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ONLINE ARTICLES

Accelerated rehabilitation following reverse total shoulder arthroplasty

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Background: Postoperative rehabilitation is considered essential and indeed routine practice following rTSA. However, the optimal approach to postoperative rehabilitation is unknown, based on protocols for anatomic TSA, and published literature is sparse, as is the quantity and quality of research evidence.

The aim of this study is to outline the accelerated rehabilitation protocol (with immediate activity and no immobilization at all) following reverse total shoulder arthroplasty (rTSA) and assess its safety and effectiveness compared to the more conservative rehabilitation protocols of immobilization in a sling for 6 weeks and for 3 weeks.

Materials and methods: Between July 2005 and October 2017, a total of 357 consecutive rTSA in 320 patients underwent a primary rTSA and were included in the study. Patients were divided into 3 groups depending on rehabilitation protocol (6 and 3 weeks' postoperative immobilization, respectively, for groups 1 and 2, and no immobilization for group 3). Patients were assessed preoperatively and reviewed at 3 weeks, 3, 6, and 12 months, and yearly thereafter postoperatively. Constant score (CS), Subjective Shoulder Value (SSV), patient satisfaction, and pain scores were used at each appointment and patients assessed both clinically and radiographically.

Results: Mean age at surgery was 76 years (range 40-93). At 1-year follow-up, the CS improved from 16.6 (adjusted 23.9) to 63.2 (adjusted 91.5) in group 1 (n = 114), from 21.5 (adjusted 30.7) to 67.7 (adjusted 98.4) in group 2 (n = 125), and from 22.6 (adjusted 31.3) to 66.6 (adjusted 94.9) in group 3 (n = 118). Pain score improved from 3.1/15 preoperatively to 12.5/15 postoperatively in group 1, from 3.5/15 to 13/15 in group 2, and from 3.7/15 to 12.5/15 in group 3. SSV improved to 8.5/10, 8.6/10, and 8.1/10 for groups 1, 2, and 3, respectively. Mean range of motion (ROM) improved to 142° elevation and 131° abduction in group 1, 153° elevation and 144° abduction in group 2, and 149° elevation and 146° abduction in group 3. No statistically significance differences were observed in CS, SSV, patient satisfaction, pain, and ROM between the 3 groups. Less postoperative complications were observed in group 3 (No immobilization).

Conclusion: Accelerated rehabilitation regime post rTSA without immobilization is safe and lead to reliable good clinical results and quick return to function. This study confirms noninferiority of the accelerated rehabilitation regime with fewer postoperative

This study was approved by the Institution Review and Audit Board and the Clinical Quality Assurance office at the Royal Berkshire Hospital NHS Foundation Trust (approval no. N3114).

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complications related to falls. Accelerated rehabilitation regime post rTSA have further psychological and emotional advantage to the patient, with earlier return to normal function and regaining independence. We recommend the accelerated rehabilitation regime without immobilization following rTSA.

Level of evidence: Level III; Retrospective Cohort Comparison; Treatment Study

Keywords: Rotator cuff; arthropathy; pain; physiotherapy; reverse shoulder

The use of reverse total shoulder arthroplasty (rTSA) has substantially increased in recent years worldwide. Joint registry–based studies in Australia, the United States, the United Kingdom, and Europe reported increasing incidence.[3,21,29] In the United Kingdom, the use of rTSA has increased from 823 rTSA, in 2012,[29] to 4206 rTSA surgeries performed in 2018. There are some suggestions of a 7-fold increase over the next 15 years.[10] This increase in incidence is largely due to the good clinical outcomes, including reduced pain, increased function, and high patient satisfaction[12,13,15,16,30,32] and the expanding surgical indications around pathology, such as cuff tear arthropathy (CTA), massive rotator cuff tears, osteoarthritis, rheumatoid arthritis, and fracture sequela made possible by rTSA.[19,28,34]

In shoulder arthroplasty, postoperative physical therapy is considered essential, and indeed routine practice following rTSA. Restoration of shoulder strength has shown to be a determinant of functional outcomes, shoulder range of motion (ROM) and satisfaction following rTSA.[1,2] This is considered essential for optimizing patient outcomes and best achieved via graduated and progressive physical therapy, consisting of range of motion and strengthening-based exercises.[11]

Despite this apparent importance, the optimal approach to postoperative physical therapy is unknown, published literature is sparse, as is the quantity and quality of research evidence.

Very few articles outlining a structured and validated rehabilitation protocol exist.[4,7] Current postoperative management in shoulder arthroplasty is based on biomechanical considerations and clinical consensus; typically, it involves either a period of prolonged immobilization or restrictions on ROM, alongside a series of precautions[7,8,31] due to perceived potential complications. Differences are expected between total shoulder arthroplasty postoperative rehabilitation protocols, based on recovery of the rotator cuff function[5,8,14,41] and rTSA rehabilitation, which has to be focused, instead, on the conditioning of the deltoid muscle.[4,7]

Our rehabilitation protocol has evolved over the years through evaluation of scientific evidence alongside our own observations and adaptations. The initial rehabilitation protocol was cautious and conservative in line with the evidence at the time, advocating a 6-week immobilization period[7] because of concerns regarding postoperative complications documented in the literature, especially dislocations.[6,18,36-40,43]

As early results demonstrated encouraging short- to midterm outcome with low complication rates,[24,33] the immobilization period was carefully reduced, initially to 3 weeks and later on to none at all (immobilization in a sling only for 24-48 hours until the interscalene block wears off). Thus, the accelerated rehabilitation protocol was introduced (Table I).

