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Presentation

I have been interested about neurological problems of the shoulder since 2002.
I organized the first course on neurological shoulder on May 2011, followed by the publication of my first monograph "Spalla Neurologica" (Neurological Shoulder) in 2012. At that time, there weren't many works, congress or course about this problem.
In the last ten years, however, interesting studies have been performed, about the way to recognize, face and treat this pathology. I have analyzed all these studies, combining the new notions with my clinical and surgical experience and so it has been necessary to renew completely the old version of the book Neurological Shoulder with this new one.
It is always difficult to correctly understand these complex problems and to reach the right diagnosis. The aim of this book is to help the reader to achieve this goal and to perform the right treatment. I believe that the interaction between different specialists is necessary to achieve the best results.
I have involved neurologists, physiatrists, microsurgeons and nerve surgeons, orthopedic surgeons. The collaboration and contribution of colleagues with a great experience in the treatment of this pathology, has been fundamental in providing the

tools to deal with it properly. I thank all of them for the great care and the time they have spent for this monograph.
Very important was also the work of my son Michele who has supported me in the research of scientific literature, collecting the clinical cases, and above all studying and performing the sEMG.
A special thanks to Prof. Christian Gerber for everything he has taught me in these years, for his availability and friendship and for the valuable advice that he has given to me in writing this work.
Great thanks to Bassem Elhassan for his availability and for his work that has helped to improve the knowledge and the approach to this complex diseases.
I am grateful to my friend Alex Castagna, who from the beginning supported me in this adventure.
Finally, a thank you from the bottom of my heart goes to my wife Simona, professional painter, for the great work she does in creating so many anatomical drawings for many chapters and the subject for the cover. I am also grateful for the understanding, suggestions and support she gave me over all these months.

Giulio Peretti

Preface

I'm from the orthopedic world that bases on "mechanism" its principles and, in the past, too often has stopped at this starting basic level.
The shoulder is a multiple joint, complex and sophisticated, like and maybe more than others. It manages and guides the movement of the whole upper limb, impressing, in a leading way, every life's activity. Osteo-cartilaginous structures and muscle-tendons components constitute the functional and bearing frame.
But, like in the super-technologic modern cars, the "electronic control unit" can by itself to condition and, sometime, to stop the right function of all the system.
The "electronic control unit" in the human being is represented by the nervous system.
The improvement of the neurological aspect's knowledge, interesting the shoulder, is frequently ignored or superficially approached.
Because of these considerations I appreciated the educational and disclosing effort that my friend Giulio Peretti went to face with his work "Spalla Neurologica" some years ago.

This initiative contributed to switch on the spotlights about several unclear or even not much known conditions of this joint.
Culture and experience evolve in all fields and the Dr. Peretti's idea to update his precious work seems to me perfect and clever right now. Many chapters have been rewritten updating the contents to the latest acquisitions, while other new aspects of the neurological shoulder pathology have been introduced and deepened to yield to the professionals an important tool to update and improve their knowledge in this field. All with the single but very important objective to provide the best diagnosis and the most effective treatment for our patients, in complex situations like those in which the neurological lesion plays an important of the clinical picture.
I therefore thank Giulio Peretti for the effort made and I wish everyone a good read.
This is a book to keep close at hand in your library.
It will be a very useful aid to consult in intricate situations.

Alessandro Castagna

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- Serratus anterior: sensors must be placed between the anterior margin of latissimus dorsi and pectoralis major costal insertion of the seventh rib. The direction is from the median third of latissimus dorsi belly to the 7th rib.
- Latissimus dorsi: place electrodes three fingers below the inferior angle of the scapula. The direction is on a line connecting this point with the posterior axillary pillar.
- Infraspinatus: halfway between the inferior scapular angle and a point located between acromion and scapular trigone. The direction is from the medial border of the scapula to the posterior acromial angle.
- Teres major: on an horizontal line along inferolateral margin of the scapula. Direction is from the inferior third of the lateral border of the scapula to the posterior axillary pillar.
- Pectoralis major: for the clavicular portion electrodes has to be placed on the 2nd intercostal space, for the sternocostal portion in 5th intercostal space. For both muscles line of reference is the midclavicular one.

