Platelet-Rich Plasma versus Corticosteroid Injections in Rotator Cuff Related Shoulder Pain: A Comparative Study with Up to 18 Months of Follow-Up

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Research Article

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Abstract

Purpose: Given the complications involved in corticosteroid (CS) injections, subacromial platelet-rich plasma (PRP) injections may provide a valid alternative to CS in the treatment of rotator cuff related shoulder pain (RCRSP).

Methods: We retrospectively reviewed a total of 98 patients affected by RCRSP who were treated with either subacromial injection of PRP or CS. The PRP group received three injections of autologous PRP at two weeks interval, and the CS group received one injection of CS. Western Ontario Rotator Cuff Index (WORC) was the primary outcome measure, while secondary outcome measures were the Visual Analogue Scale (VAS), Range of Motion (ROM) and need for cuff repair surgery, which were analyzed at interval of 6, 12, and 18 months.

Results: A total of 75 patients were included in the analysis (PRP $n = 35$, CS $n = 40$). Mean follow-up was (PRP 21.1 ± 8.7 months vs CS 33.6 ± 16.3 months, $p < 0.001$). Both groups showed improvement in WORC, VAS and ROM. No significant differences were detected between the two groups in any of the primary (WORC) or secondary outcomes during 6, 12 and 18 months (all $p > 0.05$). No adverse events were detected.

Conclusion: Both treatments improve RCRSP patient's symptoms, but none of them seems to result in a significant better outcome in this series of patients. PRP can be a safe and feasible alternative to CS in treatment of RCRSP even at long follow-up, to reduce local and systemic effects involved with CS injections.

Introduction

Shoulder area pain incidence is estimated to be 0.9–2.5% and prevalence is increasing rapidly with age, reaching as high as 6.7 to 66.7% during lifetime. [1] The pathology often complex and multifaceted, which has led to describing the problem as rotator-cuff related shoulder pain (RCRSP). [2] RCRSP includes subacromial impingement syndrome, rotator cuff tendinopathy and subacromial pain syndrome (SAPS), which is also used to describe shoulder area pain with several potential underlying causes. [2, 3] General guidelines suggest that RCRSP/SAPS should be treated non-operatively. [3, 4] Treatment options include various injection therapies, analgesic drugs, physical therapy, extracorporeal shockwave therapy or ultrasound guided needling (barbotage). [2, 3]

Injection therapy options include corticosteroids (CS), platelet-rich plasma (PRP), hyaluronic acid (HA) and botulinum toxin. [5] A meta-analysis suggests that corticosteroids may yield beneficial results in the short-term symptom alleviation, however, PRP and prolotherapy may be better in the long term. [5] The PRP injection therapies have shown great potential in rotator cuff (RC) related problems, but also in other tendon and joint related disorders. [6–7]

Previous studies of both *in vivo* and *in vitro* suggest that CS injections may reduce symptoms in tendinopathies, but also may cause further damage to the soft tissue and systemic disorders. [8–14] There is also evidence that analgesic substances which are commonly used concurrently with CS injections may cause unfavorable effects in the soft tissue structures. [15] The safety of CS injections with local analgesic is therefore questionable.

In contrast, PRP injections have not shown any significant negative effects or adverse effects in previous studies, suggesting that PRP may have a multitude of beneficial effects regarding soft tissue healing. [16, 17] Only few studies directly compared subacromial injections of PRP versus CS and further comparisons to the widely used corticosteroid injections are still warranted. Most of the previous studies were conducted using a very small number of patients and/or with a short follow-up. [6, 16, 18–22] Despite the encouraging results of PRP injections used concurrently with arthroscopic RC repair, there is still little information about its effects as injection therapy solely. [6, 23, 24] There is no certainty how PRP compares to other conservative treatment options, and a meta-analysis suggests that the results of the previous studies are to be interpreted with caution due to the aforementioned reasons. [6]

The aim of this study was to investigate and compare the effects of subacromial PRP and corticosteroid injections in the RC and shoulder disorders best described as RCRSP, in terms of symptoms relief and functional improvement. We hypothesized that subacromial PRP injections may yield equal results to CS injections in RCRSP treatment.

