

# Artroplastia com Balão Subacromial: Desenvolvimento de um Protocolo de Reabilitação através de Revisão da Literatura

## *Subacromial Balloon Arthroplasty: Development of a Rehabilitation Protocol through Literature Review*

Gonçalo Gomes Engenheiro<sup>(1)</sup> | Paulo Couto<sup>(1)</sup> | Jorge Moreira<sup>(1)</sup> | Maria Inês Táboas<sup>(1)</sup> | Catarina Aguiar Branco<sup>(1)</sup> | Tiago Pinheiro Torres<sup>(2)</sup> | Herculano Nascimento<sup>(2)</sup> | António Miranda<sup>(2)</sup>

### Abstract

**Introduction:** Subacromial balloon arthroplasty is a promising new arthroscopic solution for massive to irreparable rotator cuff tears, consisting of insertion of a biodegradable device into the subacromial space. Despite the growing interest in this procedure since it was introduced in 2012, details concerning postoperative rehabilitation are yet very scarce.

Our objective was to develop a rehabilitation protocol following subacromial balloon insertion without rotator cuff tear repair based on literature review.

**Methods:** To develop the protocol, we reviewed the available literature in Scopus, Web of Science and PubMed until 2020, and collected experts' opinion in PRM and Orthopedics departments of our institution.

**Results** We found 9 studies including information on postoperative rehabilitation. Duration of rehabilitation was 12 weeks. Main goals were: regaining range of motion, strength, and scapulotoracic balance. Shoulder immobilization was required for 1 to 4 weeks. Range of motion started in the first days, with variable progression. Strengthening began by the third/fourth weeks. Overhead activity was usually allowed after 6 weeks.

**Conclusion:** According to these findings, we elaborated a 12-week rehabilitation program divided into 4-week blocks,

*focused on flexibility and early strengthening of scapular depressors and stabilizers to promote the lowering of the humeral head achieved by the balloon implantation. The ultimate goal is to recover independence in activities of daily living. The protocol presented in this article addresses the lack of proper details on the subacromial balloon arthroplasty postoperative rehabilitation process. In the future, prospective studies are warranted to provide evidence of the effectiveness of this comprehensive program.*

**Keywords:** Rotator Cuff/surgery; Rotator Cuff Injuries/rehabilitation; Shoulder

### Resumo

**Introdução:** A artroplastia com balão subacromial é uma promissora nova solução artroscópica para pacientes que sofrem de roturas maciças/irreparáveis da coifa dos rotadores, consistindo na inserção de um dispositivo biodegradável no espaço subacromial. Apesar do crescente interesse neste procedimento desde a sua introdução em 2012, os detalhes acerca da reabilitação pós-operatória são ainda muito escassos.

O nosso objetivo foi desenvolver um protocolo de reabilitação para pacientes submetidos a inserção de balão subacromial sem reparação de rotura da coifa dos rotadores, baseado na revisão da literatura.

(1) Serviço Medicina Física e Reabilitação - Centro Hospitalar de Entre o Douro e Vouga, Santa Maria da Feira, Portugal.

(2) Serviço Ortopedia - Centro Hospitalar de Entre o Douro e Vouga, Santa Maria da Feira, Portugal.

© Autor(es) (ou seu(s) empregador(es)) e Revista SPMFR 2022. Reutilização permitida de acordo com CC BY-NC. Nenhuma reutilização comercial.

© Author(s) (or their employer(s)) and SPMFR Journal 2022. Re-use permitted under CC BY-NC. No commercial re-use.

Autor correspondente: Gonçalo Gomes Engenheiro. email: goncalo.engenheiro@gmail.com. Orcid: <http://orcid.org/0000-0002-0408-8148>. Rua Dr. Cândido de Pinho, 4520-211 Santa Maria da Feira.

Data de submissão: agosto 2021

Data de aceitação: julho 2022

Data de publicação: agosto 2022

**Métodos:** Para desenvolver o protocolo, realizámos uma revisão da literatura publicada nas bases de dados Scopus, Web of Science e PubMed até 2020 e recolhemos a opinião de peritos dos departamentos de MFR e Ortopedia da nossa instituição.

**Resultados:** Encontrámos 9 estudos que incluíram informação sobre a reabilitação pós-operatória. A duração do processo de reabilitação pós-operatório foi de 12 semanas. Os principais objetivos mencionados foram recuperar a amplitude de movimentos, a força e o ritmo escapulotorácico. A imobilização pós-operatória do ombro foi necessária entre 1 a 4 semanas. A mobilização articular foi iniciada nos primeiros dias, com progressão variável entre estudos. O fortalecimento muscular começou pela terceira/quarta semana. As atividades acima do plano dos ombros foram habitualmente permitidas após 6 semanas.

