International Orthopaedics (2024) 48:495–503
https://doi.org/10.1007/s00264-023-05999-0

ORIGINAL PAPER

Continuous suprascapular nerve blockade to potentiate intensive rehabilitation for refractory adhesive shoulder capsulitis: a cohort study

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Received: 25 August 2023 / Accepted: 25 September 2023 / Published online: 17 October 2023

Abstract

Purpose Evaluating the short- and long-term efficacy of a continuous ten day suprascapular nerve block combined with daily multidisciplinary rehabilitation on shoulder range of motion (ROM), pain, and function in patients with refractory adhesive capsulitis (AC).

Methods In this retrospective cohort study, patients admitted to a specialized pain clinic for refractory AC for more than 6 months underwent continuous suprascapular nerve blockade for ten days and received 2 hours of physiotherapy and occupational therapy daily. Standardized assessments were performed at baseline, at days three, six, ten, 30, 90, and 180, and included active and passive ROM measurements, the visual analog scale (VAS) for pain and the disabilities of the arm, shoulder and hand (DASH) questionnaire to assess pain, disability, and quality of life. Improvements over time were assessed using ANOVAs.

Results Thirty-two patients were followed (age: 52 ± 8 years, 25 females, mean symptoms duration of two years). There was a significant improvement in ROM for all amplitudes at day ten (short-term; range: 20–35°, $p < 0.001$) and at day 180 (long-term; range: 18–47°, $p < 0.001$). The pain and disability scores significantly reduced by day 180 (mean VAS reduction: 2.6 units, $p < 0.001$; mean DASH reduction: 9.5 points, $p < 0.001$).

Conclusion Continuous SSNB combined with intensive multidisciplinary rehabilitation represents an efficient therapeutic option for patients with chronic AC who did not respond to conventional treatments.

Keywords Adhesive capsulitis · Frozen shoulder · Suprascapular nerve block · Anesthesia · Rehabilitation · Range of motion

Introduction

Adhesive capsulitis (AC), also known as frozen shoulder, is characterized by severe shoulder pain, restricted movement, and diminished quality of life [1–3]. The prevalence of this complex condition is relatively high, ranging from two to five percent in the general population [4–7]. Although the pathophysiology is not entirely understood and often deemed idiopathic, the primary pathophysiologic processes involve inflammatory contracture of the shoulder capsule, leading to inflammatory reactions, synovitis, and subsequent fibrotic contracture [8, 9]. The symptomatic course tends to be prolonged, with reported recovery delays ranging between 15 and 52 months, and 41% of individuals still reporting symptoms at 52 months [5, 10]. Pain significantly contributes to decreased shoulder function, particularly by

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hindering active movement [11]. The therapeutic options are limited and encompass analgesics, nonsteroidal anti-inflammatory drugs, and intra-articular steroid injections [12]. A reasonable body of evidence supports the combination of intra-articular corticosteroids with physiotherapy interventions involving manual therapy, stretching exercises, and exercise-based home programs [2, 13, 14]. Regrettably, AC frequently proves unresponsive to these treatments, and their efficacy remains a topic of debate [1–3, 8, 9].

Blockade of the suprascapular nerve with local anaesthetics has been proposed as an alternative treatment [11, 12, 15, 16]. The suprascapular nerve provides innervation to the shoulder girdle muscles and the shoulder joint, with sensory fibres covering about 70% of the shoulder joint [17]. By utilizing local anaesthetics to block nerve transmission, a suprascapular nerve block (SSNB) can alleviate acute or chronic AC-related pain and facilitate intensive and effective rehabilitation. Promising findings showed that combining SSNB with rehabilitation reduces chronic shoulder pain, including AC, when compared to steroid injections or standard care [18, 19]. However, when administered intermittently rather than continuously, SSNB exhibited no significant effect [20]. Existing studies do not concentrate on chronic AC that is unresponsive to conventional treatments. Additionally, the long-term outcomes (beyond three months) remain unexplored. Consequently, our study aims were twofold: (i) to evaluate the effectiveness of continuous SSNB in combination with an intensive multidisciplinary rehabilitation program on pain, range of motion (ROM) and shoulder function and (ii) to compare short-term (10 days) and long-term (6 months) effects at the six month follow-up in patients with refractory AC within an inpatient setting. We hypothesized that this therapeutic approach would significantly enhance range of motion, reduce disability, and substantially alleviate pain.

