World Journal of Orthopedics

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DOI: 10.5312/wjo.v7.i11.752

World J Orthop 2016 November 18; 7(11): 752-757
ISSN 2218-5836 (online)

ORIGINAL ARTICLE

Retrospective Study

Improvements after mod Quad and triangle tilt revision surgical procedures in obstetric brachial plexus palsy

Rahul K Nath, Chandra Somasundaram

Rahul K Nath, Chandra Somasundaram, Texas Nerve and Paralysis Institute, Houston, TX 77030, United States

Author contributions: Nath RK conceived of the study, performed all the surgeries and revised the manuscript; Somasundaram C participated in the design of the study, performed the statistical analysis and drafted the manuscript; both authors read and approved the final manuscript.

Institutional review board statement: This was a retrospective study of patient charts, which exempted it from the need for IRB approval in the United States. Patients were treated ethically in compliance with the Helsinki declaration. Documented informed consent was obtained for all patients.

Informed consent statement: Written informed consent was obtained from all patients for publication and accompanying images. A copy of the written consent is available for review on request.

Conflict-of-interest statement: The authors report that there are no conflicts of interest.

Data sharing statement: No.

Manuscript source: Invited manuscript

Correspondence to: Dr. Rahul K Nath, Texas Nerve and Paralysis Institute, 6400. Fannin St., Houston, TX 77030, United States. drnath@drnathmedical.com
Telephone: +1-713-5909900
Fax: +1-713-5909921

Received: March 23, 2016
Peer-review started: March 24, 2016
First decision: July 5, 2016
Revised: August 6, 2016
Accepted: September 7, 2016
Article in press: September 8, 2016
Published online: November 18, 2016

Abstract

AIM

To compare outcomes of our revision surgical operations in obstetric brachial plexus palsy (OBPP) patients to results of conventional operative procedures at other institutions.

METHODS

We analyzed our OBPP data and identified 10 female and 10 male children aged 2.0 to 11.8 years (average age 6.5 years), who had prior conventional surgical therapies at other clinics. Of the 20 patients, 18 undergone triangle tilt, 2 had only mod Quad. Among 18 patients, 8 had only triangle tilt and 10 had also mod Quad as revision surgeries with us. We analyzed the anatomical improvements and functional modified Mallet statistically before and after a year post-revision operations.

RESULTS

Pre-revision surgery average modified Mallet score was 12.0 ± 1.5. This functional score was greatly improved to 18 ± 2.3 ($P < 0.0001$) at least one-year after revision surgical procedures. Radiological scores (PHHA and glenoid version) were also improved significantly to 31.9 ± 13.6 ($P < 0.001$), -16.3 ± 11 ($P < 0.0002$), at least one-year after triangle tilt procedure. Their mean pre-triangle tilt (yet after other surgeon's surgeries) PHHA, glenoid version and SHEAR were 14.6 ± 21.7, -31.6 ± 19.3 and 16.1 ± 14.7 respectively.

CONCLUSION

We demonstrate here, mod Quad and triangle tilt as

successful revision surgical procedures in 20 OBPP patients, who had other surgical treatments at other clinics before presenting to us for further treatment.

Key words: Revision surgery; Obstetric brachial plexus palsy; Shoulder movements; Joint incongruity; Upper limb

Core tip: We compared functional and anatomical improvements from our revision surgical treatment experiences to outcomes of other surgical treatments at other institutions in 20 obstetric brachial plexus palsy (OBPP) children. Pre-revision surgery mean modified Mallet scores and shoulder anatomical measurements were improved statistically highly significantly at least one-year after revision surgeries. We demonstrate here, mod Quad and triangle tilt as successful revision surgical procedures in 20 OBPP patients, who had other surgical treatments at other clinics before presenting to us for further treatment.

Nath RK, Somasundaram C. Improvements after mod Quad and triangle tilt revision surgical procedures in obstetric brachial plexus palsy. *World J Orthop* 2016; 7(11): 752-757 Available from: URL: http://www.wjgnet.com/2218-5836/full/v7/i11/752.htm DOI: http://dx.doi.org/10.5312/wjo.v7.i11.752

INTRODUCTION

Poor recovery of neurological function in obstetric brachial plexus palsy (OBPP) results in muscle weakness and imbalances around the shoulder[1-3]. Progressive muscle imbalance causes bony deformities at the shoulder joint, affecting it's movements and functions[4,5]. Many traditional surgical interventions have been reported to improve the upper extremity functions in OBPP patients[6-11].