**Conclusão:** De acordo com estes achados elaborámos um programa de reabilitação de 12 semanas dividido em 3 blocos de 4 semanas, focado no trabalho precoce de flexibilidade e de fortalecimento muscular dos depressores e estabilizadores da escápula, para promover a depressão da cabeça umeral alcançada com a interposição do dispositivo biodegradável. O objetivo final do nosso programa é a recuperação da independência nas atividades de vida diária. O protocolo apresentado neste artigo vem colmatar a escassez de detalhes adequados acerca do processo de reabilitação consecutivo à artroplastia com balão subacromial. No futuro, estudos prospetivos são necessários para providenciar evidência da efetividade deste abrangente programa de reabilitação.

**Palavras-chave:** Coifa dos Rotadores/cirurgia; Lesões da Coifa dos Rotadores/reabilitação; Ombro

## Introduction

Chronic massive rotator cuff tears (RCTs) are common, represent up to 40% of all RCTs, and often cause major morbidity and disability. They comprise the supraspinatus and/or infraspinatus tendons and can have the size of at least 5 cm in anteroposterior length. In 20%-30% of the cases these are considered irreparable, and optimal management is still not consensual.<sup>1,2</sup>

Subacromial balloon spacer implantation is a relatively new arthroscopic technique, for patients suffering from massive to irreparable RCTs, without glenohumeral arthropathy, before undergoing more aggressive procedures, such as total shoulder arthroplasty.<sup>3</sup>

The procedure consists of the insertion of a biodegradable balloon-shaped device into the subacromial space in order to widen it, and to contribute to maintenance of force

coupling. The device is believed to biodegrade within 12 months, and allows for reducing impingement, and pain, ultimately restoring the biomechanics of the glenohumeral joint.<sup>2,3</sup>

Reviews have concluded that balloon arthroplasty is successful in the short- and middle- term (mean follow-up periods from 6 to 60 months).<sup>4-7</sup> It is a minimally invasive, technically simple, and safe procedure that is being performed alone or in combination with other techniques, namely partial repair. Indeed, discussion exists whether the positive outcomes are in fact more related to the concomitant procedures than to the spacer insertion itself.<sup>4</sup> Nevertheless, the results have been favorable, and the effects seem to last even beyond the device retention time in the shoulder.<sup>4,5</sup> The temporary restoration of force coupling, initially provided by the balloon spacer, might allow the shoulder girdle to transition from a symptomatic to an asymptomatic status. Thereafter, muscle exercise and strengthening, rather than the balloon, might continue the recovery of range of motion (ROM) and function throughout the rehabilitation process.<sup>4,7</sup>

Despite its importance, until today little is known about rehabilitation following subacromial balloon arthroplasty. One of the advantages advocated for enrolling this surgery is precisely the faster rehabilitation process when a partial tear is not simultaneously repaired, therefore making it suitable for patients unable to undergo prolonged rehabilitation after a more aggressive surgery, in which tissue healing is a major concern.<sup>5</sup>

Due to increasing popularity, this novel procedure was recently introduced in our hospital, thereby creating the need for proper rehabilitation following surgery. However, to the best of our knowledge there is no detailed rehabilitation protocol currently available in literature. Therefore, the aim of this study is to review all available information on the rehabilitation following subacromial balloon arthroplasty without RCT repair in order to develop a standardized and comprehensive rehabilitation program.

## Methods

In order to develop the rehabilitation program, we first reviewed the literature to assess information on rehabilitation following subacromial balloon arthroplasty. Afterwards, all relevant data was analyzed and discussed in the light of our clinical expertise to propose a comprehensive rehabilitation protocol.

### Search strategy

A comprehensive literature search of Scopus, Web of Science, and PubMed electronic databases was performed from 2012, the year of publication of the first article on subacromial balloon implantation,<sup>3</sup> until October 2020. An initial search identified no article specifically addressing the rehabilitation after subacromial balloon arthroplasty. Therefore, we decided to screen all articles on the procedure for any report on the rehabilitation process by searching all databases with the following strategy (Fig. 1): (“subacromial spacer” OR “subacromial balloon” OR “balloon spacer” OR “biodegradable balloon” OR “biodegradable spacer” OR

“subacromial balloon arthroplasty”) AND (“rotator cuff tear” OR “rotator cuff injury” OR “rotator cuff rupture” OR “massive rotator cuff tear” OR “irreparable rotator cuff tear” OR “irreparable massive rotator cuff tear”).