Material and methods

This observational retrospective study has been approved by an institutional ethics committee (EudraCT 2004-000194-39). The study was based on a medical chart review of patients treated at the University Hospital of Liège between July 2014 and March 2018. Preliminary results have been published elsewhere [21]. The diagnosis of AC was made based on the combination of (1) decreased glenohumeral ROM (active and passive) compared to normal maximal values and (2) presence of shoulder pain. Only patients with refractory AC for at least six months were included. This was defined as an absence of ROM improvement with conventional treatment including enteral analgesic medications (minimum WHO class 2) and rehabilitation associated with intra-articular injection of corticosteroids. Included patients were admitted to a specialized program consisting in intensive rehabilitation sessions (daily physical and occupational therapy) over two weeks of hospitalization following a continuous SSNB (Fig. 1). The control condition was the contralateral shoulder not affected by AC.

Intervention: suprascapular nerve block

The ultrasound-guided SSNB was performed in an operating room under sterile conditions combined with an intravenous injection of prophylactic antibiotics (cefazolin 2 grams or clindamycin 600 mg in case of allergy to penicillin) and using the technique described by Price [22]. An ultrasound linear probe (high frequency probe (13–6 MHz); Sonosite M-Turbo; Bothell, WA) was placed in the superior part of the scapular spine. The bony floor of the supraspinous fossa was imaged and used as surrogate marker of the position of the suprascapular nerve. The needle (Tuohy Ultra-360 18, B-Braun Contiplex, Melsungen, Germany) was inserted

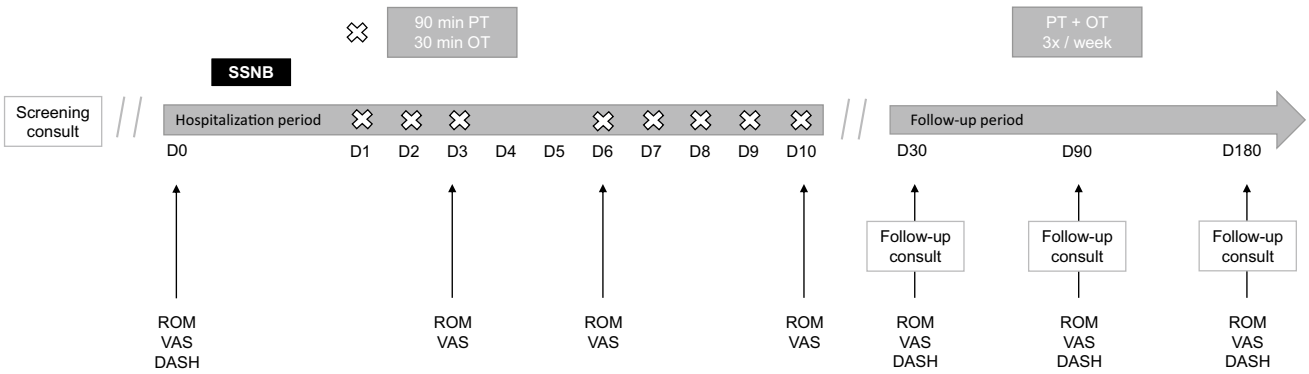

Fig. 1 Timeline of interventions and outcomes in days (D0 = baseline to D180 = 6-month follow-up). SSNB, suprascapular nerve block; PT, physical therapy; OT, occupational therapy; ROM, range of motion; VAS, visual analog scale; DASH, disability of arm-shoulder-hand questionnaire