Muscle release and tendon transfer procedures have been shown[12-19] to reduce the muscle contractures and improve shoulder movements. Humeral rotational osteotomy corrects the arm at resting position, but does not address the glenohumeral and *Scapular Hypoplasia, Elevation and Rotation* (SHEAR) deformities. These surgical treatments do not address these two osseous deformities.

We have published extensively the effectiveness of triangle tilt surgery in correcting glenohumeral joint incongruity and thereby improving upper extremity functions in OBPP patients[20-28]. Here, we show both functional and anatomical improvements significantly after triangle tilt and or mod Quad as revision surgeries in 20 OBPP patients, who had other surgical treatments at outside clinics before visiting our clinic for further treatment.

MATERIALS AND METHODS

We analyzed our OBPP data and identified 10 female and 10 male patients, aged 2.0 to 11.8 years (average age 6.5 years), who had operative procedures at other clinics.

Of the 20 OBPP patients in our present study group, 8 patients undergone only the bony procedure, triangle tilt and 10 had both triangle tilt and mod Quad (Tables 1 and 2). Therefore, these 18 patients (Table 2) have anatomical and radiological scores (PHHA, SHEAR and glenoid version), in addition to functional modified Mallet scale (Table 1). Two patients, number 19 and 20 in Table 1, underwent only mod Quad procedure, as they did not have shoulder subluxation. Therefore, these two patients did not need to undergo triangle tilt procedure, which addresses shoulder subluxation. Modified Mallet and radiological scores were measured, statistically analyzed to compare. All measurements were done at least one-year after surgical treatments.

The nerve involvement was C5-6 (n = 5), C5-7 (n = 8), and total (n = 7). Traditional operative procedures that these OBPP children had in the past at other clinics are nerve transfer/graft, neurolysis, brachial plexus exploration, botox, muscle/tendon transfer and release, humeral osteotomy and anterior capsule release. Outcomes of our revision procedures in OBPP patients were compared to the results of other traditional surgical treatments at other clinics. Further, these patients' radiological scores were measured from computed tomography and magnetic resonance images and statistically compared.

Patient examination

We examined physically all OBPP children and their video recordings pre- and post-operatively, scoring their modified Mallet parameters on a scale between one and five. One and five denote lack of movement and normal function respectively.

Anatomical measurements of shoulder

We measured PHHA, glenoid version[29] and Scapular hypoplasia, elevation and rotation[30] using computed tomography and magnetic resonance imaging pre- and post-TT operative procedure.

Operative technique

Triangle tilt[20-28] and mod Quad procedures[14,31,32] have been demonstrated successful outcomes in OBPP.

We used the student's t test and compared pre- and post-operative results in this group of OBPP. $P < 0.05$ was considered statistically significant.

RESULTS

Pre-revision surgery mean modified Mallet score was 12.0 ± 1.5 (Table 1 and Figure 1 upper panels). This functional score was greatly improved to 18 ± 2.3 ($P <$

Table 1 Comparing functional improvements of other surgeon's surgeries to mod Quad and/or triangle tilt in obstetric brachial plexus palsy

Patients	Other surgeons' surgery	Gender	Age (yr)	Nerve involved	TT/MQ	Total Mallet pre-revision surgery	Total Mallet post-revision surgery
1	Botox	F	2.5	C5-C7	TT	13	23
2	Partial MQ, subscap release lat dorsi rerouting	M	6.4	C5-C7	TT	11	16
3	Neurolysis/nerve graft	F	4.2	Total	TT and MQ	13	18
4	Humeral osteotomy	F	11.1	C5-C7	TT and MQ	11	15
5	Neuroma excision, nervegraft	M	11.8	Total	TT	11	14
6	Nerve graft, HO, botox	F	7.1	Total	TT	11	17
7	Coracoacromial release/coracoid resection	M	5.5	C5-C7	TT	14	21
8	Botox	M	11.3	C5-C7	TT and MQ	10	15
9	Sural nerve graft	F	5.0	Total	TT	10	17
10	Botox	M	3.5	C5-C6	TT and MQ	12	20
11	Botox	M	4.3	Total	TT and MQ	12	18
12	Neurolysis	F	2.0	C5-C6	TT and MQ	11	17
13	Capsule release	F	8.5	Total	TT and MQ	13	19
14	Tendon transfer, neurolysis	M	4.3	C5-C8	TT and MQ	14	20
15	Neurolysis and botox	F	5.0	C5-C6	TT	13	20
16	Muscle transfer	M	7.9	C5-C7	TT	14	21
17	BP exploration	M	2.0	C5-C6	TT and MQ	15	20
18	Steindler flexorplasty	F	10.0	C5-C7	TT and MQ	13	18
19	Humeral osteotomy	M	14.0	C5-C6	MQ	12	18
20	Tendon transfer	F	3.0	C5-C7	MQ	14	20
	Mean ± STD		6.5			12 ± 1.5	18 ± 2.3
	P value					< 0.0001	