### Study selection

Screening of titles and abstracts was conducted followed by full-text reviews. Articles about the use of subacromial balloon spacers without RCT repair for the management of massive/irreparable RCT that reported a postoperative rehabilitation protocol were included. If the authors also reported a RCT repair, the study was only included if the

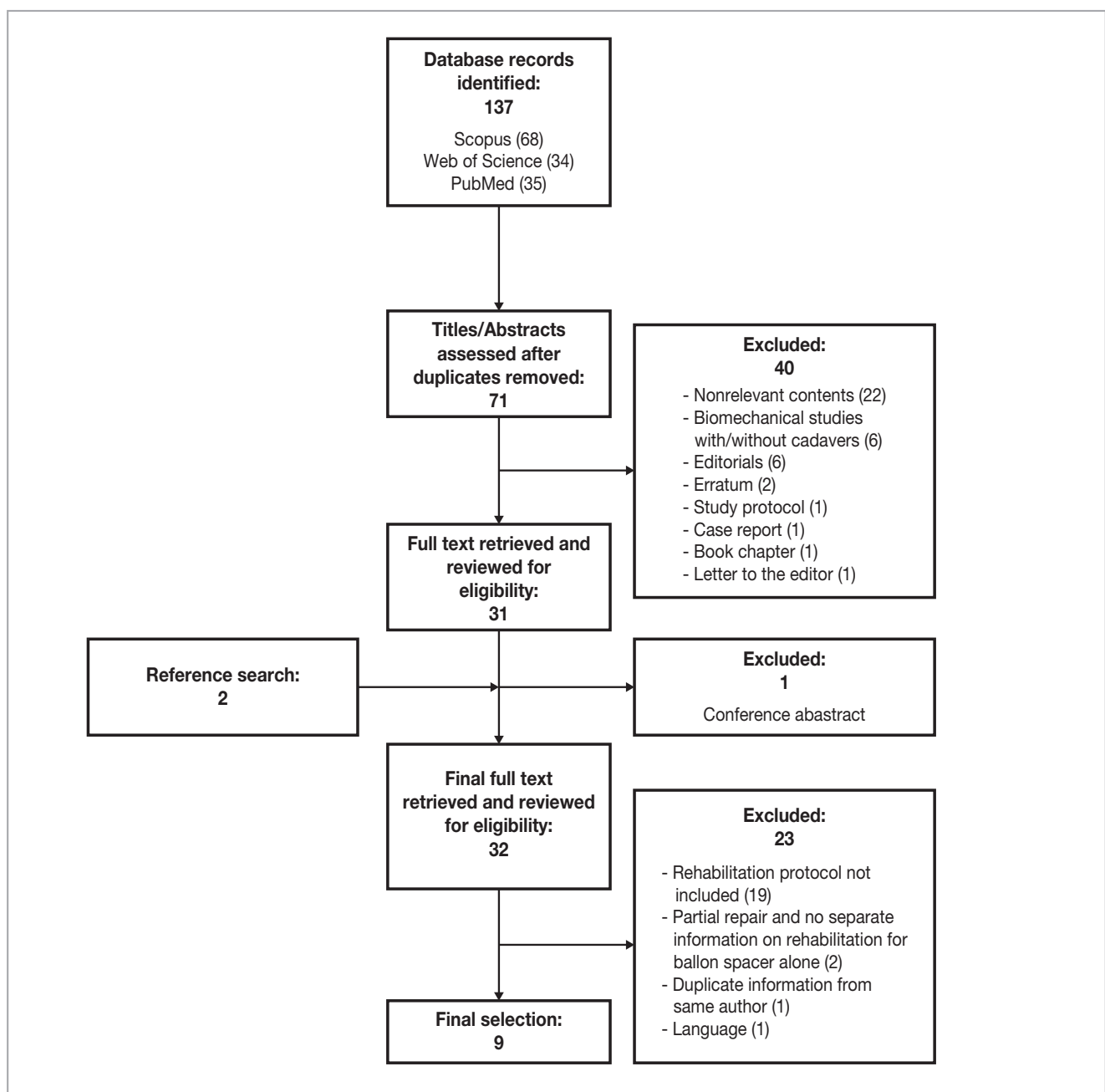


Figure 1. Flow chart of search strategy.

information regarding rehabilitation of patients submitted to balloon arthroplasty alone was clearly provided separately. We excluded conference abstracts, editorials, letters to the editor, study protocols, basic scientific texts, book chapters, and investigations involving animals, or cadaveric specimens. Articles were also excluded if a full-text was not available, or they were written in languages others than Portuguese, Spanish or English. Review papers were included if the authors provided a rehabilitation protocol. Additionally, all references of the articles included for full-text review were screened for further relevant papers. In case of duplicate information provided by the same author, only the most recent paper was considered. Articles were assessed by two independent reviewers and any differences in article inclusion were discussed and resolved by consensus.