using the in plane approach, from a medial to lateral direction towards the supraspinous fossa, where the suprascapular nerve lies under the transverse scapular ligament. An initial 15 mL bolus of ropivacaïne 0.5% (Naropin, Aspen Pharma, Dublin) was injected around the nerve beneath the transverse scapular ligament. A catheter (B-Braun Contiplex 100 mm catheter, Melsungen, Germany) was inserted through the needle for 3–4 cm out of the tip and a continuous infusion of ropivacaine 0.2% (Naropin, Aspen Pharma, Dublin) was delivered at a rate of five mL per hour, with the possibility of three bolus of three mL ropivacaine 0.2% per hour at patient's discretion (pump infusion system Micrel Rythmic (TM) Evolution Yellow, Athens, Greece). The catheter was left in place for continuous infusion during nine days (i.e., continuous SSNB). Patients continued their regular per os antalgic medication.

Intervention: rehabilitation

During the ten day hospitalization period, patients received intensive standardized and specific multidisciplinary rehabilitation with a physiotherapist and an occupational therapist twice daily for a total of two hours a day. Physiotherapists initially applied decoaptation manoeuvres, glenohumeral mobilizations, and scapulothoracic mobilization, in order to restore all shoulder amplitudes [13, 23, 24]. Active techniques were then used to restore muscular strength of rotator cuff and periscapular muscles. The intensity was continuously adapted according to the patient's pain reports. The exercises included different contractions modes and proprioceptive components. The rehabilitation was continued after discharge with outpatient visits three times a week during six months.

Measurements: range of motion

Standard passive shoulder movements (anterior elevation, frontal abduction, and internal and external rotation at 0° of abduction) were recorded in degrees with the use of a goniometer. Active movements were recorded similarly with the exception of internal rotation which was assessed according to the vertebral level reached on the back of the spine by the tip of the extended thumb as described by Edwards et al. [25]—see supplementary Table S1 for the classification. The subjects positioning for each movement are depicted in Fig. 2. Range of motion (ROM) was measured for every movement before initiating the block (baseline), three days later (D3), six days later (D6), and 10 days later at the end of the hospitalization period (D10) when the catheter was removed. Measurements were repeated 30 days (D30), three months (D90), and six months (D180) after initiating the block (Fig. 1). For the control condition, the ROM of the contralateral healthy shoulder was measured for every movement at baseline.

Measurements: pain and functional scores

A ten point visual analog scale (VAS) assessing shoulder pain during daily activities was collected at baseline (D0) and thereafter at D3, D6, D10, D30, D90, and D180. The disability of arm-shoulder-hand (DASH) questionnaire [26] was also collected at baseline (D0), D30, D90, and D180 (Fig. 1). The DASH score reflects not only the pain but also the disability and the quality of life. It consists of a 30-item disability/symptom scale and is scored from 0 (no disability) to 100 (maximum disability). Potential adverse events (i.e.,