MQ: Mod Quad; HO: Humeral osteotomy.

Table 2 Comparing anatomical improvements of triangle tilt to other surgeon surgeries in obstetric brachial plexus palsy

Patients	Other surgeons and previous surgeries	PreTT-PHHA	PostTT-PHHA	PreTT-Version	PostTT-Version	PreTT-SHEAR	PostTT-SHEAR
1	Subscap release and lat dorsi rerouting	8	33	-47	-14		
2	Neurolysis, MQ, HO	16	14	-41	-35	24	10
3	MQ	-12	19	-65	-33	40	39
4	Nerve graft, FO, BTL, MQ	32	37	-21	-10	3	1
5	Botox, MQ	33	45	-18	-15	15	3
6	Nerve graft	47	48	-10	-1	5	14
7	Neurolysis, nerve graft	-7	22	-62	-12	8	22
8	Neuroma excision, nerve graft	34	35	-20	-11	0	0
9	Nerve transfer	33	29	-16	-21	15	12
10	Coracoacromial release/resection	-12	17	-51	-35	30	15
11	Neurolysis, nerve graft	13	4	-20	-15	7	4
12	Wrist Caps, HO	39	50	0	0	9	0
13	Sural nerve graft	38	51	-10	-4	0	1
14	Botox, MQ	-8	44	-38	-22	11	2
15	Neurolysis, MQ	-14	35	-33	-10	25	30
16	Muscle release	0	19	-45	-27	32	8
17	Anterior capsule release	-11	34	-53	-22	48	41
18	Tendon transfer and neurolysis	33	39	-18	-7	1	1
Mean		14.6 ±	31.9 ±	-31.6 ±	-16.3 ±	16.1 ±	11.9 ±
STD		21.7	13.6	19.3	11.0	14.7	13.5
P value			0.001		0.0002		0.087

Normal values are PHHA 50, glenoid version and SHEAR 0. TT: Triangle Tilt; MQ: Mod Quad; HO: Humeral Osteotomy; FO: Forearm Osteotomy; BTL: Biceps Tendon Lengthening; PHHA: Percentage of the Humeral Head Anterior.

0.0001) at least one-year after our revision surgeries (Table 1, Figure 1 lower panels). Furthermore, their shoulder anatomical scores were improved significantly to 31.9 ± 13.6 ($P < 0.001$) and -16.3 ± 11 ($P < 0.0002$) at least one-year after triangle tilt operation (Table 2 and Figure 2, lower panels). This was in comparison to their radiological outcomes of other procedures before having triangle tilt with us (mean PHHA, glenoid version and SHEAR were 14.6 ± 21.7, -31.6 ± 19.3 and 16.1 ± 14.7 respectively; Table 2 and Figure 2 upper panels).

DISCUSSION

Twenty OBPP children in our present study had one or

Figure 1 Modified Mallet functions performed by an obstetric brachial plexus palsy child, who had surgeries at other clinics before presenting to us (upper panels) and the same child, at least one-year after having mod Quad and triangle tilt as revision surgeries at our clinic (lower panels).