Material And Methods

This study was approved by the Institutional Review Board (39/13.01.01/2018, Welfare District of Forssa, Finland), and it was conducted in accordance with the ethical principles of the World Medical Association Declaration of Helsinki. Individual informed consent for study participation was obtained from all participants and ethical approval was given by the local Ethics Committee of the University of Turku.

We reviewed 98 consecutive patients with rotator-cuff and shoulder disorders best described RCRSP or SAPS between 2014 and 2018 at the Department of Surgery, of the Welfare District of Forssa, Finland. This was a single center study. The patients received either subacromial PRP injections or single CS injections. We retrospectively compared the outcomes of the two groups.

Patients received either single injection of 2 mL (40 mg/mL) methylprednisoloneacetate (Solomet, Orion Oyj, Espoo, Finland, or Depo-Medrol Pfizer Inc, New York City, New York, United States) or three 4–5 mL injections of autologous PRP (Commercial Glo PRP kit, GloFinn corporation, Salo, Finland) in subacromial space. PRP injections were given at two weeks interval. All the patients were also instructed by a physical therapist to exercise their shoulder with pendulum motion and wall climbing with the upper extremity as per routine protocol in patients with RCRSP.

Inclusion criteria were following: age between 18 and 90 years, diagnosed RCRSP, other causes ruled out by imaging and clinical inspection, preintervention Visual Analogue Scale (VAS) of 30–100. The

diagnosis and ruling out other disorders not fitting to be RCRSP were conducted with X-ray imaging and magnetic resonance imaging (MRI) and/or ultrasound (US), as well as clinical inspection by an experienced orthopedist. Exclusion criteria were: traumatic rotator cuff ruptures, fractures, frozen shoulder, nerve-related symptoms, labral and long tendon of the biceps muscle tears, osteoarthritis of the acromion-clavicular joint and glenoid-humeral joint and in general conditions requiring surgical intervention as a primary care were excluded. We also excluded patients with major systemic disorders (hematological diseases, infections, immunodeficiency), pregnancy or possible pregnancy, and patients who received any other kind of subacromial injections or oral medication other than paracetamol or NSAID.

Patients' demographics, treatment modality, frequency of the treatment, imaging results and clinical outcomes were carefully collected both from the patients' electronic medical records as well as prospectively maintained departmental database. The primary outcome measurement was Western Ontario Rotator Cuff Index (WORC) and secondary outcome measures were: visual analogue scale (VAS), range of motion (ROM) and need for surgical intervention. The parameters were recorded before the treatments and at 6 months, 12 months and 18 months or over. Typical findings in the patients' MRI scans were tendinosis/tendinitis in the tendon of supraspinatus muscle with or without subacromial bursitis and in some cases tendinosis/tendinitis of other RC muscle (infraspinatus, teres minor or subscapularis). One patient in the CS group had also subscapularis and infraspinatus tendinitis/tendinosis with edema, but without supraspinatus tendinosis. The PRP group included one patient with a minor intra-tendinotic rupture of the supraspinatus tendon with accompanying tendinosis.

Patients' selection protocol and drop-outs in each follow-up points are described in Fig. 1. (Fig. 1) A total of 75 patients (PRP $n = 35$, CS $n = 40$) were included in the final analysis after inclusion and exclusion criteria were applied.

We showed the measures of parametric and nonparametric as mean ± standard deviation (SD). Statistical analysis was carried out using SPSS statistical software (IBM SPSS Statistics, version 23, Armonk, NY, U.S.A). Two-sided P value of ≤ 0.05 was set as statistically significant. For comparisons between the study groups we used Student's t-test for continuous variables and Fisher's exact test for discrete variables, according to the data type. We calculated the post hoc statistical power of 47.5% concerning the primary outcome measure including an observed effect size of 0.436 (Cohen's d).