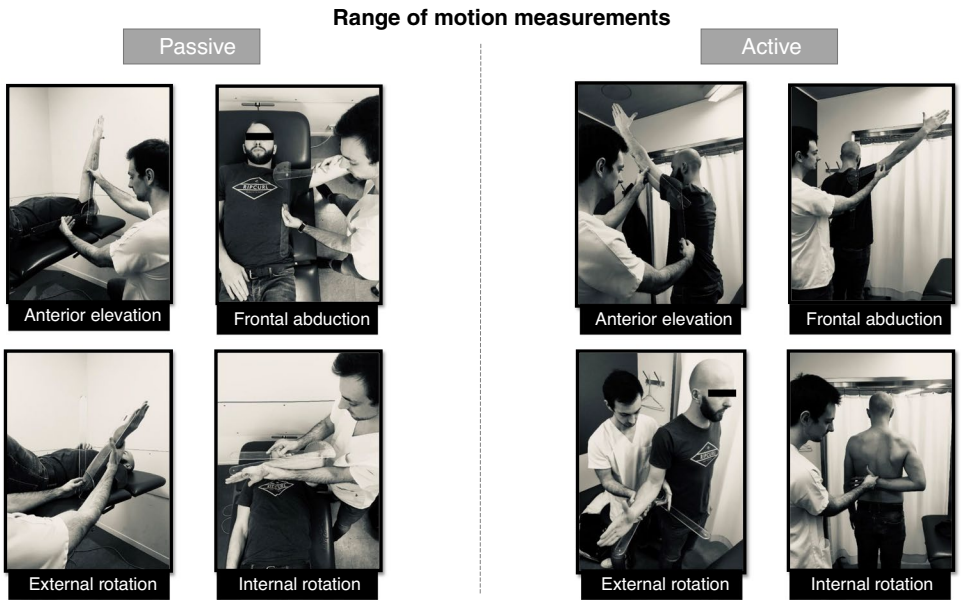

Fig. 2 Subjects' positioning for range of motion measurement

allergy, infection, and neuropathy) were monitored during the whole study duration based on patients' reports.

Outcomes

The primary outcome was the short-term evolution in passive and active ROM at D10 (i.e., hospitalization). Secondary outcomes included (i) the long-term evolution in passive and active ROM (i.e., six-month follow-up) and (ii) evolution of pain (VAS scores) and function (DASH scores) over time (i.e., six-month follow-up).

Statistical analysis

Statistical analyses were performed using R 3.6.2 [27]. The nature of the data distribution (normality) was assessed using Shapiro–Wilk tests. Descriptive statistics were provided using counts (*n*) and proportions (%), and variables were expressed with means and standard deviations (SD) or medians and interquartile ranges (IQR) according to the nature of the distribution. Bilateral differences between shoulders with AC and contralateral healthy control shoulders were expressed as $\left(1-\frac{\text{ROM AC shoulder (°)}}{\text{ROM control shoulder (°)}}\right)\times 100\,(\%)$.

Missing values were reported in terms of proportions (%) over time points and replaced by single imputation using the last observation carried forward (LOCF) method, under the data missing completely at random hypothesis. When LOCF was not possible (i.e., when no baseline value was available), the patient was excluded from the ad hoc analysis. According to the distribution, parametric (normal; ANOVA) or non-parametric (non-normal; Friedman test) ANOVAs were used to assess for differences over time in amplitudes (ROMs), pain (VAS scores), and function (DASH scores). Post hoc pairwise comparisons were performed using Tukey's HSD test. Results were considered significant at the $p < 0.05$ level.

Results

Thirty-two participants, aged around 53 with chronic refractory capsulitis for two years on average, were included in the study and received the SSNB. Demographic and clinical characteristics of the sample are presented in Table 1. No adverse effects were reported for the total duration of the protocol.

The rate of dropout increased throughout the study, especially for the follow-up period, and is presented in Table 2. The follow-up rate was 97% (31/32) at D10, 78% (25/32) at D30, 69% (22/32) at D90, and 59% (19/32) at D180. Overall, 221 over 1,728 (12.8%) values were imputed.

Table 1 Demographic and medical characteristics of the study population

N	32
Age (years)[a]	52.8 ± 10.1 [31 – 75]
Gender[b]	
Female	25 (78)
Male	7 (22)
Dominance[b]	
Right	27 (84)
Left	5 (16)
AC duration (months)[a]	23.9 ± 25.7 [6 – 144]

[a]mean ± standard deviation [minimum – maximum]; [b]count (*n*), proportion (%)

Primary outcome: short-term effects ROM (10 days)

The data was not normally distributed. The evolution of the ROMs over time is presented in Table 3. ROM increased gradually over time while bilateral differences with the controls contralateral shoulders decreased. The gains in ROM from D0 to D10 were as follows: passive anterior elevation: + 31.5° (18% reduced bilateral difference); active: + 32° (20%); passive frontal abduction: + 32° (19%); active: + 35° (23%); passive internal rotation: + 20° (64%); active: + 6 units (35%); passive external rotation: + 23.5° (36%); active: + 28.5° (48%). This is presented in Fig. 3. We found a statistically significant improvement for all movements over time (D0-D3-D6-D10); Friedman's $p < 0.001$. Post hoc pairwise comparisons can be found in Supplementary Table S2 and showed the greatest significant differences between D0 and D10 and no significant differences between D3 and D6.