Figures from 1 to 4 show how we place sensors from an anterior, oblique, lateral and posterior point of view. For each muscle the maximum size of the electrode in the direction of the muscle's fibers is 10 mm. Inter electrode distance is 20 mm.

CONDITIONING AND PROCESSING OF THE SIGNAL

High pass filtering is mostly determined by the need to reduce slow variations in the signal caused by the movement artefacts, instability at electrode-skin interface as well as noise produced by electromagnetic radiations. That's the case of dynamic movements.
A low pass filter has to be applied to the signal with the aim to reduce noise produced by electrode and equipment [1, 3, 7, 9, 11].
The aim is to balance a proper filtering of the noise, maintaining the highest possible level of information.
The most frequently utilized sensors collect data in a frequency domain which ranges from 0 to 400 Hz. Obviously, at the high frequencies it must be set a low pass filter corner frequency value whose corresponding ampli-

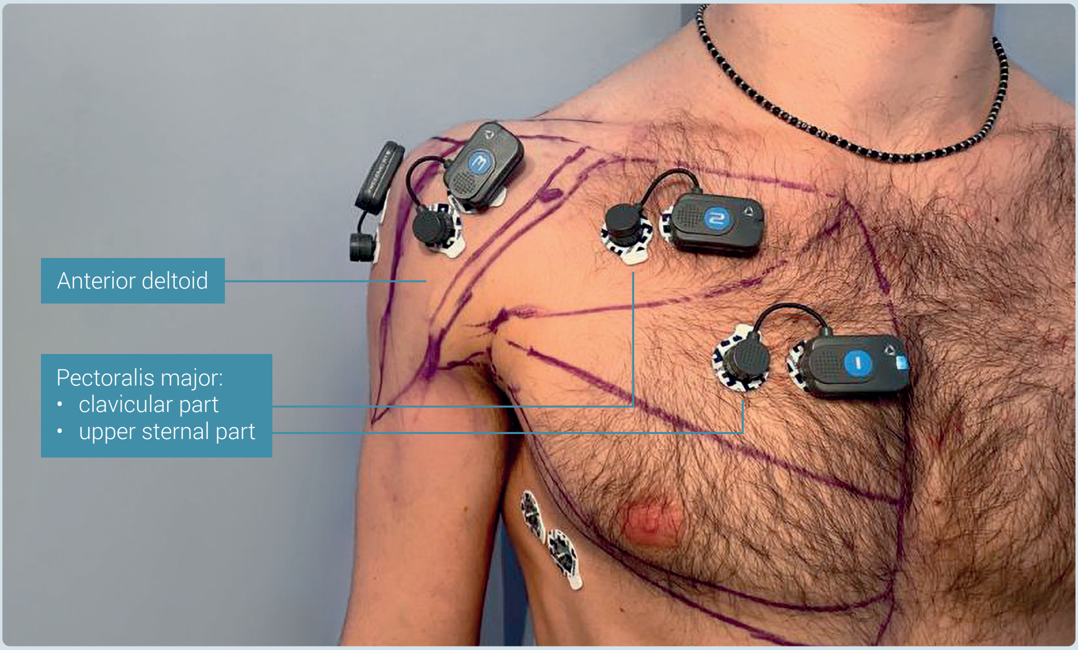


Figure 1 Electrode placement from the anterior point of view. Pectoralis major: upper sternal part (electrode 1) and clavicular part (electrode 2); anterior deltoid (electrode 3)

