

# Assessment of Triangle Tilt Surgery in Children with Obstetric Brachial Plexus Injury Using the Pediatric Outcomes Data Collection Instrument

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**Abstract:** *Background:* The benefits of triangle tilt surgery in children with OBPI have been previously validated through measurements of statistical improvements in Mallet scores and in glenohumeral congruity. The purpose of the current study was to evaluate the effectiveness of triangle tilt surgery through the application of the Pediatric Outcomes Data Collection Instrument, a well validated questionnaire designed to evaluate function and comfort in children with musculoskeletal disorders.

*Methods:* OBPI patients between 2 and 10 years of age who came to our institute for routine office visits between May 2009 and October 2009 were considered to participate in the study. Among the patient group, the first 130 completed surveys who met the study criteria were included in the study. The Pediatric Outcomes Data Collection Instrument was completed by the parents of patients who have undergone triangle tilt surgery (Group 1: N=63) or those who were considered candidates for this procedure (Group 2: N=67). The results were compared between the two patient groups and analyzed using the unpaired student's *t*-test. Later, 23 patients from the group 2, underwent triangle tilt surgery (Group 3). We collected post-op data, compared and analyzed the outcome of the surgery in these patients to their own pre-op PODCI scores, using the paired student's *t* test.

*Results:* In patients who have undergone triangle tilt surgery, significantly higher PODCI scores were observed in the parameters of upper extremity function ( $p < 0.05$ ), sports/physical function ( $p < 0.05$ ), basic mobility ( $p < 0.0001$ ) and global functioning ( $p < 0.05$ ), when compared to patients who have not undergone triangle tilt surgery. Further, PODCI scores in group 3 patients were significantly higher after surgery in the parameters of upper extremity function ( $p < 0.03$ ), Pain/Comfort ( $p < 0.05$ ), basic mobility ( $p < 0.0002$ ) and global functioning ( $p < 0.03$ ), when compared to before triangle tilt surgery.

*Conclusion:* The results of the Pediatric Outcomes Data Collection Instrument demonstrate the functional benefits of triangle tilt surgery in patients with obstetric brachial plexus injury.

**Keywords:** Triangle tilt surgery, Obstetric brachial plexus injury, Pediatric outcome data collection instrument.

## BACKGROUND

Obstetric brachial plexus injury (OBPI) is a nerve complication that presents 0.5-4.6 times per 1000 live births [1]. Although spontaneous recovery occurs in many cases, some OBPI children have persistent weaknesses that lead to anatomical and functional deformities of the upper extremity [2]. The upper C5-C6 roots of the brachial plexus are most frequently injured (60%) and subsequently result in shoulder dysfunction [3]. OBPI patients face difficulty performing daily activities, especially those involving abduction and external rotation of the shoulder [4].

Traditional approaches that are aimed at treating OBPI include nerve transfer, contracture release, axillary nerve decompression, and external derotational osteotomy of the humerus [5-8]. As conventional surgical approaches fail to address the scapular hypoplasia, elevation and rotation (SHEAR) deformity [3, 9] associated with most OBPI cases, the triangle tilt procedure was developed by the senior author to mainly correct this bony deformity and has shown to have

a high success rate [9, 10]. The operative technique includes osteotomies of the clavicle, acromion, and scapula in order to release the distal acromioclavicular triangle and allow it to reorient itself in a more neutral position in the glenoid [9, 10].

The benefits of triangle tilt surgery in OBPI patients were previously demonstrated by examination of their radiological reports as well as by using the modified Mallet functional scale [9], which is based on the ability to perform a specified set of motions. However, the functional improvements in shoulder movement have not been previously assessed by the parent of the child in his or her daily environment. An evaluation of the ability of the child to perform day-to-day activities would be a valuable clinical tool in determining the surgical outcome.

The Pediatric Outcome Data Collection Instrument (PODCI), also known as the AAOS/POSNA Outcomes Instrument [11, 12] is one such tool developed in 1994 to assess function, happiness, and pain in children with musculoskeletal disorders [13]. The questionnaire was mutually developed by the American Academy of Orthopaedic surgeons, the Pediatric Orthopaedic Society of North America, the American Academy of Pediatrics, and

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Shriner's Hospitals to provide a standard assessment of pediatric orthopedic patients [4]. The six parameters of the PODCI include upper extremity function, transfers and basic mobility, sports/physical function, pain/comfort, happiness, and global functioning. Four of these six parameters are functional parameters. For patients ages 2-10, the survey was designed to be answered by the parents of these patients. The PODCI has been shown to be reliable, through various other studies, in evaluating aspects of function, happiness, and pain in children with orthopedic limitations [4, 11, 14, 15].

