

Old title:

Significant improvements after modified Quad and triangle tilt as revision surgeries in obstetric brachial plexus injury patients, who had other traditional surgical procedures at other institutions

Nath RK and Somasundaram C.

New title:

Outcomes of modified Quad and triangle tilt as revision surgeries in obstetric brachial plexus injury patients.

Our response highlighted in red.

This is an informative paper, generally well-written and of interest to readers of the WJO. I suggest a few minor revisions, as specified below:

We thank the reviewer for his/her corrections and suggestions to our manuscript.

1. Abstract, Methods: Please re-word the sentence commencing with ‘Of the 20 patients...’ to fix the grammar- **corrected it.**
2. Background, Paragraph 2: Please write the definition of the acronym SHEAR in full – **Scapular Hypoplasia, Elevation and Rotation- added it to our revised manuscript.**
3. Background, Paragraph 3: Can the authors please be a bit more explicit in this paragraph on how their study differs to previously-published work in this area. From what they have stated, this study is different as the patients have had previous treatment elsewhere. Please clarify and re-word. **re-written**
4. Patients and Methods, Paragraph 1: ‘Table 1 and 2’ should be ‘Tables 1 and 2.’ Please change ‘2’ to ‘Two’ at the start of the sentence. **corrected it.**
5. Patients and Methods, Clinical Assessment: Could the authors please provide a short explanation of what the modified Mallet clinical assessment is, perhaps with some accompanying references? This will make the paper more understandable to the wider orthopaedic audience. **added 2 more referenes**
6. Patients and Methods, Statistical Analysis: This should be ‘A student’s t-test...’ (not ‘The’). **corrected it.**
7. Discussion: What is MRC? **medial rotation contracture – added it to our revised manuscript.**

Abstract:

Purpose:

To compare results from our revision surgical treatment experiences in children with obstetric brachial plexus injury (OBPI) to outcomes of other traditional surgical treatments at other institutions.

Methods:

We conducted a retrospective study in our medical records consisting of OBPI patients, who came to our clinic with a history of prior operative procedures at other hospitals. We identified 20 OBPI children (10 girls and 10 boys), aged between 2.0 and 11.8 years (mean age 6.5 years), who had other traditional surgical treatments at other institutions.

Of the 20 patients, 18 undergone bony surgical procedure, the triangle tilt, 2 had only modified Quad. Among 18 patients, 8 had only triangle tilt and 10 had also moadQuad as revision surgeries with us. Mean modified Mallet and radiological scores were measured and compared. All measurements were done at least one-year post surgery.

Results:

Pre- revision surgery mean 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 modified Quad and or triangle tilt revision surgeries. Further, their radiological scores such as posterior subluxation and glenoid version were improved significantly to 31.9 ± 13.6 ($P < 0.001$), -16.3 ± 11 ($P < 0.0002$) respectively, at least one-year after triangle tilt surgery. 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, the triangle tilt and modified Quad as successful revision surgeries in 20 OBPI patients, who had other conventional surgical treatments at other clinics before presenting to us for further treatment.

Background:

Inadequate recovery of neurological function in obstetric brachial plexus injuries (OBPI) results in muscle weakness and imbalances around the shoulder [1-4]. Long-standing muscular imbalance leads to progressive glenohumeral dysplasia and joint incongruity [5-7]. 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 limb functions in this group of patients [8-13].

We and other investigators have demonstrated that soft tissue procedures such as muscle release and tendon transfers [14-21] lead to better shoulder abduction and flexion through releasing the existing contractures. Derotational osteotomy of the humerus [13–16] improves the resting position of the arm, but neglects the glenohumeral and SHEAR (Scapular Hypoplasia, Elevation and Rotation) deformities. Surgical treatments such as humeral osteotomy are likely to fail or have significant rates of recurrence, as they 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 OBPI patients, who had treatments primarily with us [22-31]. Here, we show both functional and anatomical improvements significantly after triangle tilt and or mod

Quad as revision surgeries in 20 OBPI patients, who had other traditional surgical treatments at outside clinics before visiting our clinic for further treatment.