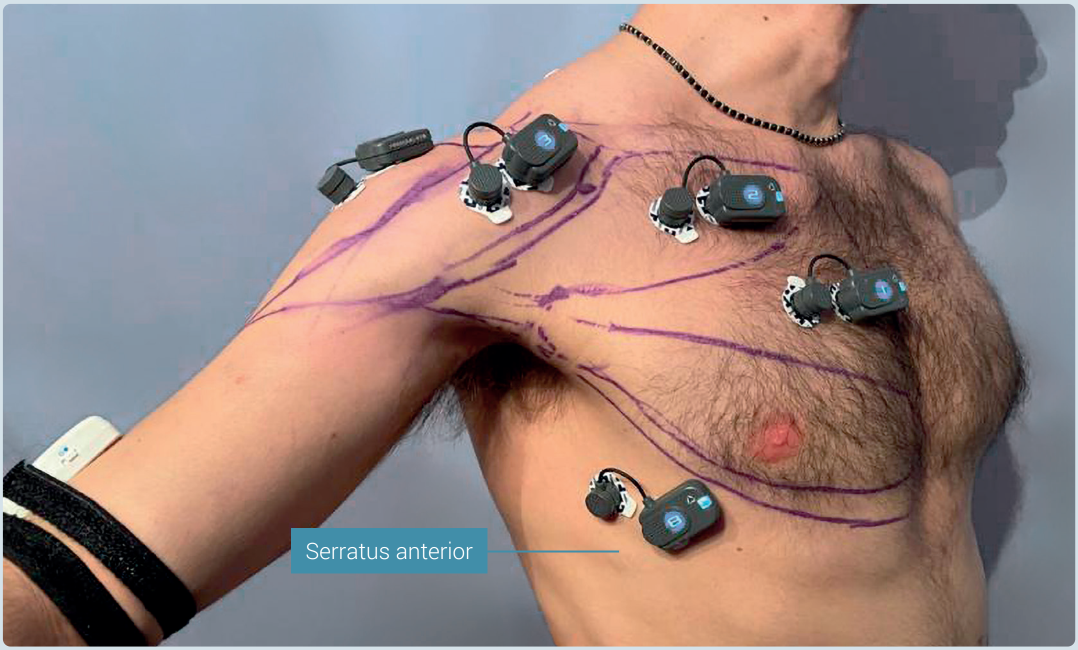


Figure 2 Electrode placement from the olique point of view. It is clearly visible how to place electrodes for serratus anterior (electrode 8)

METHODS OF NERVE REPAIR

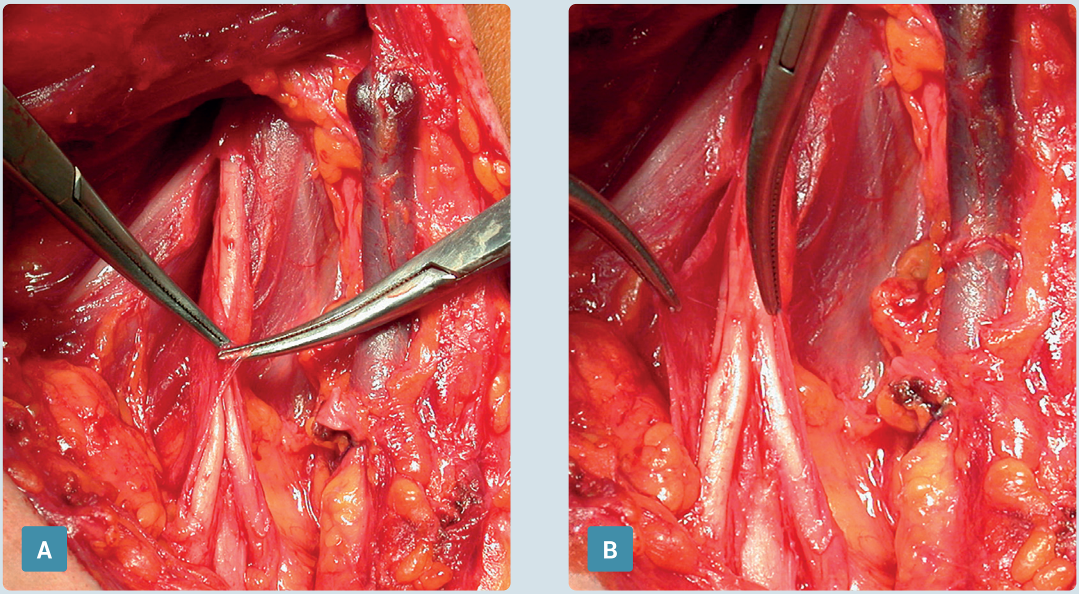
Neurolysis constitutes a fundamental technique and results in the release or "lysis" from external or internal compressive elements that constrict or damage the nerve sufficiently to impair proper axonal flow. Neurolysis aims to eradicate the external or internal scarring of the nerve without altering its residual vascularization and may be differentiated into external and internal neurolysis. External neurolysis is indicated when the scar or fibrosis is external and is divided into simple neurolysis, epineurotomy and epineurectomy. Epineurectomy is the removal of the epineurium over the entire circumference of the nerve or partially and thus directly verifies whether internal fibrosis or endofibrosis is also present, which would impose an internal neurolysis. The latter aims to excise the most extreme internal fibrosis and is divided into three types: simple internal neurolysis, fasciculotomy, and fasciculectomy (fig. 8).