Results

A total of 75 patients, treated for RCRSP between 2014 and 2018, were included into the final analysis. Surgery was the most common reason for losing patients before 18 months of follow-up. (Fig. 1) A total of 15 patients (42,8 %) from the PRP group and 11 (27,5 %) from the CS group did not complete the 18 months follow-up (Fig. 1).

Of them, 35 patients (47%) received PRP injections while 40 (53%) received CS injection. Demographic data are outlined in Fig. 2, showing significant difference in the sex ratio (PRP female to male 28:7 vs CS

23:17, $p = 0.048$), and having any comorbidities, which were higher in the CS-group (PRP 7 [20%] vs CS 19 [47.5%], $p = 0.013$ - Fig. 2). There were no statistically significant differences between the groups in other demographics data (Fig. 2).

Considering the pre-intervention parameters, there was difference in WORC emotions subscore (PRP 189.7 ± 56.0 vs CS 146.7 ± 74.7, $p = 0.007$), but no other parameters (Table 1). Preintervention WORC lifestyle subscore showed a trend towards PRP group, but with no statistical significance was detected (PRP 253.3 ± 76.0 vs CS 222.9 ± 68.2, $p = 0.072$ - Table 1).

The post-interventional data showed no significant differences in the WORC, ROM or VAS scores between the two groups at 6, 12 or 18 months (all $p > 0.05$ - Table 2,3, Fig. 3,4). We also detected the number of shoulder surgeries during the follow-up period, but there was no difference between the groups, although less cases in the PRP gourp (PRP 7 [20%] vs CS 11 [27.5%], $p = 0.589$ - Table 3).

No adverse events were detected during the follow-up because of the injection procedures. The PRP group had more injections than CS group due to the different treatment protocol. The mean follow-up was over 20 months in both groups, but there was a significant difference between groups favoring patients treated with corticosteroids (PRP 21.1 ± 8.7 vs CS 33.6 ± 16.3, $p < 0.001$ - Table 2).

Table 1
Comparison of pre-interventional parameters in the two groups of patients

	PRP group (n = 35)	*Corticosteroid group (n = 40)*	*p-value*
Bilateral	2 (5.7%)	2 (5.0%)	1.000
VAS score (mean ± SD)	70.4 ± 10.7	69.4 ± 13.7	0.714
WORC physical total (mean ± SD)	49.2 ± 14.4	49.5 ± 13.3	0.921
WORC sports total (mean ± SD)	25.3 ± 18.6	26.4 ± 14.7	0.786
WORC work total (mean ± SD)	30.3 ± 19.8	32.8 ± 18.1	0.560
WORC lifestyle total (mean ± SD)	253.3 ± 76.0	222.9 ± 68.2	0.072
WORC emotions total (mean ± SD)	189.7 ± 56.0	146.7 ± 74.7	0.007
WORC total (mean ± SD)	1331.1 ± 307.6	1233.1 ± 270.0	0.146
ROM frontal (degrees, mean ± SD)	138.3 ± 40.7	145.5 ± 44.0	0.466
ROM abduction (degrees, mean ± SD)	123.6 ± 46.4	121.2 ± 50.6	0.838

Table 2
Comparison of post-interventional parameters in the two groups of patients at 6- and 12-months follow-up