#### Data extraction and analysis

The following data was extracted: first author, year of publication, study type, and rehabilitation protocols. Concerning rehabilitation, studies were specifically assessed for: phases (number and duration), goals, sling usage (including duration), timings for initiation of ROM and strengthening, and restrictions/precautions. A qualitative analysis was performed to present the results in narrative summary fashion.

#### Development of the rehabilitation program

After the conclusion of the review process, meetings between the authors, from both the Orthopedics and the Physical and Rehabilitation Medicine departments of our

hospital, were held to discuss the results in the light of our clinical expertise, and to inform clinical practice. At this stage, further literature<sup>8-11</sup> was consulted to cover issues of general shoulder rehabilitation not directly related to balloon arthroplasty and/or not addressed by the articles retrieved for review.

## Results

### Review of the literature on rehabilitation following subacromial balloon arthroplasty

Information concerning postoperative rehabilitation is summarized in (Table 1). A formal division of the rehabilitation program into phases was only outlined by Horneff and Abboud.<sup>13</sup> Timing for starting formal physiotherapy was provided by 3 authors,<sup>13,15,16</sup> and duration for the program was discriminated in 2 studies.<sup>13,16</sup> Rehabilitation goals were mentioned in 3 articles,<sup>13,15,16</sup> namely regaining ROM,<sup>16</sup> strength,<sup>13,15,16</sup> and scapulothoracic balance.<sup>16</sup> The use of a shoulder sling was reported in all studies, ranging from 1<sup>17,18</sup> to 4<sup>13</sup> weeks, but 2 authors<sup>14,19</sup> did not mention the duration. Precise timings for starting passive ROM (PROM) of the shoulder were reported in only 1 article,<sup>19</sup> for the initiation of active assisted or active ROM (AAROM or AROM) were mentioned in 6 studies,<sup>14,15,17-20</sup> and for beginning strengthening were included in 3 papers.<sup>12,13,15</sup> Restrictions/precautions were outlined in 4 articles,<sup>12,13,17,20</sup> with specific mention to avoid overhead activity for 6 weeks.<sup>12,17,20</sup>

**Table 1** - Summary of available data on rehabilitation following subacromial balloon arthroplasty.

Study Type	Phases (number, duration, goals)	Shoulder immobilization	ROM	Strengthening	Precautions/Restrictions
Basat <i>et al</i> (2017) <sup>15</sup> Prospective case series	Physiotherapy start: 3 <sup>rd</sup> po week Goals: strengthen shoulder joint and adjacent muscles	First 2-3 po weeks	Pendulum exercises: 1 <sup>st</sup> po day AROM: after 1 week to perform daily activities	3 <sup>rd</sup> po week	-
Deranlot <i>et al</i> (2017) <sup>19</sup> Retrospective case series	-	Duration not specified	PROM and AROM: 1 <sup>st</sup> po day	-	-
Ricci <i>et al</i> (2017) <sup>17</sup> Retrospective case series	-	1 <sup>st</sup> po week	After surgery: full AAROM and early AROM at low level	-	Overhead activity avoided for 6 weeks

<b>Ruiz Ibán et al (2018)<sup>16</sup></b> Prospective case series	Supervised physiotherapy start: 3 <sup>rd</sup> po week Duration: at least 2 months Goals: regaining ROM, strength and scapulothoracic balance	First 2 po weeks (gradually removal according to comfort afterwards) Removal allowed for personal grooming, dressing and feeding, and for elbow, wrist exercises and soft shoulder mobilization exercises.	-	-	-
<b>Riff et al (2018)<sup>12</sup></b> Review	-	1-2 po weeks	Progression from PROM to AAROM permitted as tolerated Resisted AROM: 6 <sup>th</sup> po week	Begin with light isometrics with arm adducted Progress to bands as tolerated Weights: 5 <sup>th</sup> po week	Overhead activity restricted for 6 weeks
<b>Horneff et al (2018)<sup>13</sup></b> Review	3 Phases (12 weeks) Weeks 0-4: immobilization Weeks 4-8: formal physiotherapy start Weeks 8-12: full strengthening; development of home exercise program	First 4 po weeks Allowed to use arm for light ADL (e.g. eating, writing, hygiene)	Start stretching between 4-8 po weeks	Start between 4-8 po weeks, up until 3 pounds (close to 1.5 Kg) Advance to full strengthening between 8-12 po weeks	Weeks 0-4: non-weightbearing Weeks 4-8: resume ADL Week 12: all restrictions lifted
<b>Oh et al (2019)<sup>14</sup></b> Retrospective cohort study	-	Duration not specified Shoulders supported in neutral rotation in a sling	AAROM: immediately after surgery	-	-
<b>Familiari et al (2020)<sup>8</sup></b> Retrospective cohort study	-	1 <sup>st</sup> po week (afterwards progressive weaning according to comfort) First 2 po weeks	Finger, wrist, hand, and elbow AROM: immediately after surgery Active abduction and anterior elevation: 1 <sup>st</sup> po week, depending on tolerance and ability	-	-
<b>Kaisidis et al (2020)<sup>20</sup></b> Retrospective cohort study	-	First 2 po weeks	After surgery: full AAROM and early AROM at low level	-	Overhead activity avoided for 6 weeks

- = information not mentioned in original article; po = postoperative; ROM = range of motion; PROM = passive ROM; AAROM = active assisted ROM; AROM = active ROM; ADL = activities of daily living.