End-to-end neurorrhaphy is primarily indicated in emergencies, in cases of complete or partial clean sharp nerve sections, without loss of substance, as is typical in stab wounds. Epiperineural suture is the preferred technique. Delayed nerve suture is an unusual but possible eventuality. A delayed neurorrhaphy is feasible, especially in the following two cases:

- interruption of the nerve with minimal retraction of the two heads, which are approachable by exerting slight traction between them;
- in-continuity nerve injury with the presence of minimal area of nerve or neuroma degeneration.

In these cases, both ends are addressable with light and acceptable tension, and the suture can be performed while keeping the joints in slight flexion.

Nerve grafting has been the most widely used technique in the repair of delayed nerve injury. It is still so today although nerve transfer in recent years has become more widespread. Nerve grafting is rarely performed in urgent cases. The most commonly used graft is the sural nerve. Alternatively, one or both medial brachial and antebrachial cutaneous nerves may be grafted. The number of grafts for nerve reconstruction varies according to the size between the caliber of the injured nerve tract and the caliber of the nerve graft (figs. 2-4).



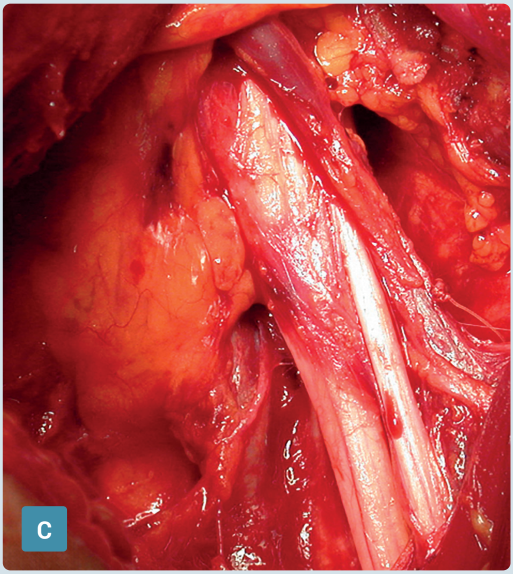


Figure 8
Clinical case: intraoperative images of left brachial plexus traumatic lesion (C5-C6 and upper trunk) with axillary, musculocutaneous and suprascapular nerve palsy.
A-C) extensive neurolysis of the left supraclavicular brachial plexus. In A and B forceps holds the thick epineurium that has been removed from the C5, C6, upper trunk and suprascapular nerve. At the end of the neurolysis procedure nerves are free from scar tissue and responsive of electrical stimulation
D, E) clinical result with optimal recovery of muscle function

THORACIC OUTLET IMAGING

MAGNETIC RESONANCE IMAGING EVALUATION

Magnetic resonance imaging allows a comprehensive evaluation of the brachial plexus from the spinal cord to the terminal branches, as well as its relationships with other structures in the thoracic outlet.