Secondary outcome: long-term effects ROM (6 months)

The data was not normally distributed. The long-term evolution of the ROMs over time can be found in Table 3. Again, ROM increased gradually over time and bilateral differences with the contralateral control shoulders decreased.

The gains from D0 to D180 were as follows: anterior elevation passive: + 35° (20% reduced bilateral difference); active: + 39° (24%); frontal abduction passive: + 38° (22%); active: + 46.5° (30%); internal rotation passive: + 19° (61%); active: + 6 units (35%); external rotation passive: + 20° (30%); active: + 18° (31%). We found a statistically significant improvement for all movements over time (D0-D30-D90-D180); Friedman's $p < 0.001$. Post hoc pairwise comparisons showed the greatest significant differences between D0 and

Table 2 Proportion (percentage of total sample) of participants presenting missing values across time points for all measured variables. The shading intensity reflects the higher rates of missing values. Where applicable, missing values have been imputed using the last observation carried forward method. Due to the severity of their movement's restrictions, some patients could not perform the passive internal rotation ROM testing (i.e., could not raise their shoulder at 90°), which explains the higher amount of missing data for this variable. Ten values, concerning 7 patients, were missing from baseline and therefore not imputed (patient's data excluded from ad hoc analysis)

Proportion of missing values (%)			D0	D3	D6	D10	D30	D90	D180
ROM	Passive	Anterior Elevation	0	0	3	3	22	31	41
		Frontal Abduction	0	0	3	3	22	31	41
		External Rotation	3	6	6	3	22	31	41
		Internal Rotation	22	6	3	9	25	41	41
	Active	Anterior Elevation	0	0	3	3	22	31	41
		Frontal Abduction	0	0	3	3	22	31	41
		External Rotation	0	0	3	6	25	34	41
		Internal Rotation	0	0	3	3	22	31	41
Pain	VAS		6	13	9	22	47	38	47
Function	DASH		0	NA	NA	NA	38	28	41

D90 with no significant differences for D30 vs. D90, D30 vs. D180, and D90 vs. D180 (see Supplementary Table S2).

Secondary outcome: pain and function

The data was normally distributed. VAS scores decreased gradually over time with a stabilization at the end of the hospitalization period (D10) and an overall decrease (baseline to D180) of 2.6 units. The decrease over time was statistically significant for both the short- and long-term periods (all p <0.001)—see Table 3. Post hoc pairwise comparisons showed the greatest significant differences for D0 vs. D10, D30, D90, and D180 (Supplementary Table S2). Likewise, the DASH score decreased significantly over time with an overall decrease (baseline to D180) of 9.5 points. This decrease for the long-term period was statistically significant ($p < 0.001$), and post hoc pairwise comparisons showed the greatest significant differences between D0 and D90 as well as D0 and D180.

Discussion

The present study was aimed at assessing the efficacy of continuous suprascapular nerve block (SSNB) in combination with intensive rehabilitation over a ten-day period in a cohort of 32 patients with AC who had not responded to conservative treatment within six months. The investigation revealed significant improvements in ROM, VAS, and DASH scores in both the short term (hospitalization) and the long term (6-month follow-up). The most substantial ROM improvement occurred during hospitalization, facilitated by daily intensive, and tailored multidisciplinary rehabilitation involving physiotherapy and occupational therapy. This implies that the analgesic context created by continuous SSNB might disrupt the cycle of immobility and pain, by allowing for passive and active mobilizations and strengthening exercises. The decrease in pain scores over time, reaching its lowest point by the end of the hospitalization period and showing an overall decrease of 2.6 points, considered clinically significant [28], further supports this hypothesis.