**Rehabilitation protocol developed**

The full comprehensive rehabilitation protocol developed is available in (Table 2). The program was divided into 3 main phases, with estimated duration of 12 weeks, focusing on improving ROM and the early strengthening of scapular

depressors and stabilizers to promote the lowering of the humeral head achieved by the balloon implantation. The ultimate goal is to achieve independence in activities of daily living (ADL).

**Table 2** - Summary of the proposed rehabilitation protocol following subacromial balloon arthroplasty.

Phase Goals Restrictions/Precautions	Time frame	Interventions	Complementary information
<p><b>Phase I (First 4 po weeks)</b></p> <p><b>Goals</b></p> <ul style="list-style-type: none"> <li>- Control of pain and edema;</li> <li>- Prevention of muscle atrophy;               <ul style="list-style-type: none"> <li>- Recovery of ROM;</li> <li>- Functional recovery;</li> </ul> </li> <li>- Light muscle strengthening.</li> </ul> <p><b>Restrictions/Precautions</b></p> <ul style="list-style-type: none"> <li>- No lifting of objects and no supporting of body weight with operative extremity;</li> <li>- No exercises behind the frontal plane;               <ul style="list-style-type: none"> <li>- No sudden movements;</li> </ul> </li> <li>- Avoid sleeping on the involved extremity.</li> </ul>	First 1 – 4 po weeks	Shoulder immobilization with sling	Allowed to remove the sling for personal grooming, dressing and feeding, and for rehabilitation exercises
	1 <sup>st</sup> po day – ...	Pain control strategies (analgesics, NSAIDs, cryotherapy, analgesic)	Continued as needed throughout rehabilitation
	1 <sup>st</sup> po day – indefinitely	Pendulum exercises	
	First po days – indefinitely	AROM of elbow, wrist and fingers	Shoulder immobilized and ipsilateral elbow against the side of the body
	3 <sup>rd</sup> po day – 2 <sup>nd</sup> po week	Shoulder PROM	Non-painful, performed in supine position, with shoulder aligned in the scapular plane. Initially limited to 0-90° of anterior elevation and
	1 <sup>st</sup> week po – 3 <sup>rd</sup> week po	Shoulder AAROM	Non-painful, performed with shoulder aligned in the scapular plane. Initially limited to 0-90° of anterior elevation and abduction, and 0° of extension  Progress from supine to orthostatic position as tolerated
	1 <sup>st</sup> po week – indefinitely	Proprioceptive training and upper arm ROM	Begin with CKC exercises in the horizontal plane (e.g. table slides)
	2 <sup>nd</sup> po week	Shoulder PROM	Progress in anterior elevation until tolerance limit
	2 <sup>nd</sup> po week – end of phase I	Strengthening of scapular depressors and stabilizers – NMES	
	3 <sup>rd</sup> po week – indefinitely	Shoulder PROM	Non-painful, with shoulder aligned in the scapular plane
	3 <sup>rd</sup> po week – end of program	Upper arm AAROM with pulleys or stick	
	3 <sup>rd</sup> po week – indefinitely	Proprioceptive training and upper arm ROM	Progress to the vertical plane (e. g. wall walking exercises)