Therefore, the aim of this study was to outline the accelerated rehabilitation protocol (with immediate activity and *no immobilization at all*) and assess its safety and effectiveness compared to the more conservative rehabilitation protocols of immobilization in a sling for 3 weeks and 6 weeks.

Materials and methods

Between July 2005 and October 2017, a total of 357 consecutive rTSA in 320 patients were included in the study. All patients underwent rTSA in a specialized shoulder center by a single surgeon or under his direct supervision. In order to reduce any bias, only elective primary rTSAs were included in the study. rTSAs performed for acute proximal humeral fracture and revision rTSAs were excluded. There were 103 men and 237 women, with a mean age of 76 years at surgery. There were 151 left shoulders, 178 right, and 37 bilateral shoulders.

All the patients were assessed preoperatively and postoperatively at 3 weeks, 3 months, 6 months, 1 year, and annually thereafter clinically and radiographically. All the data were collected prospectively on a computerized database (Table II).

The patients were allocated to 3 groups according to the rehabilitation protocol they followed (6 weeks and 3 weeks of immobilization or immediate mobilization). The patients were allocated to the rehabilitation protocol chronologically, to the protocol that was employed by the senior author at the time of their surgery. The rehabilitation protocol evolved by the senior author as he observed minimal complications following the rTSAs (much less than was expected from the knowledge and literature at the time). As his confidence grew as a result of these observations, the immobilization period post rTSA was shortened. These happened in 2 time points: reduction of the immobilization period from 6-3 weeks in 2013, and change from immobilization for 3 weeks to no immobilization at all in 2015.

The principles of the rehabilitation protocol were not changed, only the immobilization time and timing of introduction of the different exercises.

The rehabilitation protocol groups were as follows:

Table I Physiotherapy protocols for rTSA

Group 1: 6-week immobilization	Group 2: 3-week immobilization	Group 3: Accelerated rehabilitation protocol—no immobilization
First 3 weeks	First 3 weeks	Immediately postoperation
The patient's arm is placed in a master sling with a body belt for 3 weeks.	The patient's arm is placed in a master sling with a body belt for 24-48 h (until the interscalene block wears off).	The patient's arm is placed in a master sling with a body belt for 24-48 h (until the interscalene block wears off).
Commence with shoulder girdle exercises and postural awareness, fingers, wrist and radio-ulnar mobilization exercises, as well as active elbow flexion and extension.	When the Interscalene block wears off—Discard the body belt and the arm is kept in a simple sling for 3 weeks.	When the Interscalene block wears off—Discard the sling
Gentle pendulum exercises. Commence gentle passive assisted shoulder exercises in elevation and external rotation, stretching exercises.	Commence with pendulum exercises and passive assisted shoulder exercises in elevation and external rotation, stretching exercises. Commence with passive internal rotation in abduction in the scapular plane. Start active assisted to active shoulder exercises.	Commence with pendulum exercises and passive assisted shoulder exercises in elevation and external rotation, stretching exercises. Commence with passive internal rotation in abduction in the scapular plane. Start active assisted to active shoulder exercises.
		Progress to active assisted to active shoulder exercises.
		Commence the Deltoid Rehabilitation regime—and progress
		In the final stages of the rehabilitation in all the 3 groups, supplementary strengthening including isometric exercises, scapular strength and control exercises, and proprioceptive rehabilitation is performed.
		Return to full ADL—as soon as possible
3-6 weeks	At 3 weeks	
Discard the body belt of the sling	Discard the sling	
Continue passive assisted shoulder exercises	Continue passive assisted shoulder exercises in elevation and external rotation, stretching exercises. Progress to active assisted to active shoulder exercises.	
Start passive internal rotation in a protected position of at least 60° of abduction in the scapular plane to ensure avoidance of IR with adduction and extension.	Commence the Deltoid Rehabilitation regime—and progress	
Start active assisted to active shoulder exercises.	In the final stages of the rehabilitation in all the 3 groups, supplementary strengthening including isometric exercises, scapular strength and control exercises, and proprioceptive rehabilitation is performed.	
	Return to full ADL	

(*continued on next page*)

Table I Physiotherapy protocols for rTSA (*continued*)

Group 1: 6-week immobilization	Group 2: 3-week immobilization	Group 3: Accelerated rehabilitation protocol—no immobilization
At 6 weeks Commence the Deltoid Rehabilitation regime In the final stages of the rehabilitation in all the 3 groups, supplementary strengthening including isometric exercises, scapular strength and control exercises, and proprioceptive rehabilitation is performed. Return to full ADL Comment Throughout the first 6 weeks, the patient is NOT allowed to perform forceful movement with the hand behind his or her back and not to weightbear through the arm (Patients are instructed not to "push themselves out of a chair") for 6 weeks postoperation.	Comment Throughout the first 6 weeks, the patient is NOT allowed to perform forceful movement with the behind his or her back and not to weightbear through the arm (Patients are instructed not to "push themselves out of chair") for 6 weeks postoperation.	Comment Throughout the first 6 weeks, the patient is NOT allowed to perform forceful movement with the behind his or her back and not to weightbear through the arm (Patients are instructed not to "push themselves out of chair") for 6 weeks postoperation.