The purpose of the current study was to analyze and compare PODCI scores between OBPI patients who underwent triangle tilt surgery, and OBPI patients who have not undergone triangle tilt surgery. Further, we compared and analyzed the post-op PODCI scores in the later group of patients to their own pre-op PODCI scores to determine whether the operative procedure provided significant functional improvement to the patient.

## METHODS

### Patients

OBPI patients between 2 and 10 years of age who came to our institute for routine office visits between May 2009 and October 2009 were considered to participate in the study. Among the patient group, the first 130 completed surveys, by the parent or guardian of patients who met the criteria below, were included in the study. If a patient had previously triangle tilt surgery, then the patient has to be at least 1 year post-operation to be included. The PODCI is divided into different age groups and is modified for each group. For patients 2-10 years of age, the PODCI was designed to be answered by the parent of the patient. The parents of the patients signed informed consent forms before participating in the study.

The patient population consisted of sixty-two males and sixty-eight females. The study cohort was grouped as either non-triangle tilt patients (patients who have not undergone triangle tilt surgery, group 2: N=67, mean age=5.03 years) or triangle tilt patients (patients who underwent surgery, group 1: N=63, mean age=6.08). The non-triangle tilt group consisted of 49 Erb's palsy and 18 total palsy patients. The triangle tilt group was comprised of 48 Erb's palsy and 15 total palsy patients. The patients were matched for the severity of injuries between groups. In addition, we assessed the pre-op severity in these 2 groups by comparing their total Mallet scores ( $13.2 \pm 2.1$  in TT/ group 1;  $13.8 \pm 1.6$  in non-TT/group 2). Among these non-TT patients, 23 underwent triangle tilt surgery later, and 14 patient's parents completed 1 year follow-up survey questionnaire (Group 3). We collected and compared the PODCI scores before and after surgery in this group of patients. PODCI scores were rated on a scale of 0 to 100, with 100 as the highest level of function/satisfaction.

### Surgical Procedure

The triangle tilt procedure was developed by the surgeon and senior author (RKN) who has seen over 4000 OBPI patients and performed several successful operations. The operative technique involves a clavicle osteotomy at the junction between the middle and distal thirds of the clavicle, an osteotomy of the acromion at its intersection with the

scapular spine, and an osteotomy of the scapula. The surgery is followed by immobilization of the shoulder in a splint for six weeks [9].

### Statistical Analysis

The mean PODCI scores for each of the six parameters were compared between the two patient groups (group 1 and 2) by the Mann-Whitney test using the Analyse it software (Leeds, United Kingdom) for Microsoft Excel 2003. A two-tailed p value of  $p < 0.05$  was considered significant. Paired student's t test was used to compare the PODCI scores before and after triangle tilt surgery in group 3 patients.

## RESULTS

The PODCI scores were collected for patients grouped as either triangle tilt patients (group 1) or non-triangle tilt patients (group 2) at the latest clinic visit. All patients had initially presented with severe deficits in shoulder function. The mean score for upper extremity function was 54.1 in non-triangle tilt patients, compared to a significantly higher ( $p < 0.05$ , Table 1) mean score of 73.2 in patients who underwent triangle tilt surgery. The mean mobility (77.6) and sports/physical scores (70.8) were also significantly higher in patients who have undergone the surgical procedure compared to the mean scores (50.7 and 54.8 respectively) of the non-triangle tilt patients. Although the mean scores for pain/comfort and happiness were higher in triangle tilt patients, they were not significantly different ( $p > 0.05$ ) from the non-triangle tilt cohort. Overall, the global functioning score was significantly higher (70.4,  $p < 0.05$ ) in triangle tilt patients compared to the patient population that have not undergone the surgery (Table 1). Further, we compared the PODCI scores before and after triangle tilt surgery in group 3 patients. PODCI scores were significantly higher after surgery in the parameters of upper extremity function (73.4,  $p < 0.03$ ), basic mobility (94.1,  $p < 0.0002$ ), pain/comfort (94.8,  $p < 0.05$ ), and global functioning (85.9,  $p < 0.03$ ), when compared to before triangle tilt surgery (Table 2).