Patients and Methods:

We conducted a retrospective study in our medical records consisting of OBPI patients, who came to our clinic with a history of prior operative procedures at other hospitals. We identified 20 OBPI children (10 girls and 10 boys), aged between 2.0 and 11.8 years (mean age 6.5 years), who had other traditional surgical treatments at other institutions and had modified Quad and or triangle tilt as revision surgeries with us. Of 20 OBPI patients in our present study group, 8 patients undergone only the bony procedure, triangle tilt and 10 had both triangle tilt and modQuad (Tables 1 and 2). Therefore, these 18 patients (Table 2) have anatomical and radiological scores (PHHA, SHEAR and glenoid version), in addition to functional modifies Mallet scale (Table 1). Two patients, number 19 and 20 in Table 1, underwent only modQuad surgery, as they did not have shoulder subluxation. Therefore, these 2 patients did not need to undergo triangle tilt surgery, which addresses shoulder subluxation. Mean modified Mallet and radiological scores were measured and compared. All measurements were done at least one-year post surgery.

The nerve involvement was C5-6 (n= 5), C5-7 (n= 8), and total (n = 7). Prior surgical procedures that the patients had at other clinics are included nerve transfer/graft, neurolysis, brachial plexus exploration, botox, muscle/tendon transfer and release, humeral osteotomy and anterior capsule release. We compared statistically the results obtained from other procedures performed in other institutes to outcomes of our procedures at least with a follow up of one-year. In addition, their radiological scores

such as posterior subluxation, and glenoid version were measured from CT scans and MRI in both groups and compared.

Clinical assessment

Patients were evaluated with a physical exam and through the modified Mallet clinical assessment[32, 33] with video recordings of patients performing external rotation, hands to mouth, hands to neck, hands to spine, and supination pre- and post-operatively. For each functional Mallet parameter, patients were scored on a scale of 1–5 with 5 as normal function and 1 denoting lack of any movement.

Radiological evaluation

CT or MRI images were used to measure the posterior humeral head subluxation , glenoid version [34][32], and SHEAR deformity [35][33], which evaluate the bony deformities of the patients' shoulder joint before and after triangle tilt surgery.

Operative technique

Triangle tilt [22-31] and modified Quad procedures [16] [36, 37][34, 35] have been shown to have successful outcomes in OBPI patients.

Statistical analysis

The ~~A~~ Student's t test statistic was applied to compare the mean Mallet scores and bony parameters between the both groups using the 'Analyse it' plugin (Leeds, UK) for Microsoft Excel 2003. A value of $p < 0.05$ was considered to be statistically significant.

Results:

Pre- revision surgery mean modified Mallet score was 12.0 ± 1.5 (Table 1, Figure 1 upper panels). This functional score was greatly improved to 18 ± 2.3 ($P < 0.0001$) at least one-year after modified Quad and or triangle tilt revision surgeries (Table 1, Figure

1 lower panels). Further, their radiological scores such as PHHA and glenoid version were improved significantly to 31.9 ± 13.6 ($P < 0.001$) and -16.3 ± 11 ($P < 0.0002$) respectively at least one-year after triangle tilt surgery (Table 2 and Figures 2 a and b, lower panels), when compared 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, Figures 2 a and b, upper panels). Normal values are PHHA 50, glenoid version and SHEAR 0.

Discussion:

All 20 patients in our present study had poor shoulder abduction and flexion because of C5 injury. They all had one or multiple surgical treatments with other surgeons before visiting our clinic (Table 1). These conventional treatments fail to address the SHEAR deformity [35][33] associated with most OBPI. For example, the recurrence of medial rotation contracture (MRC) after humeral osteotomy is common because of the SHEAR and the impingement of the distal acromioclavicular triangle against the humeral head. Without addressing the joint incongruity and SHEAR deformity, procedures such as humeral osteotomy are likely to fail or have significant rates of recurrence. Open reduction or arthroscopic anterior capsulectomy alone or with tendon transfers may improve passive external rotation and active range of motion, but results in external rotation deformity with significant internal rotation contracture [8, 18–20]. Another example, Steindler flexoroplasty, which is used to improve active flexion of the elbow. One patient in our study group had Steindler flexoroplasty at other clinic before presenting to us. This treatment obviously did not improve overall upper extremity functions. Therefore, these patients had poor functions after having such traditional

treatments at other clinics (Table 1, Figure 1 upper panels), (Table 2, Figure 2 a and b, upper panels).