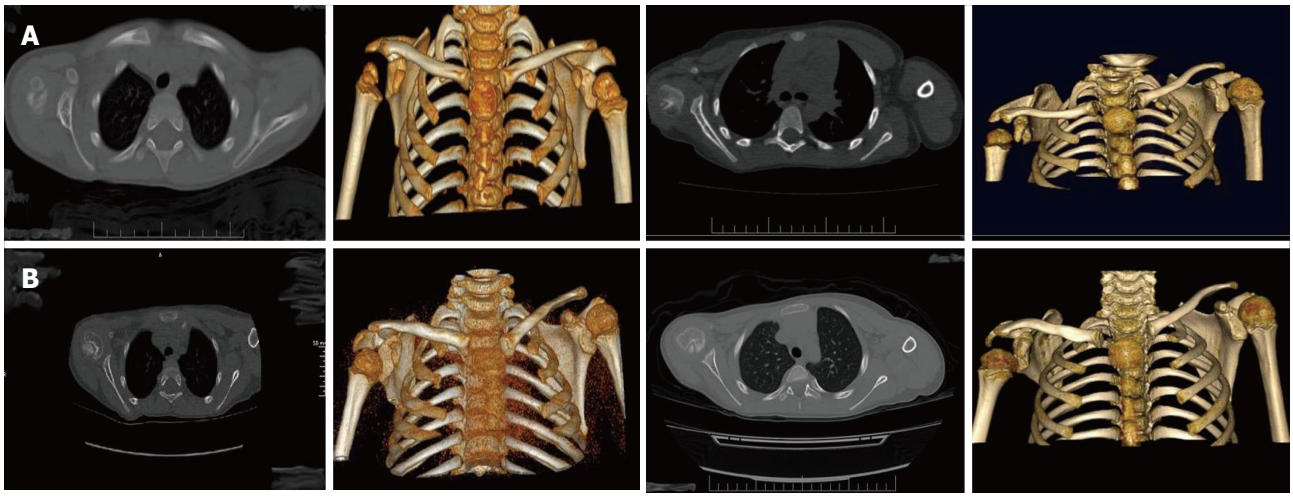

Figure 2 Comparison of computed tomography images of obstetric brachial plexus palsy children, who had surgeries at other clinics before presenting to us (A) and the computed tomography images of the same children at least one-year after having triangle tilt as revision surgery at our clinic (B).

multiple operative procedures at other clinics before visiting our institute for further treatments (Table 1). One patient in our study group had Steindler flexoroplasty, which improves active flexion of the elbow. These conventional treatments fail to address the SHEAR deformity[30] associated with majority of OBPP patients. Therefore, these OBPP patients in our study had persistent shoulder contractures and joint incongruency. Hence, they also had poor upper extremity functions. (Tables 1 and 2; upper panels in Figures 1 and 2).

Mod Quad procedure addresses poor shoulder abduction in permanent OBPP. However, this procedure is ineffective to correct the glenohumeral joint and SHEAR deformities. Eighteen OBPP children, who had shoulder joint incongruency and SHEAR undergone TT bony operation with us. We demonstrated that this procedure effectively addressed the bony deformities of the affected upper extremity and improved it's anatomy and functions[20-28]. After undergone these two revision surgical procedures with us, these twenty patients had better results both functionally and anatomically. This is highly significant in comparison to the outcomes of

other surgical treatments at other clinics.

There was statistically significant improvement anatomically, after having triangle tilt compared to the radiological outcomes of other operative procedures.

In conclusion, we demonstrate here that mod Quad and triangle tilt as successful revision surgical procedures in 20 OBPP patients, who had conventional surgical therapies at other clinics before presenting to us for further treatment.

COMMENTS

Background

Many traditional surgical interventions such as posterior glenohumeral capsulorrhaphy, biceps tendon lengthening, humeral osteotomy, anterior capsule release, nerve transfer/graft, botox, muscle and or tendon transfer and release have been reported to improve upper limb functions in obstetric brachial plexus palsy (OBPP) patients.

Research frontiers

The authors compared functional and anatomical improvements from the revision surgical treatment experiences to results of other traditional surgeries at other clinics in 20 children with OBPP.

Innovations and breakthroughs

Pre-revision surgery mean mod Mallet scores and radiological scores such as posterior subluxation and glenoid version were improved statistically highly significantly at least one-year after mod Quad and or triangle tilt revision surgeries.

Applications

The authors demonstrate here, the triangle tilt and mod Quad as successful revision surgeries in OBPP patients, who had other surgical treatments at other clinics.

Terminology

SHEAR: Scapular Hypoplasia, Elevation and Rotation; Triangle tilt surgery: This surgical procedure includes osteotomies of the clavicle, neck of the acromion and scapula in order to release the distal acromioclavicular triangle and allow it to reorient itself in a more neutral position into the glenoid.

Peer-review

This is an informative paper, generally well-written and of interest to readers.

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P- Reviewer: Anand A, Franklyn M **S- Editor**: Ji FF **L- Editor**: A
E- Editor: Lu YJ