These findings offer deeper insights into the underlying pathophysiological mechanisms of AC. It seems that the limitations in movement, particularly associated with pain, may stem primarily from inflammation-induced joint stiffness and muscle contractures. The improvements in ROM after effective analgesia through nerve blockade affirm this proposition. This suggests that AC conditions primarily marked by pain-related inflammation might show significant response to SSNB intervention. On the contrary, AC conditions characterized by fibrosis-related capsular adhesions, often referred to as frozen shoulder contracture syndrome [3], might be less responsive to SSNB intervention. Consequently, improvements in ROM observed after SSNB in painful AC could be attributed to relief from muscular contractures and the absence of actual capsular adhesions.

SSNB comes with fewer side effects compared to its alternative, the interscalene block, and minimal associated motor blockade [29–31]. In addition, the advantages of ultrasound guidance have been largely described [32]. The advantages of this technique should be balanced by the risk of catheter dislocation following mobilization during physiotherapy that has been reported in 25% of cases in a cadaveric study [33].

The noteworthy aspect of the study's long-term (6 months) improvement, unusual in the context of current literature on continuous SSNB, underscores the value of continuous SSNB in promoting more intensive and effective

Table 3 Range of motion (ROM), pain (VAS), and function (DASH) scores across all study timepoints. Variables are depicted as median (interquartile range). Control refers to the baseline assessment of the contralateral shoulder of the 32 participants

	n	Control	Baseline	Short term			Long term			*p* value	
			D0	D3	D6	D10	D30	D90	D180	Short term	Long term
	Range of motion (ROM)[a]										
	Passive range of motion (°)										
Anterior elevation	32	170.5 (18.5)	108.5 (53.8)	124.0 (22.8)	127.0 (19.0)	140.0 (23.3)	145.0 (17.8)	140.0 (23.3)	143.5 (25.3)	<0.001	<0.001
Bilateral difference (%)			36	27	26	18	15	18	16		
Frontal abduction	32	169 (36.3)	75.5 (26.5)	95.0 (32.5)	92.0 (17.8)	107.5 (19.5)	110.0 (25.5)	109.5 (29.3)	113.5 (27.5)	<0.001	<0.001
Bilateral difference (%)			55	44	46	36	35	35	33		
Internal rotation	25	31.5 (17)	8.0 (12.0)	17.0 (19.8)	19.0 (16.5)	28.0 (17.0)	26.5 (18.3)	27.5 (15.8)	27.0 (12.5)	<0.001	<0.001
Bilateral difference (%)			75	46	40	11	16	13	14		
External rotation	31	65 (24.3)	18.0 (25.0)	27.0 (25.5)	29.0 (25.3)	41.5 (24.5)	33.0 (33.3)	35.0 (24.5)	38.0 (21.5)	<0.001	<0.001
Bilateral difference (%)			72	59	55	36	49	46	42		
	Active range of motion (°)										
Anterior elevation	32	161.5 (24)	92.5 (39.3)	105.0 (30.3)	110.0 (26.8)	124.5 (32.3)	126.0 (25.8)	128.0 (23.3)	131.5 (25.5)	<0.001	<0.001
Bilateral difference (%)			43	35	32	23	22	21	19		
Frontal abduction	32	151.5 (35.5)	67.5 (33.3)	85.0 (36.0)	90.0 (20.5)	102.5 (27.8)	104.0 (29.3)	108.0 (24.3)	114.0 (32.5)	<0.001	<0.001
Bilateral difference (%)			55	44	41	32	17	29	25		
Internal rotation	32	17 (7)	2.5 (2.0)	4.0 (3.0)	5.0 (4.0)	8.5 (6.3)	7.5 (6.3)	7.4 (5.3)	8.5 (6.5)	<0.001	<0.001
Bilateral difference (%)			85	77	71	50	56	56	50		
External rotation	32	59 (28)	13.0 (31)	30.0 (33.3)	30.0 (24.5)	41.5 (24.5)	30.0 (26.8)	27.0 (23.3)	31 (21.8)	<0.001	<0.001
Bilateral difference (%)			78	49	49	30	49	54	47		
	Pain – visual analog scale (VAS)[b]										
VAS	30		6.6 (2.4)	5.0 (3.3)	4.0 (2.3)	3.0 (3.5)	4.0 (3.3)	4.0 (2.1)	4.0 (3.0)	<0.001	<0.001
	Function – disability of arm-shoulder-hand (DASH)[b]										
DASH	32		63.4 (17.8)	/	/	/	58.7 (18.9)	51.3 (25.0)	53.9 (32.9)	/	<0.001