ADL, activities of daily living.

Patients operated between 2005 and 2013 (114 shoulders [left 40, right 74, bilateral 6]) were allocated to group 1—with 6 weeks' immobilization.

Patients operated between 2013 and 2015 (125 shoulders [left 48, right 77, bilateral 5]) were allocated to group 2—with 3 weeks' immobilization.

Patients operated between 2015 and 2017 (118 shoulders [left 63, right 55, bilateral 6]) were allocated to group 3—no immobilization at all.

The patients' demographics and etiologies as indications for surgery in the different groups are detailed in Table II. All consecutive primary rTSAs were included in the study for all etiologies. Exclusion criteria included all the rTSAs for acute fractures and those as revision surgery (Table III).

The same implant was used in all the cases, a stemless metaphyseal rTSA prosthesis (Verso, Innovative Design Orthopaedics, London, UK). The anterosuperior Neviaser-MacKenzie approach was used in all the cases as previously described.[22,24,26,27] During closure in all cases, attempted retensioning and repair of any remnants of the anterior and posterior rotator cuff were performed and secured with transosseous stitches to the metaphysis. The Deltoid muscle was reattached to the acromion using a double row equivalent intraosseous technique with Ethibond 5 nonabsorbable sutures.

There may be several potential confounding factors between the groups. As the development of the different rehabilitation groups was over time, arguably, advancements in surgical technique and patient selection could influence the outcome. However, the surgical technique did not change at all over this time. Indeed, the patient selection may have changed a bit for selection of a larger range of pathologies. The composition of the primary diagnosis of the patients in the different groups differ slightly.

Rehabilitation

Prescreening

Prior to listing for surgery patients were screened and educated to ensure they understand what their surgery would entail, what their rehabilitation would involve and estimations on time scales for returning to activities of daily living.

Although the rehabilitation principles were the same, obviously there were differences between the groups because of the different times of immobilization and earlier return to activities of daily living (ADL) as the immobilization period became shorter.

Estimations on time scales for returning to activities of daily living for group 1 (6 weeks' immobilization) was 6-8 weeks, for group 2 (3 weeks' immobilization) 3-4 weeks, and for group 3 (no immobilization) within a week.

Rehabilitation protocols

Group 1: 6 weeks' immobilization in a sling

Initially the patient's arm is placed in a master sling with a body belt for 3 weeks (Table I).

Table II Patient demographics

	Group 1 (6-week immobilization)	Group 2 (3-week immobilization)	Group 3 (no immobilization)	All
rTSA	114 (left 40, right 74, bilateral 6)	125 (left 48, right 77, bilateral 5)	118 (left 63, right 55, bilateral 6)	357 (left 151, right 178, bilateral 37)
Patients, n	108	120	112	340 (male 103, female 237)
Mean age at surgery, yr (SD)	76 (54-93)	76 (40-92)	74 (53-90)	76 (40-93)
Cuff arthropathy	77	66	42	185
Osteoarthritis	4	39	67	110
Rheumatoid arthritis	18	9	7	34
Failed rotator repair	12	2	1	15
Massive irreparable rotator cuff tear	3	6	1	10
Instability arthropathy	0	2	0	2
Postinfection arthropathy	0	1	0	1

Cryo-cuff administered to reduce inflammation.

During the first 3 weeks, commence with shoulder girdle exercises and postural awareness; fingers, wrist, and radio-ulnar mobilization exercises; as well as active elbow flexion and extension.

Gentle pendulum exercises. Commence gentle passive assisted shoulder exercises in elevation and external rotation, stretching exercises.

At 3-6 weeks: discard the sling body belt but remain with the arm in the sling for 3 more weeks.

Continue passive assisted shoulder exercises in elevation and external rotation, stretching exercises.

Start passive internal rotation in a protected position of at least 60° of abduction in the scapular plane to ensure avoidance of IR with adduction and extension.

Start active assisted to active shoulder exercises.

At 6 weeks: Commence the Deltoid Rehabilitation regime[23] (Table IV) and progress according to the principles of low weight and high repetition, to enhance shoulder endurance and minimize the risk of injury/dislocation.

Throughout the first 6 weeks, the patient is NOT allowed to perform forceful movement with the behind his or her back and not to weightbear through the arm (Patients are instructed not to ''push themselves out of a chair'') for the 6 weeks postoperation.