	After sling discontinuation	Strengthening of scapular depressors and stabilizers – Isometric exercises	Begin submaximal isometrics, performed in CKC
<p><b>Phase II (5<sup>th</sup> – 8<sup>th</sup> po weeks)</b></p> <p><b>Goals</b></p> <ul style="list-style-type: none"> <li>- Progression in ROM;</li> <li>- Progression in muscle strengthening;</li> <li>- Functional recovery;</li> <li>- Normalization of scapulothoracic balance;</li> <li>- Restoration of glenohumeral and scapular force and resistance.</li> </ul> <p><b>Restrictions/Precautions</b></p> <ul style="list-style-type: none"> <li>- No supporting of body weight with operative extremity;</li> <li>- No sudden movements;</li> <li>- Avoid sleeping on the involved extremity.</li> </ul>	Throughout Phase II	Shoulder ROM	Progress in anterior elevation, and abduction until tolerance limit  Begin motion in extension, and progress according to tolerance
	6 <sup>th</sup> po week	Shoulder resisted AROM	
	Throughout Phase II	Strengthening of scapular depressors and stabilizers – Isometric exercises	Progress to maximal isometrics according to tolerance
<p><b>Phase II (9<sup>th</sup> – 12<sup>th</sup> po weeks)</b></p> <p><b>Goals</b></p> <ul style="list-style-type: none"> <li>- Pain-free arc of motion;</li> <li>- Enhancement of shoulder biomechanics, strength, power and endurance;</li> <li>- Recovery of functional independence in ADL.</li> </ul> <p><b>Restrictions/Precautions</b></p> <ul style="list-style-type: none"> <li>- Avoid overhead activities;</li> <li>- No lifting of heavy objects (5kg limit) with operated arm;</li> <li>- Avoid any activity that promotes pain, tenderness, or edema.</li> </ul>	Throughout Phase III	Strengthening of scapular depressors and stabilizers – Isotonic exercises	Progress to concentric isotonic exercises in OKC, with shoulder aligned in the scapular plane  Add progressive resistance using elastic bands or dumbbells (5Kg limit), as tolerated
		Strengthening of other upper arm muscles	According to individual needs

po = postoperative; NSAIDs = nonsteroidal anti-inflammatory drugs; ROM = range of motion; PROM = passive ROM; AAROM = active assisted ROM; AROM = active ROM; CKC = closed kinetic chain; NMES = neuromuscular electrical stimulation; OKC = open kinetic chain

## Discussion

The review performed to establish the basis for the postoperative rehabilitation program confirmed our initial expectation that the available information is still very scarce. There are no articles published specifically on the subject yet, and there is also no detailed rehabilitation program currently available. Therefore, our study is the very first to properly address the subject of rehabilitation after subacromial balloon arthroplasty. Based on current evidence (Table 1), and our clinical expertise, we propose a postoperative rehabilitation program for the patient undergoing subacromial spacer insertion without RCT repair for the management of a massive/irreparable RCT.

We divided our protocol Table 2 into 3 main phases. Each proposed phase has an estimated duration of 4 weeks, totaling up to 12 weeks of hospital-based rehabilitation, following previous authors indications.<sup>13,16</sup> Indeed, physiotherapy programs were only formally started after 3<sup>15,16</sup> or 4<sup>13</sup> postoperative weeks. However, Basat *et al* began pendulum exercises in the first postoperative day,<sup>15</sup> and Ruiz Ibán *et al* mentioned permission for starting elbow, wrist exercises and soft shoulder mobilization exercises early after surgery,<sup>16</sup> which are both core interventions of the first phase of our program.

Although not mentioned in any of the included studies, medication and modalities, such as cryotherapy and analgesic electrical stimulation, are advised to control pain and edema.<sup>10,11</sup>

Sling use should last for 1 to 4 weeks, according to Orthopedist discretion. This immobilization should be intermittently removed for performing light ADL (personal grooming, dressing and feeding), and for rehabilitation, namely ROM.

Patients begin AROM of elbow, wrist, hand and fingers in the first hours after surgery.<sup>18</sup> Shoulder PROM should commence in the first or second postoperative day,<sup>19</sup> performed in supine position, with shoulder aligned in the scapular plane, and limited to 0°-90° of anterior elevation and abduction, and 0° of extension.<sup>11</sup>

Non-painful shoulder AAROM begins in the first week.<sup>14,17,20</sup> Patients may already start proprioceptive training and ROM of upper arm in closed kinetic chain, starting in the horizontal plane (e. g. using a hard desk).<sup>10,11</sup>

Progression in anterior elevation until tolerance limit in shoulder PROM is attempted in the second postoperative week. Although not mentioned in any of the included literature, neuromuscular electrical stimulation of scapular depressors and stabilizers (predominantly inferior trapezius and latissimus dorsi) with co-contraction may be beneficial,<sup>8</sup> allowing for an earlier muscle strengthening.

From the third postoperative week on, patients may begin pain-free shoulder AROM, performed in the scapular plane. Some authors have indicated that this can be started much earlier, in the first postoperative days or week,<sup>15,17,19</sup> depending on the tolerance and the ability of the patient,<sup>18</sup> and only to perform ADL.<sup>15</sup> However, the vast majority of our patients still experience some degree of pain in the first weeks, not enabling them to progress in ROM so early.

At the end of the first phase it is expected patients to progressively wean off from sling immobilization, according to surgeon indication. After this event, if clinically feasible, patients may begin pool therapy for joint mobilization.<sup>9</sup>

Optimal timing for initiating strengthening could not be clearly determined. Horneff and Abboud started strengthening between 4 and 8 postoperative weeks, limited to 3 pounds (approximately 1.5 kg).<sup>13</sup> Riff and Verma indicated that strengthening should initially consist of light isometrics with arm adducted.<sup>12</sup> Basat *et al* were more specific, pointing out the third postoperative week as their timing for beginning strengthening.<sup>15</sup> Given these indications, in most patients we advocate for starting submaximal isometric strengthening of scapular depressors and stabilizers in closed kinetic chain by the fourth week.