Modified Quad procedure addresses poor shoulder abduction and flexion due to C5 injury in all permanent OBPI patients, but does not realign the deformed glenohumeral joint (GHJ) and does not correct SHEAR deformity. Therefore, triangle tilt surgery was performed on these patients. This procedure has been shown to effectively address these bony deformities, and improves the anatomy and overall functions of the shoulder [22-31, 38]. The functional benefits of mod Quad [16], and triangle tilt surgeries have been extensively discussed in our previous publications [22-31,38]. After undergone these surgical procedures with us, these patients had better results both functionally and anatomically, which is statistically significant, when compared to the outcomes of other traditional surgical treatments at outside clinics.

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

Conclusion:

We demonstrate here, the triangle tilt and modified Quad as successful revision surgeries in 20 OBPI patients, who had other conventional surgical treatments at other clinics. before presenting to us for further treatment.

Conflicts of interest:

The authors report that there are no conflicts of interest.

Funding:

None.

Ethical approval 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.

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MQ- modified Quad, HO- Humeral osteotomy.

Table 2: Comparing anatomical improvements of triangle tilt to other surgeon surgeries in OBPI.

Patients	Other surgeons & previous Surgeries	PreTT- PHHA	PostTT PHHA	PreTT- Version	PostTT- Version	PreTT- SHEAR	PostTT- SHEAR
1	Subscap release& 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 & 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- modified Quad, HO- Humeral Osteotomy, FO- Forearm Osteotomy, BTL- Biceps Tendon Lengthening, PHHA- Percentage of the Humeral Head Anterior.

Figure legends:

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

Figure 2a and b: Comparison of CT images of OBPI children, who had surgeries at other clinics before presenting to us (upper panels) and the CT images of the same children at least one-year after having triangle tilt as revision surgery at our clinic (lower panels).



Figure 1.