Group 2: 3 weeks' immobilization in a sling

Initially the patient's arm is placed in a master sling with a body belt for 24-48 hours (until the interscalene block wears off) and kept in a sling for 3 weeks.

Cryo-cuff administered to reduce inflammation.

During the first 3 weeks, commence with shoulder girdle exercises and postural awareness; fingers, wrist, and radio-ulnar mobilization exercises; as well as active elbow flexion and extension.

Gentle pendulum exercises. Commence with passive assisted shoulder exercises in elevation and external rotation, stretching exercises. Commence with passive internal rotation in abduction in the scapular plane. Start active assisted to active shoulder exercises.

At 3 weeks: Continue passive assisted shoulder exercises in elevation and external rotation, stretching exercises. Progress to active assisted to active shoulder exercises.

Table III Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
All patients undergoing reverse TSA: • Rotator cuff arthropathy • Osteoarthritis • Rheumatoid arthritis • Failed rotator cuff repair • Massive irreparable rotator cuff tears • Fracture sequela • Instability arthropathy	Acute proximal humerus fracture Intraoperative complication—fracture Questionable intraoperative fixation of the components due to glenoid and proximal humerus bone deficiency Insufficient comprehension of the surgery and the demands of the post-operative rehabilitation

Commence the Deltoid Rehabilitation regime[23] (Table IV) and progress according to the principles of low weight and high repetition, to enhance shoulder endurance.

Throughout the first 6 weeks, the patient is NOT allowed to perform forceful movement with the hand behind his or her back and not to weightbear through the arm (Patients are instructed not to "push themselves out of a chair") for the 6 weeks postoperation.

Group 3: Accelerated rehabilitation protocol—No immobilization

Initially the patient's arm is placed in a master sling with a body belt for 24-48 hours (until the interscalene block [ISB] wears off). Cryo-cuff administered to reduce inflammation.

Restoration of movement—from day 1+ onwards

Immediately as the ISB wears off and return of neural control, the sling is removed.

Commence with ROM exercises for the hand, wrist, elbow, and shoulder girdle, and for maintaining good posture. The patient begins pendulum exercises in a forward leaning posture and begins passive mobility exercises for the shoulder (in supine initially) which progressing to active assisted, then active exercises as pain allows.

The anterior deltoid strengthening regime[23] (Table IV) commences immediately, as soon as the patient can cope with the pain, usually second or third day postoperatively. It follows a logical and progressive sequence. Progression can only occur once a satisfactory level of strength, control, and endurance is achieved at each level/stage. Supplementary strengthening includes isometric exercises, scapular strength and control exercises, and proprioceptive rehabilitation.

Normal use of the arm and the shoulder for ALL activities without restrictions is encouraged.

We allow the patients to perform external rotation and internal rotation in abduction and in extension and even reach with their hand behind their back to allow them to perform their personal hygiene. We only limit the patients for the first 6 weeks from performing internal rotation + adduction + extension together with forceful movement like to push themselves out of a chair, as this combination increases the risk of dislocation. Without the application of force in this position, there are no limitations.

The only restriction for the first 6 weeks is NOT to perform forceful movement with the hand behind his or her back and not to weightbear through the arm (patients are instructed not to "push themselves out of a chair") for the 6 weeks postoperation.

In the final stages of the rehabilitation in all the 3 groups, supplementary strengthening including isometric exercises, scapular strength and control exercises, and proprioceptive rehabilitation is performed. Scapular training with conscious muscle control of the scapular muscles to restore the scapular force-couple activation in the scapular muscles, with special attention to activation of the lower trapezius and serratus anterior, to improve proprioception and to normalise the scapular resting position. A detailed description of these exercises goes beyond the scope of this article.

Clinical assessment

Patient demographics, including the preoperative diagnosis and preoperative shoulder function using the Constant score[9] (pain, activities of daily living, active range of motion, and shoulder strength), were obtained. Patient satisfaction was assessed using the Subjective Shoulder Value (SSV)[17] or Single Assessment Numeric Evaluation (SANE).[42] Operative findings, complications, or revision surgery were recorded.

Patients were assessed postoperatively with the Constant score,[9] the patient satisfaction score (SSV or SANE score),[17,42] a functional questionnaire assessing return to work, sport, and leisure activities, and the function and ROM are recorded in video clips recording of in every follow-up appointment at 3 weeks; 3, 6, 9, and 12 months; and annually thereafter.

Radiographic assessment

All radiographs were assessed by 2 independent experienced shoulder surgeons. Postoperative radiographic analysis was performed using a true anteroposterior view of the shoulder and an axillary view. A standardized template was used to critically assess postoperative radiographs for displacement, migration, or subsidence of the implant and appearance of radiolucent lines, osteolysis, or signs of stress shielding. The Sirveaux-Nerot glenoid notching classification[38] was assessed as well.

Statistical analysis

Statistical data analyses were performed. A paired t test was conducted to compare the preoperative and postoperative results in the 3 protocols of rehabilitation following rTSA at various times after surgery for pain, mobility, and function. Kruskal-Wallis test was conducted to examine for significant differences between the 3 groups.