MRI enables the identification of structural and microscopic changes such as neural edema, degeneration, and inflammation, which manifest as signal intensity changes in T2 or abnormal postcontrast enhancement.

In addition to depicting direct nerve injuries, magnetic resonance imaging is useful for assessing indirect signs of injury, such as muscle denervation, in both acute and chronic phases. Acute denervation results in muscle edema within a few days after injury, faster than electromyographic changes, which may take weeks to develop. Chronic denervation is characterized by muscle mass loss and fatty replacement. In the first 4 weeks after injury, there may be increased post-contrast enhancement of the muscles, possibly due to a change in sympathetic vascular tone [2]. Therefore, magnetic resonance imaging can be useful in localizing nerve involvement and characterizing the chronicity of the injury.

IMAGING PROTOCOL

The biggest challenge when performing magnetic resonance imaging of the brachial plexus is obtaining high spatial resolution images of the small nerve structures in the neck region where air-tissue interfaces cause significant magnetic susceptibility artifacts.

A dedicated brachial plexus MRI exam typically involves a combination of two-dimensional (2D) and three-dimensional (3D) acquisitions. 2D sequences yield better spatial resolution with shorter acquisition times. Ideally, sagittal acquisitions should be oriented perpendicular to the neurovascular bundles to obtain images perpendicular to the plexus, allowing for better visualization of the neural fascicular pattern. A T1-weighted sequence without fat suppression is useful for delineating nerves against perineural fatty tissue, outlining anatomical structures, and asses-

Figure 5
Deltoid extension lag test: the examiner stands behind the patient holding both wrists, extending both shoulders and elbows maximally and asking the patient to maintain this position

Figure 6
Deltoid extension lag test: an extension lag is indicative of deltoid paralysis or weakness in the affected shoulder and must be documented in degrees of difference with the normal one