In a second phase (between the fifth and the eight weeks after surgery), additional goals of regaining scapulothoracic balance, and gradual restoring glenohumeral and scapular force and resistance are added. To enhance AROM, exercises can now start to be gently performed behind the frontal plane, and proper progression in anterior elevation and abduction should be attempted, according to tolerance. Resisted AROM can be performed by the sixth postoperative week.<sup>12</sup> Other phase I exercises should be maintained. Regarding muscle strengthening, the therapist should promote the progression to maximal isometrics according to patient tolerance. Pain control strategies should be continued as needed. In some cases, restriction of overhead activities may be lifted after 6 weeks,<sup>12,17,20</sup> but in general we prefer to limit this until the end of our hospital-based program.

The final stage is mainly focused on: enhancing shoulder biomechanics, muscular strength, power and endurance; and recovery of functional independence in ADL. Muscle strengthening should progress to concentric isotonic exercises in open kinetic chain, in the scapular plane.<sup>10,11</sup> Resistance should be progressively added with elastic bands or dumbbells (5 kg limit), according to tolerance. Treatment prescription should be individualized according to clinical evaluation at this time, considering the need to strengthen other upper extremity muscle groups, and to maintain modalities.

At the end of a successful outpatient hospital-based rehabilitation program, patients are expected to maintain a



pain-free total arc of motion of the shoulder, and typically to complete light household and work activities. Some patients might need to continue a community/home-based rehabilitation program. In any case, patients should be always given proper advice to continue to perform exercises learned throughout the hospital-based rehabilitation program at home, indefinitely.

### Strengths and limitations

This study is the first to systematize rehabilitation after subacromial spacer insertion. However, we were limited by the absence of studies dedicated to the rehabilitation following subacromial balloon implantation, and by the scarce reports present in the few studies that include it. This is the reason why we also considered reviews that provided a rehabilitation protocol in our article. The paucity of data also precluded a more robust assessment, and the development of a rehabilitation program based entirely on research evidence was not possible. To overcome this limitation, we relied on our clinical expertise, and on the general principals of shoulder rehabilitation to present for the first time a comprehensive rehabilitation protocol

following subacromial balloon arthroplasty. We do not provide outcomes to validate our proposal at this time. However, in this article our aim was in fact to develop a protocol that was based on the current body of knowledge. Therefore, in the future follow-up studies of patients submitted to this comprehensive rehabilitation program are needed to establish its effectiveness and feasibility.

### Conclusion

Subacromial balloon arthroplasty is a novel orthopedic procedure developed to relieve pain and improve function of patients suffering from massive/irreparable rotator cuff ruptures, before undergoing more aggressive surgeries, such as a total shoulder arthroplasty. This procedure was recently introduced in our institution, creating the need for an adequate post-operative rehabilitation in order to recover independence on ADL. However, details concerning this process are very scarce. Therefore, in this article, we present a rehabilitation protocol that establishes the basis for future research and might be adopted by other institutions.

Conflitos de Interesse: Os autores declaram não possuir conflitos de interesse. Suporte Financeiro: O presente trabalho não foi suportado por nenhum subsídio o bolsa ou bolsa. Proveniência e Revisão por Pares: Não comissionado; revisão externa por pares.

Conflicts of Interest: The authors have no conflicts of interest to declare. Financial Support: This work has not received any contribution grant or scholarship. Provenance and Peer Review: Not commissioned; externally peer reviewed.