[a]Friedman's test; [b]ANOVA

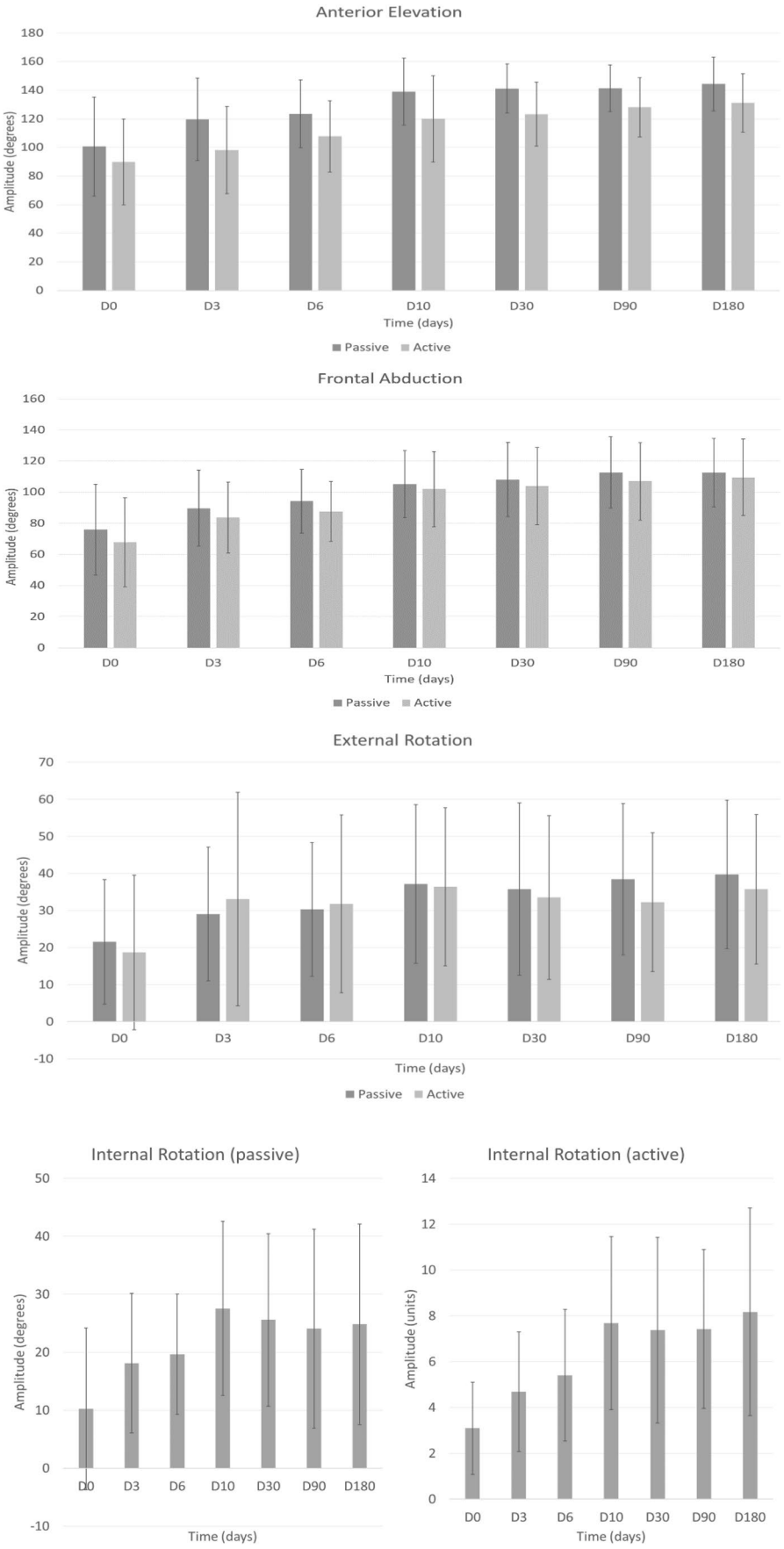

Fig. 3 Passive and active range of motion evolution across the different study time points (D0 to D180). Bar plots represent the mean while error bars represent the standard deviations

rehabilitation, difficult to achieve with intermittent blocks where the level of analgesia is variable [34]. This long-term enhancement in AC-related parameters suggests better prospects for quality of life. Complete resolution of ROM deficits may not be essential for a return to full function [35]. This is further supported by the significant improvements in DASH scores, indicating clinically relevant changes in disability levels [36].

The present study is limited by several aspects. First, there was no distinct control group as it was not feasible to provide a standard care or placebo injections as a control condition, particularly considering the extended duration of the protocol (6 months) that encompassed a ten day hospitalization period. The positive effects observed could therefore have been driven by the dedicated and intensive rehabilitation program only and not by the combination with SSNB. The overall medical attention received during hospitalization could further improve the patients' status on its own. These hypotheses could not have been tested due to the absence of a control group. Second, the length of our protocol led to an increasing number of dropouts over time and instances of missing data. This phenomenon is not uncommon in extended protocols and has been mitigated through the utilization of the LOCF imputation method, widely accepted and highly conservative for longitudinal studies [37]. An additional limitation pertains to the relatively small sample size. We decided indeed to focus on chronic (i.e., above 6 months) AC rebel to conventional treatments which reduced our recruitment capacity. Finally, the external validity was limited. The intensive nature of the protocol, involving hospitalization, surgical intervention, and comprehensive rehabilitation, may not be readily replicable across diverse healthcare systems and cultural contexts and would require implementation efforts.