**Table 1. Comparison of PODCI Scores Between the Triangle Tilt and Non-Triangle Tilt Groups**

PODCI Parameter	Non-TT Mean (SD)	TT Mean (SD)	p-Value
Upper Extremity	54.1 (23.6)	73.2 (21.7)	0.0033
Basic Mobility	50.7 (11.5)	77.6 (5.2)	<0.0001
Sports/Physical	54.8 (14.3)	70.8 (11.3)	0.013
Pain/Comfort	61.3 (19.6)	66.9 (17.7)	0.3592
Happiness	52.2 (20.3)	57.7 (17.4)	0.3514
Global Functioning	52.38 (13)	70.36 (11)	0.0048

## DISCUSSION

The triangle tilt procedure was developed by the surgeon and senior author and was shown to have successful outcomes in OBPI patients as indicated by an increase in

modified Mallet scores as well as an improvement in glenohumeral congruity [9, 16-18]. Total Mallet scores improved from 13.6 in the pre-triangle tilt group to 18.6 in the post-triangle tilt group, proving to be statistically significant ( $p < 0.0001$ ) [9]. The surgical procedure was also shown to have a beneficial effect in OBPI patients who previously underwent failed humeral osteotomies [10]. Although radiological reports and Mallet scores have assisted in determining the outcome of surgery, patient-derived information on the functional abilities of OBPI children in performing daily tasks have not been previously assessed.

**Table 2. Statistical Data Comparing PODCI Scores for OBPI Patients Before and After Triangle Tilt Surgery**

PODCI Parameter	TT (Pre-Op) Mean (SD)	TT (Post-Op) Mean (SD)	p- Value
Upper Extremity	62.0 (18.7)	73.4 (14.8)	<b>0.03</b>
Basic Mobility	88.0 (14.0)	94.1 (10.6)	<b>0.002</b>
Sports/Physical	82.6 (15.9)	83.5 (15.9)	0.41
Pain/Comfort	80.8 (30.4)	94.8 (14.0)	<b>0.05</b>
Happiness	82.3 (27.2)	84.1 (22.1)	0.43
Global Functioning	78.5 (14.5)	85.9 (6.2)	<b>0.03</b>

The PODCI is a well established tool that has been previously administered by several authors to assess function in children with musculoskeletal disorders [4, 11, 14, 15]. The current study was conducted in order to assess the functional status of OBPI patients who underwent the triangle tilt procedure and compare it to the cohort that were candidates for triangle tilt.

Patients who have not undergone triangle tilt surgery were severely disabled as indicated by low mean PODCI scores, ranging in the mid fifties for upper extremity (54.1), basic mobility (50.7) and sports/physical (54.75) functions. In comparison, patients who underwent triangle tilt surgery showed clinically and statistically significant improvements in the aforementioned functions, with mean scores ranging in the seventies for upper extremity (73.19,  $p < 0.05$ ), basic mobility (77.58,  $p < 0.001$ ) and sports/physical (70.77,  $p < 0.05$ ) functions. The mean scores for the parameters of happiness and pain/comfort in triangle tilt patients were five points higher compared to non-triangle tilt patients. This difference, however, was not statistically significant ( $p > 0.05$ ). Global function demonstrated significant differences ( $p < 0.05$ ) between the two groups, with the triangle tilt cohort displaying an 18 point improvement in mean scores.

Although the patients were matched for the level of injury and prior surgical intervention between groups, the patients in the triangle tilt group had a higher mean age (6.04) compared to the non-triangle tilt population (5.03). It has been previously suggested that an increase in the upper extremity function score can occur as an outcome of age-related development that is not related to surgical intervention [14, 19]. It is therefore plausible that there might be some age-related improvements in patients

included in the present study that might be independent of the triangle tilt surgery.

In conclusion, the current study has quantified the functional benefits of triangle tilt surgery using the PODCI scoring system. Significant improvements were observed in all the functional domains in the triangle tilt patient population compared to the cohort that have not undergone the surgery. In addition, shoulder function has improved significantly in the later group of patient population after they have undergone triangle tilt surgery. The results of the PODCI show that the triangle tilt surgery is successful in significantly improving shoulder and arm functions in children affected with OBPI. The triangle tilt surgery brings children affected with OBPI closer to leading a similar life as their peers.

## CONCLUSION

The current study was conducted to evaluate the efficacy of the triangle tilt surgical procedure through the application of the Pediatric Outcomes Data Collection instrument. The results of this investigation showed that the PODCI scores were significantly higher for all functional parameters in patients who underwent the surgery as compared to the group who did not, as well as after triangle tilt surgery when compared to before surgery. The PODCI appears to be a valuable clinical tool in being able to assess the success of surgery from the patients' perspective.

## COMPETING INTERESTS

The authors declare that they have no competing interests.

## AUTHORS' CONTRIBUTIONS

RKN conceived the study, participated in the design of the study, and drafted and revised the manuscript. MBA and CS participated in the design of the study, gathered data, and helped to draft and to revise the manuscript. PK participated in the design of the study and helped to draft and to revise the manuscript.

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