Results

The clinical results at 1-year postoperative follow-up showed marked improvement for all the parameters in all the groups. There were marginally better results in the Constant scores (CSs) (Table V), age- and sex-adjusted CSs (Table VI), and the range of motion in the no-immobilization group and the 3-week immobilization group compared with the 6-week

Table IV Physiotherapy protocol for rTSA—Deltoid Rehabilitation regime

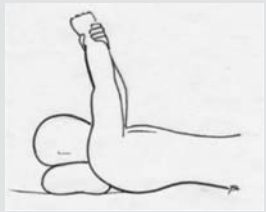
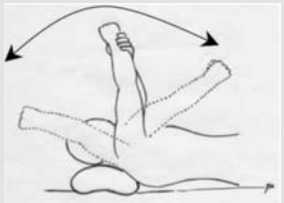
Deltoid Rehabilitation regime			
Stage 1		Level 1	Patient elevates arm to 90° of flexion with the elbow in full extension (using the other arm to assist if necessary)
		Level 2	In a controlled and slow manner, the arm is moved through flexion and extension as comfortable (using the other arm to assist if necessary)
		Level 3	The amplitude of movement is gradually increased in line with pain, control and confidence
		Level 4	A light weight is added to the movement as able
	Supine		
Stage 2		Level 1	Patient elevates arm overhead with the elbow in full extension (using the other arm to assist if necessary)
		Level 2	In a controlled and slow manner, the arm is moved through flexion and extension as comfortable (using the other arm to assist if necessary)
		Level 3	The amplitude of movement is gradually increased in line with pain, control, and confidence
		Level 4	A light weight is added to the movement as able
	Supine in 30° flexion		
Stage 3		Level 1	Patient elevates arm overhead with the elbow in full extension (using the other arm to assist if necessary)
		Level 2	In a controlled and slow manner, the arm is moved through flexion and extension as comfortable (using the other arm to assist if necessary)
		Level 3	The amplitude of movement is gradually increased in line with pain, control, and confidence
		Level 4	A light weight is added to the movement as able
	Supine progressively increase flexion angle		
Stage 4		Level 1	Patient elevates arm overhead with the elbow in full extension (using the other arm to assist if necessary)
		Level 2	In a controlled and slow manner, the arm is moved through flexion and extension as comfortable (using the other arm to assist if necessary)
		Level 3	The amplitude of movement is gradually increased in line with pain, control, and confidence
		Level 4	A light weight is added to the movement as able
	Sitting - inclined position/ standing		

Table V Constant score

	6-week immobilization group	3-week immobilization group	No-immobilization group	Kruskal-Wallis *P* value between the 3 groups	6-week vs. 3-week at 1-yr *t* test *P* value	6-week vs. 1-week at 1-yr *t* test *P* value	3-week vs. 1-week at 1-yr *t* test *P* value
Preoperation	16.61 (8.2)	21.47 (12.49)	22.56 (13.25)	.00555	.0618	.2279	.7149
At 1-yr follow-up	63.20 (16.90)	67.69 (14.32)	66.62 (19.44)	.12032			
P value (*t* test) 1 yr vs. preoperation	<.0001	<.0001	<.0001	—			
Gain (1 yr – preoperation)	46.59 (1.880)	46.21 (1.842)	44.16 (2.722)	—			
95% CI of gain	–50.30, –42.88	–49.84, –42.58	–49.54, –38.78	—			

CI, confidence interval.

Table VI Age- and sex-adjusted Constant score

	6-week immobilization group	3-week immobilization group	No-immobilization group	Kruskal-Wallis *P* value between the 3 groups	6-week vs. 3-week 1-yr *t* test *P* value	6-week vs. 1-week 1-yr *t* test *P* value	3-week vs. 1-week 1-yr *t* test *P* value
Preoperation	23.9 (12.66)	30.68 (17.63)	31.33 (17.69)	.00657	.0578	.4123	.3831
1-yr follow-up	91.46 (24.88)	98.35 (22.52)	94.91 (27.74)	.1953			
P value (*t* test) 1 yr vs. preoperation	<.0001	<.0001	<.0001	—			
Gain (1 yr – preoperation)	67.56 (2.734)	67.67 (2.747)	63.57 (3.807)	—			
95% CI of gain	–72.96, –62.17	–73.08, –62.25	–71.09, –56.05	—			

CI, confidence interval.

Table VII ROM elevation at 1-year follow-up

	6-week immobilization group	3-week immobilization group	No-immobilization group	Kruskal-Wallis *P* value between the 3 groups	6-week vs. 3-week 1-yr *t* test *P* value	6-week vs. 1-week 1-yr *t* test *P* value	3-week vs. 1-week 1-yr *t* test *P* value
Preoperation	55.00 (24.11)	70.48 (31.82)	72.09 (27.42)	.00002	.0409	.2511	.4902
1-yr follow-up	142.12 (37.6)	152.58 (29.06)	148.99 (37.33)	.13753			
P value (*t* test) 1 yr vs. preoperation	<.0001	<.0001	<.0001	—			
Gain (1 yr – preoperation)	87.11 (4.410)	82.10 (4.258)	76.89 (5.385)	—			
95% CI of gain	–95.81, –78.41	–90.50, –73.71	–87.53, –66.25	—			

CI, confidence interval; *ROM*, range of motion.