### Referências / References

- Kooistra B, Gurnani N, Weening A, van den Bekerom M, van Deurzen D. Low level of evidence for all treatment modalities for irreparable posterosuperior rotator cuff tears. *Knee Surg Sports Traumatol Arthrosc.* 2019;27:4038-8. doi: 10.1007/s00167-019-05710-0.
- Oh JH, Park MS, Rhee SM. Treatment strategy for irreparable rotator cuff tears. *Clin Orthop Surg.* 2018;10:119-34. doi: 10.4055/cios.2018.10.2.119.
- Savarese E, Romeo R. New solution for massive, irreparable rotator cuff tears: the subacromial "biodegradable spacer". *Arthrosc Tech.* 2012;1:e69-e74. doi: 10.1016/j.eats.2012.02.002.
- Moon AS, Patel HA, Ithurburn MP, Brabston EW, Ponce BA, Momaya AM. Subacromial spacer implantation for the treatment of massive irreparable rotator cuff tears: a systematic review. *Arthroscopy.* 2019;35:607-14. doi: 10.1016/j.arthro.2018.08.006.
- Stewart RK, Kaplin L, Parada SA, Graves BR, Verma NN, Waterman BR. Outcomes of subacromial balloon spacer implantation for massive and irreparable rotator cuff tears: a systematic review. *Orthop J Sports Med.* 2019;7:2325967119875717. doi: 10.1177/2325967119875717.
- Wright MA, Abboud JA, Murthi AM. Subacromial balloon spacer implantation. *Curr Rev Musculoskelet Med.* 2020;13:584-91. doi: 10.1007/s12178-020-09661-9.
- Liu F, Dong J, Kang Q, Zhou D, Xiong F. Subacromial balloon spacer implantation for patients with massive irreparable rotator cuff tears achieves satisfactory clinical outcomes in the short and middle of follow-up period: a meta-analysis. *Knee Surg Sports Traumatol Arthrosc.* 2021;29:143-53. doi: 10.1007/s00167-019-05834-3.
- Bdaiwi AH, Mackenzie TA, Herrington L, Horsley I, Cools AM. Acromioclavicular distance during neuromuscular electrical stimulation of the lower trapezius and serratus anterior muscles in healthy participants. *J Athl Train.* 2015;50:713-8. doi: 10.4085/1062-6050-50.4.03.
- Thein JM, Brody LT. Aquatic-based rehabilitation and training for the shoulder. *J Athl Train.* 2000;35:382-9.
- Romeyn R, Manske RC. Importance of the History in the Diagnosis of Shoulder Pathology. In: Giangarra CE, Manske RC, Brotzman SB, editors. *Clinical Orthopedic Rehabilitation: A Team Approach.* Philadelphia: Elsevier; 2018. p.100-9.
- Rosenthal MD, Moore JH, Lynch JR. Impingement Syndrome. In: Giangarra CE, Manske RC, Brotzman SB, editors. *Clinical Orthopedic Rehabilitation: A Team Approach.* Philadelphia: Elsevier; 2018. p.210-20.
- Riff AJ, Verma NN. Subacromial spacer for irreparable rotator cuff tears. *Oper Tech Sports Med.* 2018;26:44-7.
- Horneff JG, Abboud JA. Balloon interspace arthroplasty for irreparable rotator cuff tears. *Oper Tech Orthop.* 2018;28:232-7.
- Oh JH, Park JH, Jeong HJ, Rhee SM. Comparing clinical outcomes after subacromial spacer insertion versus other reconstruction methods in the treatment of irreparable massive rotator cuff tears. *Orthop J Sports Med.* 2019;7:2325967119869600. doi: 10.1177/2325967119869600.
- Basat HC, Kirçil C, Armangil M, Demirtaş M. Treatment alternative for irreparable rotator cuff ruptures: Arthroscopic biodegradable balloon. *Niger J Clin Pract* 2017;20:952-7.
- Ruiz Ibán MA, Lorente Moreno R, Ruiz Díaz R, Álvarez Sciamanna R, Paniagua Gonzalez A, Lorente Gómez A, et al. The absorbable subacromial spacer for irreparable posterosuperior cuff tears has inconsistent results. *Knee Surg Sports Traumatol Arthrosc.* 2018;26:3848-54. doi: 10.1007/s00167-018-5083-3.
- Ricci M, Vecchini E, Bonfante E, Micheloni GM, Berti M, Schenal G, et al. A clinical and radiological study of biodegradable subacromial spacer in the treatment of massive irreparable rotator cuff tears. *Acta Biomed.* 2017;88:75-80. doi: 10.23750/abm.v88i4-S.6797.

18. Familiari F, Nayar SK, Russo R, De Gori M, Ranuccio F, Mastroianni V, et al. Subacromial balloon spacer for massive, irreparable rotator cuff tears is associated with improved shoulder function and high patient satisfaction. *Arthroscopy*. 2021;37:480-6. doi: 10.1016/j.arthro.2020.09.048.
19. Deranlot J, Herisson O, Nourissat G, Zbili D, Werthel JD, Vigan M, et al. Arthroscopic Subacromial Spacer Implantation in Patients With Massive Irreparable Rotator Cuff Tears: Clinical and Radiographic Results of 39 Retrospectives Cases [published correction appears in *Arthroscopy*. 2018;34(2):647]. *Arthroscopy*. 2017;33:1639-44. doi: 10.1016/j.arthro.2018.05.013.
20. Kaisidis A, Pantos P, Bochlos D. The subacromial spacer system for irreparable posterosuperior rotator cuff tears: A retrospective study of 47 patients with a two-year follow-up. *Shoulder Elbow*. 2022;14:76-82. doi: 10.1177/1758573220960468.