	PRP group (n = 35)	*Corticosteroid group (n = 40)*	*p-value*
VAS score 6 months (mean ± SD)	28.1 ± 29.3	22.2 ± 31.4	0.410
WORC physical total 6 months (mean ± SD)	149.4 ± 146.0	112.2 ± 142.3	0.274
WORC sports total 6 months (mean ± SD)	143.3 ± 143.3	108.2 ± 131.1	0.278
WORC work total6 months (mean ± SD)	129.7 ± 130.2	94.9 ± 126.6	0.251
WORC lifestyle total 6 months (mean ± SD)	107.7 ± 122.5	76.8 ± 109.3	0.259
WORC emotions total 6 months (mean ± SD)	81.1 ± 96.9	54.7 ± 83.3	0.141
WORC total 6 months (mean ± SD)	606.3 ± 612.9	446.3 ± 570.9	0.224
ROM frontal 6 months (mean ± SD)	161.9 ± 34.3	168.4 ± 25.8	0.357
ROM abduction 6 months (mean ± SD)	160.4 ± 36.2	159.9 ± 35.4	0.948
VAS score 12 months (mean ± SD)	17.1 ± 27.6	13.8 ± 28.2	0.647
WORC physical total 12 months (mean ± SD)	99.1 ± 143.2	75.4 ± 121.1	0.483
WORC sports total 12 months (mean ± SD)	84.7 ± 124.2	74.2 ± 112.4	0.730
WORC work total 12 months (mean ± SD)	80.7 ± 122.2	60.1 ± 105.4	0.480
WORC lifestyle total 12 months (mean ± SD)	59.8 ± 102.8	41.7 ± 84.1	0.448
WORC emotions total 12 months (mean ± SD)	48.6 ± 83.5	34.2 ± 71.2	0.467
WORC total 12 months (mean ± SD)	372.9 ± 552.2	285.8 ± 474.0	0.506
ROM frontal 12 months (mean ± SD)	170.7 ± 22.8	174.2 ± 16.6	0.482
ROM abduction 12 months (mean ± SD)	168.8 ± 26.0	168.8 ± 25.6	0.999
Follow-up (months, mean ± SD)	21.1 ± 8.7	33.6 ± 16.3	< 0.001

Table 3
Comparison of post-interventional parameters in the two groups of patients at 18-months

	PRP group (n = 35)	*Corticosteroid group (n = 40)*	*p-value*
VAS score 18 months (mean ± SD)	15.0 ± 26.4	6.5 ± 16.6	0.168
WORC physical total 18 months (mean ± SD)	91.2 ± 141.5	44.8 ± 76.6	0.140
WORC sports total 18 months (mean ± SD)	86.2 ± 129.2	49.5 ± 83.5	0.227
WORC work total 18 months (mean ± SD)	83.5 ± 126.4	39.8 ± 83.3	0.147
WORC lifestyle total 18 months (mean ± SD)	58.7 ± 97.0	22.5 ± 55.6	0.100
WORC emotions total 18 months (mean ± SD)	46.5 ± 82.8	14.5 ± 31.1	0.060
WORC total 18 months (mean ± SD)	366.2 ± 551.5	171.2 ± 309.5	0.116
ROM frontal 18 months (mean ± SD)	168.5 ± 26.0	176.3 ± 13.8	0.172
ROM abduction 18 months (mean ± SD)	166.7 ± 28.6	173.3 ± 20.0	0.343
Any adverse event	0 (0.0%)	0 (0.0%)	1.000
Any arthroscopy	7 (20.0%)	11 (27.5%)	0.589
Any shoulder surgery	7 (20.0%)	11 (27.5%)	0.589

Discussion

Our study demonstrated that PRP is not inferior to CS in any of the measured parameters. Both of the groups experienced similar benefits from the injection therapies with no statistical differences detected in WORC, ROM or VAS scores at 6, 12 and 18 months. No adverse effects were detected in either of the two groups. This is the first study of RCRSP patients treated with either PRP or CS injections showing that PRP is not inferior to CS even in the long-term follow-up.

Our results are consistent with current literature, showing that PRP can be beneficial treatment in RCRSP. [5, 20, 22, 25] Previous studies are controversial in interpreting the efficacy of PRP injections due to the different research and treatment protocols, in many cases involving arthroscopy or different products of PRP, for example PRP fibrin matrix. [5, 23, 24] There are only three similarly conducted previous studies comparing subacromial injections of PRP to CS. [19, 21, 25] Among them, only Say et al. reported CS to be superior to PRP in the treatment of subacromial impingement syndrome, in their study including 60 patients. [19] However, the study was not randomized and the follow-up was short (six months). [19] Then, Shams et al. demonstrated that PRP group had better results in early stages of follow-up (three months), but no statistical differences were detected in the long-term (six months) results. [22] Their

study was randomized, including MRI for confirmed partial RC ruptures with persistent (over three months) shoulder pain, but only 40 patients were enrolled without documentation of detailed demographic data. [22] Finally, von Wehren et al. reported that there was earlier benefit favoring PRP in their study of 50 patients with partial RC tear, however no difference was detected at six months of follow-up. [25] Their limitations were the absence of randomization and relatively few patients. [25] Both Shams et al. and von Wehren et al. concluded that PRP might be a good alternative instead of subacromial CS injections. [22, 25]