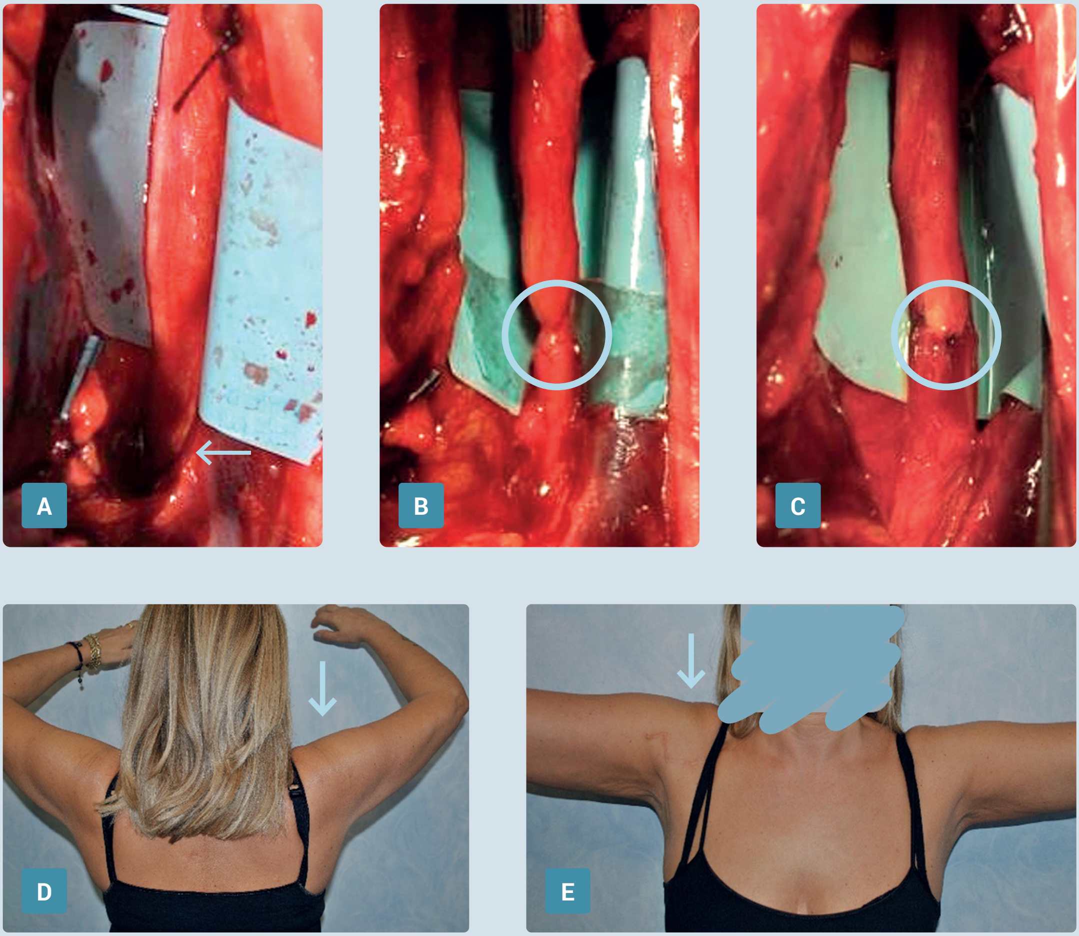


Figure 2 Intraoperative and postoperative photographs with right axillary nerve palsy caused by hourglass-like constriction.
A) axillary nerve is swollen on visual inspection, but palpation reveals a thickened area to the touch
B) epineurotomy and epineurectomy reveals the presence of hourglass-like constriction with severe nerve torsion
C) resection of the hourglass-like constriction and direct nerve suture
D, E) clinical result with recovery of muscle function

Table 4 - rTSA in advanced Parkinson's disease		
n = 10; follow-up 43 months		
	Before surgery	**After surgery**
Elevation	50°	68° ($p<0.05$)
Internal rotation	Greater trochanter	Sacrum ($p<0.05$)
External rotation		No improvement
Abduction		Minimal improvement
Pain		No improvement
Complication rate		70% (7 of 10 shoulders)
Revision rate		50% (5 of 10 shoulders)
Recurrent instability		40% (4 of 10 shoulders)
Scapular spine fractures		30% (3 of 10 shoulders)

Mean follow up was 43 months with minimal improvement of range of motion but no improvement of pain; we found a complication rate in 70% of the cases (7 shoulder) with a revision rate of 50%, recurrent instability in 40% and scapular spine fracture in 30% (figs. 2, 3).

In our hands, reverse total shoulder arthroplasty for irreparable cuff tear associated with advanced Parkinson's disease was disappointing. The functional improvements were limited and clinically irrelevant. Conversely, the complications and revision rate were excessively high.

The review of the literature and our experience suggests that patients with Parkinson's disease, who undergo a shoulder arthroplasty, are subjected to good pain relief at least, if the disease is not yet advanced, but poor functional outcome. Patients are often not satisfied and complication rates are higher if compared with subjects without Parkinson's disease. Complications may be systemic (urinary tract infection, pneumonia, acute kidney injury) or implant related. Notably, periprosthetic joint infection is frequently reported and can be a consequence of the previously mentioned systemic complications. Instability (subluxation and dislocation) and loosening are problems frequently cited in all studies [3, 6, 10-17].