In conclusion, these findings offer promising prospects for managing chronic AC. The study's focus on refractory AC patients, who showed no improvement despite prior pharmacological and rehabilitation interventions, demonstrates that the combination of continuous analgesia through SSNB and intensive rehabilitation is an effective approach for reducing pain, enhancing ROM, and improving function and quality of life.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00264-023-05999-0.

Acknowledgements The authors would like to thank all the patients for their participation in this study. The authors would like to acknowledge the work of master's students in physiotherapy involved in participants' recruitment, data collection, data management, and data curation: Kévin Fontaine, Gilles Gertz, Claire Philippe, and Nasser Yahya.

Author contribution G.M.: data curation, formal analysis, visualization, writing—original draft, and writing—review and editing; R.F.: conceptualization, investigation, methodology, and writing—review and editing; P.G.: investigation and writing—review and editing; M.R.: investigation and writing—review and editing; H.T.: investigation and writing—review and editing; J.P.L.: investigation, methodology, and writing—review and editing; K.B.: investigation and writing—review and editing; J.F.K.: conceptualization, methodology, project administration, and writing—review and editing; B.F.: conceptualization, investigation, methodology, project administration, supervision, writing—original draft, and writing—review and editing.

Data availability Anonymized participant's data will be made available by motivated request to the corresponding author (geraldine.martens@uliege.be).

Declarations

Ethics approval This study was performed in line with the principles of the Declaration of Helsinki. This observational retrospective study has been approved by the institutional ethics committee of the University and University Hospital of Liège, Belgium (reference 2014/20, Committee Nr 707-505, EudraCT 2004-000194-39).

Consent to participate Informed consent was obtained from all individual participants included in the study.

Competing interests The authors declare no competing interests.

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