The strength of our study included a larger number of patients and a long follow-up in a comparative matter compared to the previous published studies. The mean follow-up clearly was longer than in previous studies, exceeding over a year. Preintervention inclusion and exclusion criteria were strict and thorough with up to three imaging modalities involved as well as an experienced orthopedist in order to include only patients with RC tendinosis/tendinitis sometimes accompanied with subacromial bursitis or rarely a small/marginal tear in the RC tendon. Demographic and clinical data were meticulously collected.

Retrospective design and lack of randomization are the major limitations of this study. However, due to the heterogenic and multifaceted nature of shoulder and RC problems, there are often multiple imaging findings involved such as RC tendon degeneration, bursitis or minimal tears. This may limit the interpretation and generalization of the results because of multiple pathological structures involved. The rotational ROM data was incomplete which is why it was not always included in the analysis, which leaves an uncharted area in the clinical response to the treatments. PRP group included more females than the CS group, this might explain the lower mean pretreatment WORC emotions subscore in the CS group, because females usually report more symptoms than men. [26]. Furthermore, CS group had significantly more comorbidities than the PRP group, which may affect the joint pathology and symptom scores. We have no accurate information about the type and amount of NSAIDs used by the patients, which may also have affected the preintervention results. Physical therapy that all the patients received was not only a limitation to this study, but also a necessary one. Physical therapy is essential part of the treatment and rehabilitation in shoulder area diseases. However, it must be noted that often injection therapies and analgesics may enable the struggling patient to even begin the physical therapy, which may otherwise prove to be too difficult due to symptoms. The physical therapy may explain some of the symptoms' changes during the follow-up, but its impact is dramatically reduced since the same protocol was applied to both groups.

We lost 20 patients (33%) of the CS group and three patients (7.9%) of the PRP group due to the strict inclusion and exclusion criteria or patients' not completing any of the follow-up controls. The most common reason for losing a patient during the follow-up before 18 months was surgery of the shoulder area, which accounted up to seven patients (20%) in the PRP group and up to 11 patients (27.5%) in the corticosteroid group. The other factor for losing eight (22.9%) patients in the PRP group, was simply because patients did not complete the follow-up. The loss of patients leaves always an open interpretation that perhaps their symptoms were improved and they did not want to receive further

treatment. Although larger than previous studies, our sample size was relatively small, with a post hoc statistical power of 47.5%.

Management of symptoms and improving function are the main goals of the treatment. [2, 3] Current literature strongly advices against surgery in conditions that RCRSP covers, and favors conservative treatment options. [4] In this perspective, PRP may offer a valid alternative to CS, considering that there are no documented significant adverse effects in PRP treatments unlike in CS treatments. [6, 8, 12, 22] The advantages of PRP over CS are the absence of severe complications locally and systematically. It is safe and simple treatment. Disadvantages of PRP would be more injections required to achieve similar outcomes as a single CS injection. PRP treatment may be repeated whether symptoms return, but multiple CS injections should be avoided. Concurrent physical therapy is still advised because of its proven benefits.

Further larger randomized controlled trials (RCT) are warranted to validate this promising treatment modality. Moreover, the role of PRP as a potential disease modifying agent is unclear and combining imaging to the follow-up protocol would be beneficial.

Given the outcomes of our study, we recommend considering PRP as an alternative treatment to CS in order to reduce local and systemic effects involved with CS injections.