Table VIII ROM abduction at 1-yr follow-up

	6-week immobilization group	3-week immobilization group	No-immobilization group	Kruskal-Wallis *P* value between the 3 groups	6-week vs. 3-week at 1-yr *t* test *P* value	6-week vs. 1-week at 1-yr *t* test *P* value	3-week vs. 1-week at 1-yr *t* test *P* value
Preoperation	49.77 (21.53)	66.48 (36.96)	62.30 (23.89)	.00034	.0248	.0307	.8384
At 1-yr follow-up	130.96 (42.67)	144.39 (35.20)	145.61 (41.23)	.02973			
P value (*t* test)1 yr vs. preoperation	<.0001	<.0001	<.0001	—			
Gain (1 yr – preoperation)	81.19 (4.687)	77.91 (5.009)	83.31 (5.539)	—			
95% CI of gain	−90.43, −71.94	−87.78, −68.04	−94.26, −72.36	—			

CI, confidence interval; *ROM*, range of motion.

Table IX Pain

	6-week immobilization group	3-week immobilization group	No-immobilization group	Kruskal-Wallis *P* value between the 3 groups	6-week vs. 3-week at 1-yr *t* test *P* value	6-week vs. 1-week at 1-yr *t* test *P* value	3-week vs. 1-week at 1-yr *t* test *P* value
Preoperation	3.13 (2.85)	3.54 (3.11)	3.73 (3.03)	.5169	.3164	.9603	.2993
At 1-yr follow-up	12.49 (3.61)	12.98 (2.76)	12.46 (3.59)	.84562			
P value (*t* test)1 yr vs. preoperation	<.0001	<.0001	<.0001	—			
Gain (1 yr – preoperation)	9.36 (0.462)	9.43 (0.412)	8.73 (0.544)	—			
95% CI of gain	−10.27, −8.45	−10.25, −8.62	−9.80, −7.65	—			

CI, confidence interval.

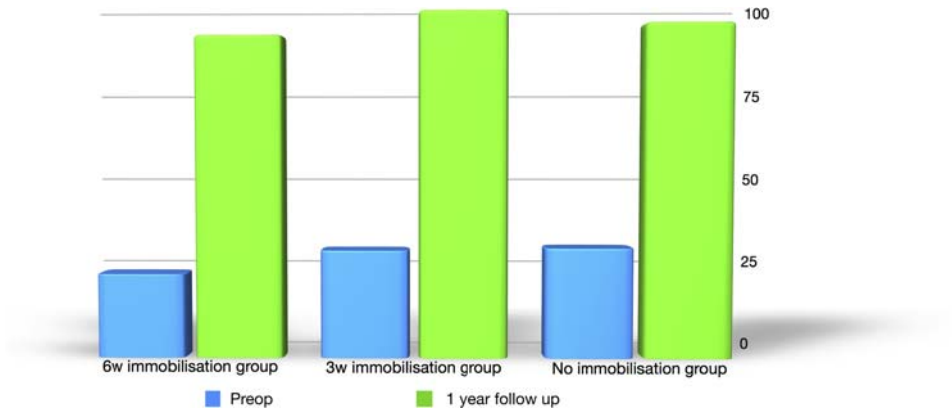


Figure 1 Age- and sex-adjusted Constant score.

immobilization group, although with no statistically significant difference (Tables V-IX and Fig. 1-3).

The mean CSs (for all diagnoses) improved from 16.6 (age- and sex-adjusted 23.9) to 63.2 (age- and sex-adjusted 91.5) in group 1, from 21.5 (age- and sex-adjusted 30.7) to 67.7 (age- and sex-adjusted 98.4) in group 2 and from 22.6 (age- and sex-adjusted 31.3) to 66.6 (adjusted 94.9) in group 3. ($P < .0001$ by paired *t* test) (Tables V and VI).