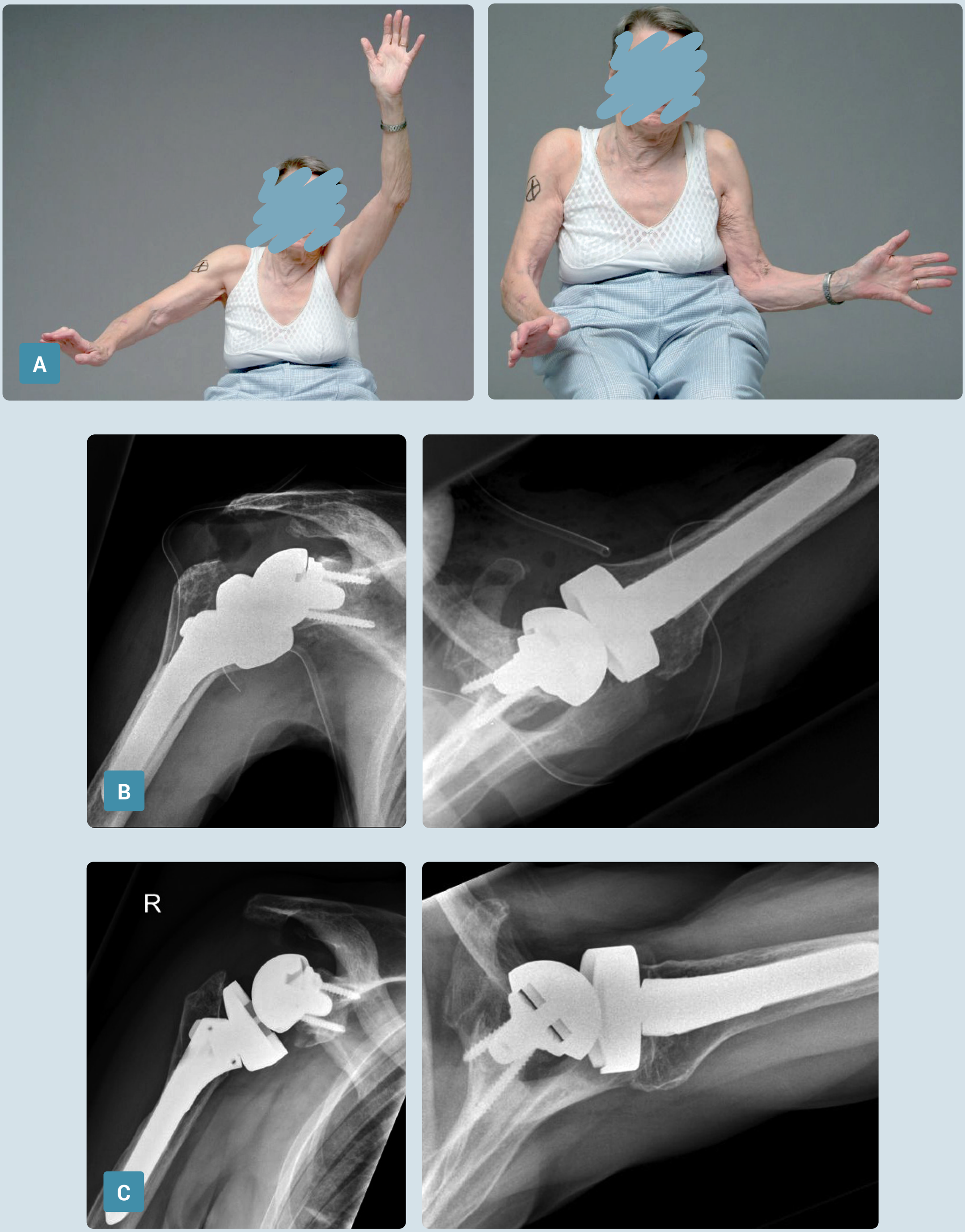


Figure 1 A) patient with Parkinson's disease and glenohumeral arthropathy with functional limitation
B) X-ray control after rTSA
C) 3 years follow-up