Declarations

Funding None

Conflicts of interest/Competing interests None

Availability of data and material Available

Code availability Not applicable

References

1. Luime, J. J. *et al.* Prevalence and incidence of shoulder pain in the general population; a systematic review. *Scand J Rheumatol.* **33**, 73–81 https://doi.org/10.1080/03009740310004667 (2004).
2. Lewis, J. Rotator cuff related shoulder pain: Assessment, management and uncertainties. *Man Ther.* **23**, 57–68 https://doi.org/10.1016/j.math.2016.03.009 (2016).
3. Diercks, R. *et al.* Guideline for diagnosis and treatment of subacromial pain syndrome: a multidisciplinary review by the Dutch Orthopaedic Association. *Acta Orthop.* **85**, 314–322 https://doi.org/10.3109/17453674.2014.920991 (2014).
4. Ketola, S., Lehtinen, J. T. & Arnala, I. Arthroscopic decompression not recommended in the treatment of rotator cuff tendinopathy: a final review of a randomised controlled trial at a minimum follow-up

of ten years. *Bone Joint J.* **99-B**, 799–805 https://doi.org/10.1302/0301-620X.99B6.BJJ-2016-0569.R1 (2017).

5. Lin, M. T. *et al.* Comparative effectiveness of injection therapies in rotator cuff tendinopathy: A systematic review, pairwise and network meta-analysis of randomized controlled trials. *Arch Phys Med Rehabil.* **100**, 336–34915 https://doi.org/10.1016/j.apmr.2018.06.028 (2019).
6. Chen, X., Jones, I. A., Park, C. & Vangsness, C. T. Jr The efficacy of platelet-rich plasma on tendon and ligament healing: A systematic review and meta-analysis with bias assessment. *Am J Sports Med.* **46**, 2020–2032 https://doi.org/10.1177/0363546517743746 (2018).
7. Shen, L., Yuan, T., Chen, S., Xie, X. & Zhang, C. The temporal effect of platelet-rich plasma on pain and physical function in the treatment of knee osteoarthritis: systematic review and meta-analysis of randomized controlled trials. *J Orthop Surg Res.* **12**, 16 https://doi.org/10.1186/s13018-017-0521-3 (2017).
8. Dean, B. J. *et al.* The risks and benefits of glucocorticoid treatment for tendinopathy: a systematic review of the effects of local glucocorticoid on tendon. *Semin Arthritis Rheum.* **43**, 570–576 https://doi.org/10.1016/j.semarthrit.2013.08.006 (2014).
9. Desai, V. S. *et al.* Increasing numbers of shoulder corticosteroid injections within a year preoperatively may be associated with a higher rate of subsequent revision rotator cuff surgery. *Arthroscopy.* **35**, 45–50 https://doi.org/10.1016/j.arthro.2018.07.043 (2019).
10. Lee, H. J., Kim, Y. S., Ok, J. H., Lee, Y. K. & Ha, M. Y. Effect of a single subacromial prednisolone injection in acute rotator cuff tears in a rat model. *Knee Surg Sports Traumatol Arthrosc.* **23**, 555–561 https://doi.org/10.1007/s00167-013-2395-1 (2015).
11. Mohamadi, A., Chan, J. J., Claessen, F. M., Ring, D. & Chen, N. C. Corticosteroid injections give small and transient pain relief in rotator cuff tendinosis: A meta-analysis. *Clin Orthop Relat Res.* **475**, 232–243 https://doi.org/10.1007/s11999-016-5002-1 (2017).
12. Nakamura, H. *et al.* Effect of corticosteroids and hyaluronic acid on torn rotator cuff tendons in vitro and in rats. *J Orthop Res.* **33**, 1523–1530 https://doi.org/10.1002/jor.22921 (2015).
13. Maman, E. *et al.* Detrimental Effect of Repeated and Single Subacromial Corticosteroid Injections on the Intact and Injured Rotator Cuff: A Biomechanical and Imaging Study in Rats. *Am J Sports Med.* **44**, 177–182 https://doi.org/10.1177/0363546515591266 (2016).
14. Freire, V. & Bureau, N. J. Injectable Corticosteroids: Take Precautions and Use Caution. *Semin Musculoskelet Radiol.* **20**, 401–408 https://doi.org/10.1055/s-0036-1594286 (2016).
15. Zhang, A. Z. *et al.* Cell toxicity in fibroblasts, tenocytes, and human mesenchymal stem cells – A comparison of necrosis and apoptosis-inducing ability in ropivacaine, bupivacaine, and triamcinolone. *Arthroscopy.* **33**, 840–848 https://doi.org/10.1016/j.arthro.2016.10.026 (2017).
16. Jo, C., Lee, S. Y., Yoon, K. S., Oh, S. & Shin, S. Allogenic pure platelet-rich plasma therapy for rotator cuff disease: A bench and bed study. *Am J Sports Med.* **46**, 3142–3154 https://doi.org/10.1177/0363546518800268 (2018).