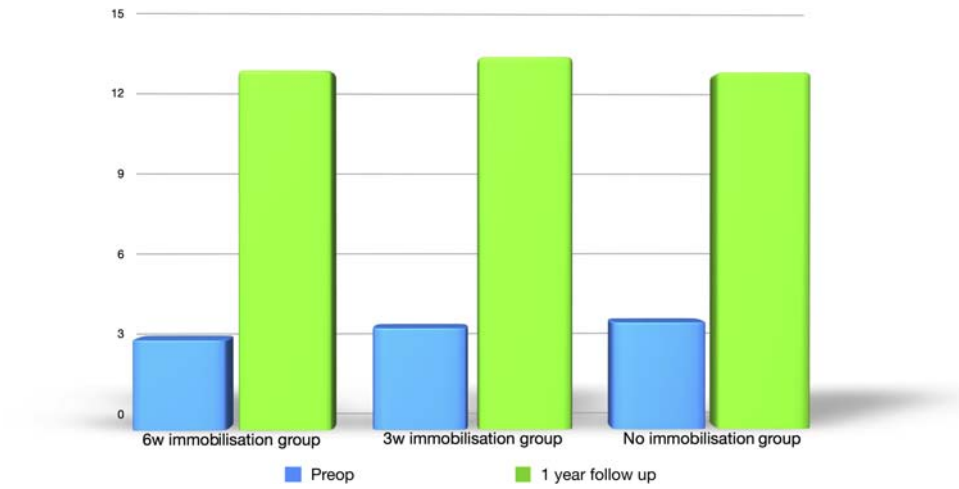


Figure 2 Pain.

Table X Subjective Shoulder Value

	6-week immobilization group	3-week immobilization group	No-immobilization group	Kruskal-Wallis *P* value between the 3 groups	6-week vs. 3-week at 1-yr *t* test *P* value	6-week vs. 1-week at 1-yr *t* test *P* value	3-week vs. 1-week at 1-yr *t* test *P* value
Preoperation (SD)	1.19 (1.57)	1.29 (1.52)	1.28 (1.83)	.70457	.7764	.2795	.1655
At 1-yr follow-up (SD)	8.51 (2.04)	8.60 (1.83)	8.11 (2.60)	.73655			
P value (*t* test) 1 yr vs. preoperation	<.0001	<.0001	<.0001	—			
Gain (1 yr – preoperation)	7.32 (0.261)	7.31 (0.229)	6.83 (0.369)	—			
95% CI of gain	−7.83, −6.80	−7.76, −6.86	−7.56, −6.10	—			

CI, confidence interval; *SD*, standard deviation.

When comparing between the groups, only the difference between the improvement in CS and the age- and sex-adjusted CS in the 3-week immobilization vs. 6-week immobilization approached significance (CS $P = .0618$; age- and sex-adjusted CS $P = .0578$). Otherwise, there was no difference in the improvement between the 3 groups (Fig. 1).

The pain score improved from 3.13/15 preoperatively to 12.5/15 postoperatively in group 1, from 3.54/15 to 13.0/15 in group 2, and from 3.73/15 to 12.5/15 in group 3. There was statistically significant difference in improvement in all groups ($P < .0001$), although no statistically significant difference between the groups ($P = .84562$) (Table IX and Fig. 2).

At 1-year follow-up, the mean ROM improved in forward elevation to 142° and 131° abduction in group 1; 153° forward elevation and 144° abduction in group 2, and 149° forward elevation and 146° abduction in group 3. There was statistically significant difference in improvement in all groups ($P < .0001$), although no statistically significant difference between the groups (forward elevation $P = .13753$; abduction $P = .02973$) (Tables VII and VIII).

The SSV improved from 1.19/10 preoperatively to 8.51/10 postoperatively in group 1 ($P < .0001$), from 1.29/10 to 8.60/10 in group 2 ($P < .0001$), and from 1.28/10 to 8.11/10 in group 3 ($P < .0001$). However, there was no statistically difference between the 3 groups ($P = .73655$). (Table X and Fig. 3).

These results suggest that following rTSA, regardless of the rehabilitation protocol and length of immobilization, there are significant improvements in CS, SSV, function, pain, and mobility.

Although a significant improvement was demonstrated for each group, when all 3 groups were directly compared no statistically significant difference between groups was demonstrated.

Complications

Overall, we observed more postoperative complications in group 1 (6 weeks' immobilization) than in the other groups. Most of the complications were fractures, either

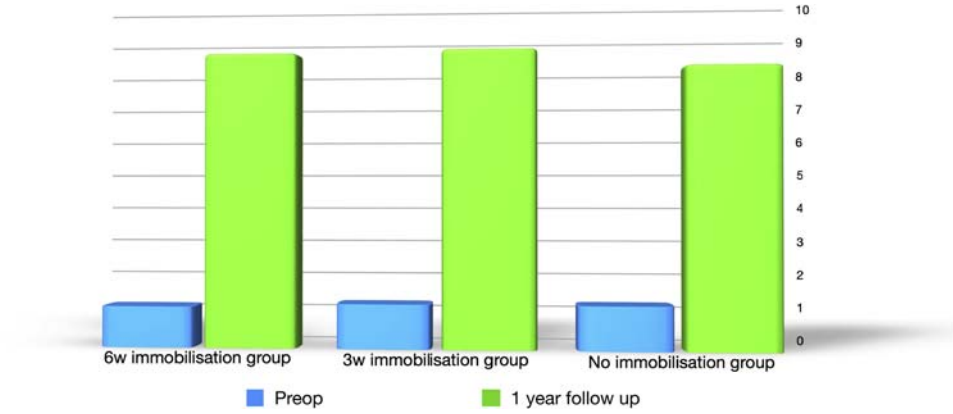


Figure 3 Subjective Shoulder Value.