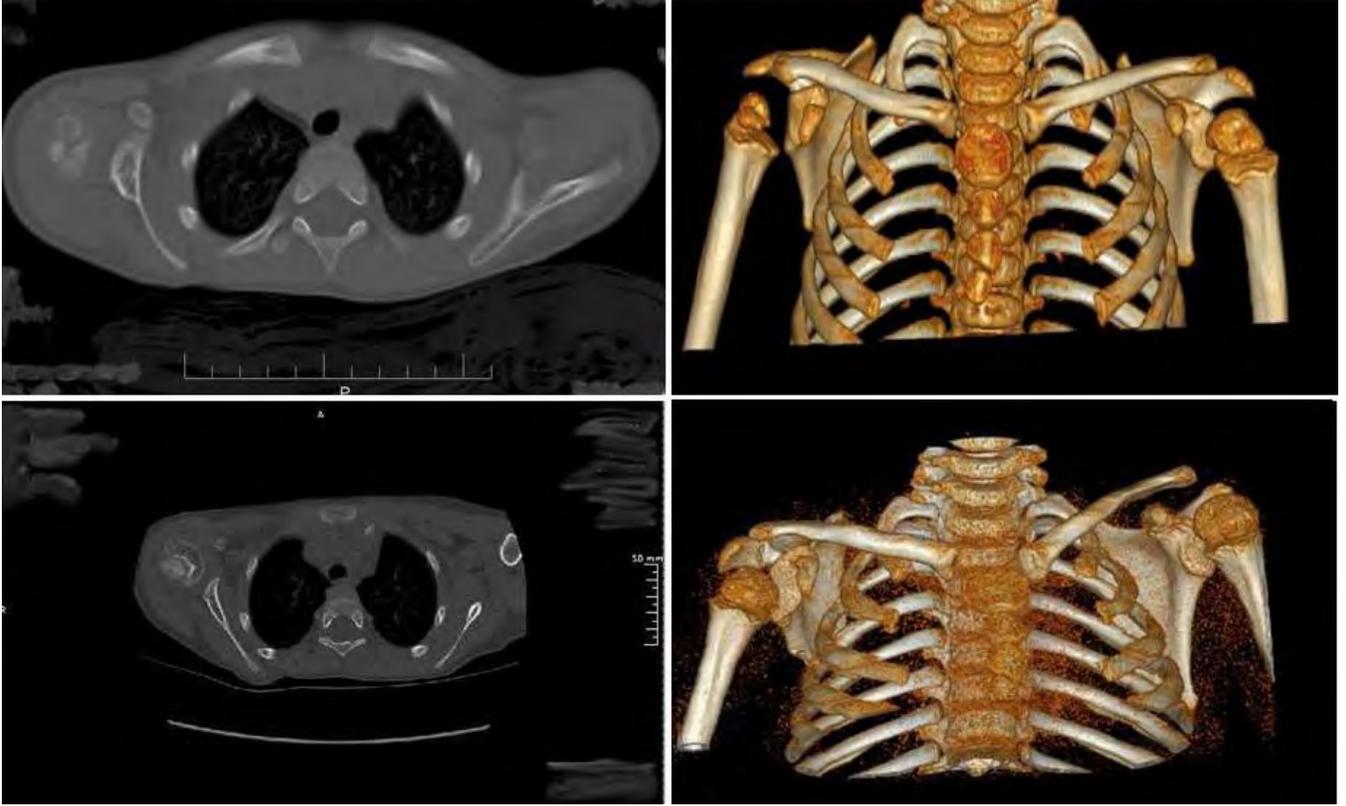


Figure 2a.

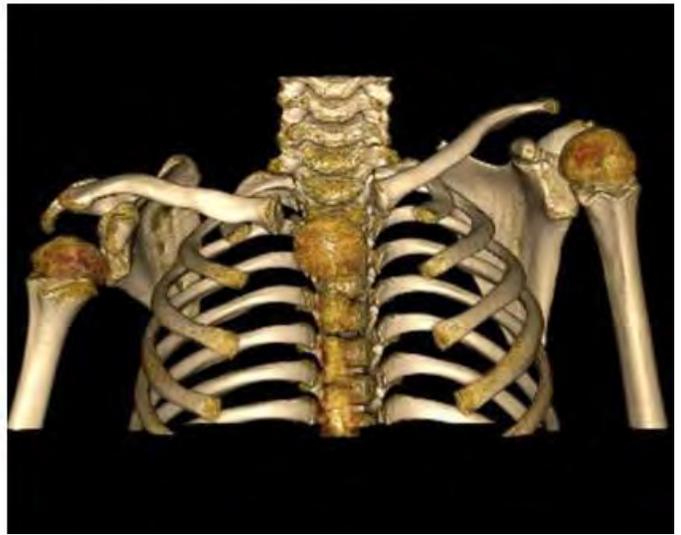
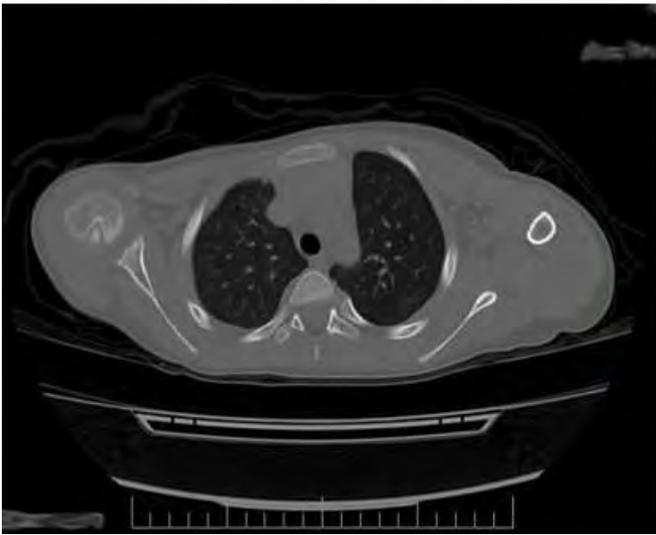
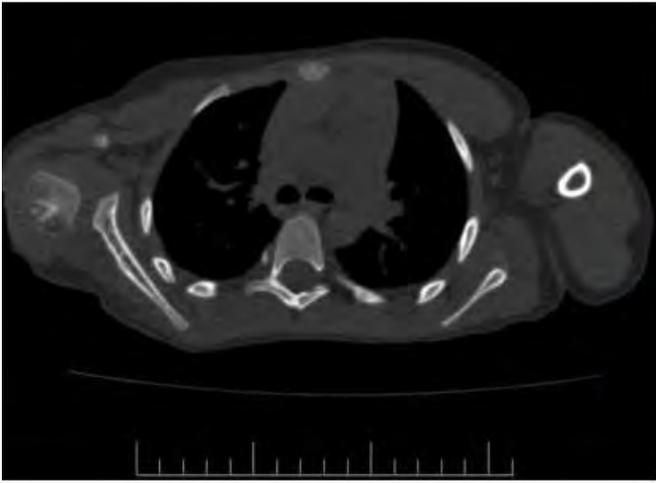


Figure 2b.