17. Pauly, S., Klatte-Schulz, F., Stahnke, K., Scheibel, M. & Wildemann, B. The effect of autologous platelet rich plasma on tenocytes of the human rotator cuff. *BMC Musculoskelet Disord.* **19**, 422 https://doi.org/10.1186/s12891-018-2339-5 (2018).
18. Kim, S. J., Kim, E. K., Kim, S. J. & Song, D. H. Effects of bone marrow aspirate concentrate and platelet-rich plasma on patients with partial tear of the rotator cuff tendon. *J Orthop Surg Res.* **13**, 1 https://doi.org/10.1186/s13018-017-0693-x (2018).
19. Nejati, P., Ghahremaninia, A., Naderi, F., Gharisbzadeh, S. & Mazaherinazhad, A. Treatment of subacromial impingement syndrome: Platelet-rich plasma or exercise therapy? A Randomized controlled trial. *Orthop J Sports Med.* **5**, 2325967117702366 https://doi.org/10.1177/2325967117702366 (2017).
20. Say, F., Gurler, D. & Bulbul, M. Platelet-rich plasma versus steroid injection for subacromial impingement syndrome. *J Orthop Surg (Hong Kong).* **24**, 62–66 https://doi.org/10.1177/230949901602400115 (2016).
21. Scarpone, M. *et al.* Effectiveness of platelet-rich plasma injection for rotator-cuff tendinopathy: A prospective open-label study. *Glob Adv Health Med.* **2**, 26–31 https://doi.org/10.7453/gahmj.2012.054 (2013).
22. Shams, A., El-Sayed, M., Gamal, O. & Ewes, W. Subacromial injection of autologous platelet-rich plasma versus corticosteroid for the treatment of symptomatic partial rotator cuff tears. *Eur J Orthop Surg Traumatol.* **26**, 837–842 https://doi.org/10.1007/s00590-016-1826-3 (2016).
23. Hurley, E. T., Lim Fat, D., Moran, C. J. & Mullett, H. The efficacy of platelet-rich plasma and platelet-rich fibrin in arthroscopic rotator cuff repair: A meta-analysis of randomized controlled trials. *Am J Sports Med.* **47**, 753–761 https://doi.org/10.1177/0363546517751397 (2019).
24. Randelli, P., Arrigoni, P., Ragone, V., Aliprandi, A. & Cabitza, P. Platelet rich plasma in arthroscopic rotator cuff repair: a prospective RCT study, 2-year follow-up.. *J Shoulder Elbow Surg.* **20**, 518–528 https://doi.org/10.1016/j.jse.2011.02.008 (2011).
25. von Wehren, L. *et al.* The effect of subacromial injections of autologous conditioned plasma versus cortisone for the treatment of symptomatic partial rotator cuff tears. *Knee Surg Sports Traumatol Arthrosc.* **24**, 3787–3792 https://doi.org/10.1007/s00167-015-3651-3 (2016).
26. Brown, D. A., Elsass, J. A., Miller, A. J., Reed, L. E. & Reneker, J. C. Differences in Symptom Reporting Between Males and Females at Baseline and After a Sports-Related Concussion: A Systematic Review and Meta-Analysis. *Sports Med.* **45**, 1027–1040 https://doi.org/10.1007/s40279-015-0335-6 (2015).