Table XI Complications in the different rehabilitation groups

	6-week immobilization	3-week immobilization	Immediate mobilization
Acromion fracture	2		
Traumatic periprosthetic glenoid fracture	4	1	2
Traumatic humeral periprosthetic fracture	13	2	1
Dislocation	3		
Fracture of scapular spine	6	1	1
Infection		1	1
Total	28	5	5

periprosthetic fractures due to falls or scapular spine fractures. It is possible that without a sling, patients have better proprioception and therefore less tendency to fall.

There were a total of 28 complications in group 1 and 5 complications each in group 2 and 3. The complications are listed in Table XI.

Discussion

Reverse TSA has been shown to be a successful procedure with significant and lasting improvements in pain relief, function, and patient satisfaction.[19,24-26,28,35] However, in the available scientific literature to date, little attention has been given to the postoperative rehabilitation programs with respect to patient outcomes and postoperative complications despite it being considered an important element in the pathway to postoperative success.[11]

This study demonstrates that accelerated rehabilitation program with early mobilization immediately following rTSA is an effective and safe postoperative rehabilitation protocol. There is a low rate of complications as well as significant improvements in validated patient-related outcome scores. Statistically significant improvements were demonstrated in all the rehabilitation groups across all outcome scores between the preoperative scores and the postoperative scores. The comparison of 3 different rehabilitation protocols following rTSA in this study showed no statistically significant differences in the clinical outcome between the groups.

Furthermore, fewer postoperative complications were observed in groups 3 and 2 (no immobilization and 3 weeks' immobilization) compared with group 1 (6 weeks' immobilization). Most of the complications were fractures, either periprosthetic fractures due to falls or scapular spine fractures.

There is no report in the literature regarding the incidence of early complications following a formal period of immobilization after rTSA. Accelerated rehabilitation with early mobilization speeds up the recovery process and allows the patient to return to daily life activities much sooner, actually immediately, without delay.

This study confirms at least noninferiority of the accelerated rehabilitation program following rTSA compared with the standard protocols, characterized by prolonged period of postoperative immobilization (3 and 6 weeks). Furthermore, this accelerated rehabilitation without immobilization, showed no increment in the complication rate, in fact, showed lower complication rate in this group. A possible explanation can be related

to the improved proprioception due to the early mobilization. Furthermore, not wearing a sling, improve on its own the balance of the patients postoperatively, especially in the elderly group. This may also apply to better core stability and lower limb proprioception, resulting in a lower percentage of falls and postoperative traumatic injuries.

Our initial protocols of 6 weeks' and 3 weeks' immobilization, as well as others' previous protocols, followed the principles of the commonly accepted rehabilitation protocols for anatomic TSA. In rTSA, unlike in anatomic TSA, the outcome is less dependent on the healing of the rotator cuff tendons (mainly the subscapularis). Furthermore, better healing of rotator cuff remnants to tuberosities is seen with rTSA. This may be due to the different angle of the rotator cuff to the tuberosities, which is different from anatomic TSA, hence, probably, less tension on repair and lesser risk for dehiscence.

Boudreau et al[7] advocated a protective period of the prosthesis and soft tissue repair for between 3 and 6 weeks and in some cases up to 12 weeks to ensure adequate bony, soft tissues, and deltoid integrity following rTSA. It was felt that early mobilization could increase the risk of dislocation, loosening and rupture of the deltoid repair. Blacknall and Neumann[20] described an rTSA postoperative rehabilitation regime that involved no formal period of immobilization; however, they did limit the ROM for several weeks postoperatively and taught the patients specific rest and sleep positions in order to prevent dislocations.[20]

Limitations

There may be several potential confounding factors between the groups. As the development of the different rehabilitation groups was over time, arguably, advancements in surgical technique, and patient selection could influence the outcome. However, the surgical technique did not change at all over this time. Indeed, the patient selection may have changed a bit for selection of a larger range of pathologies. The composition of the primary diagnosis of the patients in the different groups differ slightly. The change and final Constant and ROM scores appear to have large standard deviations with wide confidence intervals. It may be that the study is underpowered, impacting potential differences between groups. Nevertheless, this study shows noninferiority of the immediate mobilization rehabilitation group, which is the important message of this study.

It is possible that improved rTSA implant design and improved surgical technique plays a role in the reduced risk of dislocation. Good primary stability of the implant and a secure fixation of the Deltoid repair to the acromion are necessary to enroll patients in the accelerated protocol. Having no postoperative immobilization period, have further psychological and emotional advantage to the patient, with earlier return to normal function and regaining his independence.

Conclusion

Accelerated rehabilitation regime post rTSA without immobilization is safe and leads to reliable good clinical results and quick return to function. This study confirms noninferiority of the accelerated rehabilitation regime with fewer postoperative complications related to falls. Accelerated rehabilitation regime post rTSA have further psychological and emotional advantage to the patient, with earlier return to normal function and regaining his independence. We recommend the accelerated rehabilitation regime without immobilization following rTSA.

Disclaimer

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