in adapted DAFRA principles and implemented through age-appropriate, play-based activation—enabled infants and toddlers to activate and strengthen nerve transfers effectively, even in transfers with historically high failure rates. As no standardized pediatric postoperative protocols currently exist, our findings provide a practical and reproducible model for early rehabilitation. Multicenter studies remain essential to validate these approaches, reduce inter-institutional variability, and expand access to optimized rehabilitative pathways for this vulnerable population.

Ethical approval

Ethical approval to report these cases was obtained from Montefiore Medical Center's Institutional Review Board (Study ID: 2022-14122).

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CRediT authorship contribution statement

Victoria Ferrante: Writing—review and editing, writing—original draft, investigation. **Victoria Robbins:** Writing—review and editing, writing—original draft, methodology, investigation, and conceptualization. **Ann Marie Feretti:** Writing—review and editing, writing—original draft, supervision, methodology, investigation, and conceptualization. **Koehler Steven M:** Writing—review and editing, writing—original draft, supervision, methodology, and conceptualization. **Megan Gotlieb-Horowitz:** Writing—review and editing, writing—original draft, methodology, investigation, and conceptualization. **Tara DeRosa:** Writing—review and editing, investigation. **Nathan Khabyeh-Hasbani:** Writing—review and editing, writing—original draft, methodology, investigation, and conceptualization.

Declaration of competing interest

SMK is a committee member of the American Society for Surgery of the Hand (ASSH). The remaining authors declare no further potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Informed consent

Informed consent was obtained from the patient(s) for their anonymized information to be published in this article. Additionally, informed consent was obtained by the patients' guardians for the use of their images in this publication.

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Quiz: # C63

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1 Subject had had the following nerve transfer technique

a. Oberlin
b. SAN-SSN
c. MPN-AxN
d. any of the above

2 The study design was

a. RCTs
b. case report
c. case series
d. prospective cohort

3 The authors postulate that

a. applying adult generated rehab protocols to children may contribute to high rates of unsatisfactory outcomes
b. the needs of children with BPBIs have long been ignored
c. current treatment protocols are equally applicable for adults and children
d. it is impossible to develop appropriate treatment protocols for a child population due to their inability to comply with instructions

4 In Phase I therapy included

a. 3-5 repetitions of high resistance activities
b. high-repetition, low-resistance activities
c. isometric exercises
d. eccentric exercises

5 The authors advocate incorporating a play component to treatment plans

a. not true
b. true

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