Figures

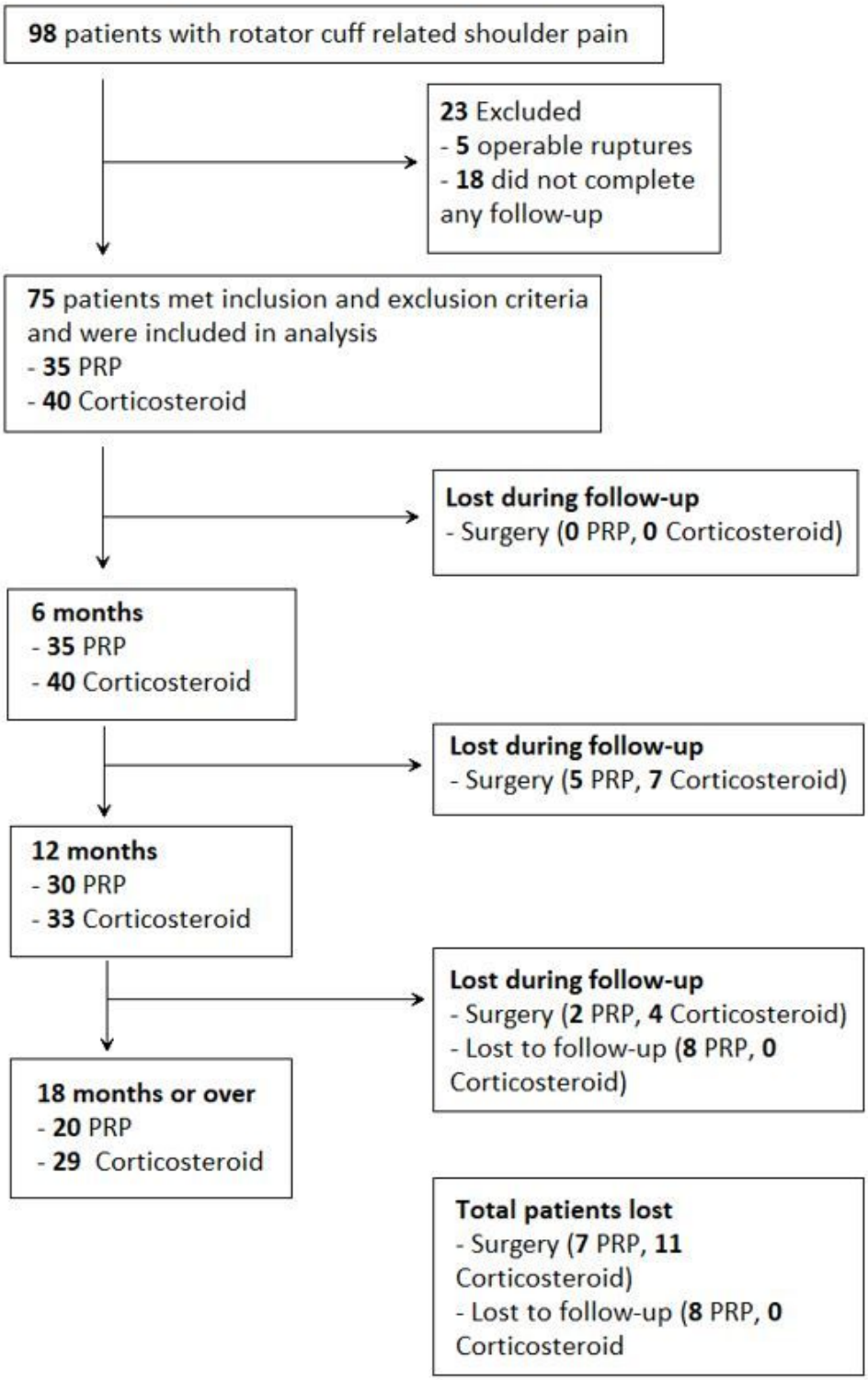

Figure 1

Patient selection protocol and follow-up flow

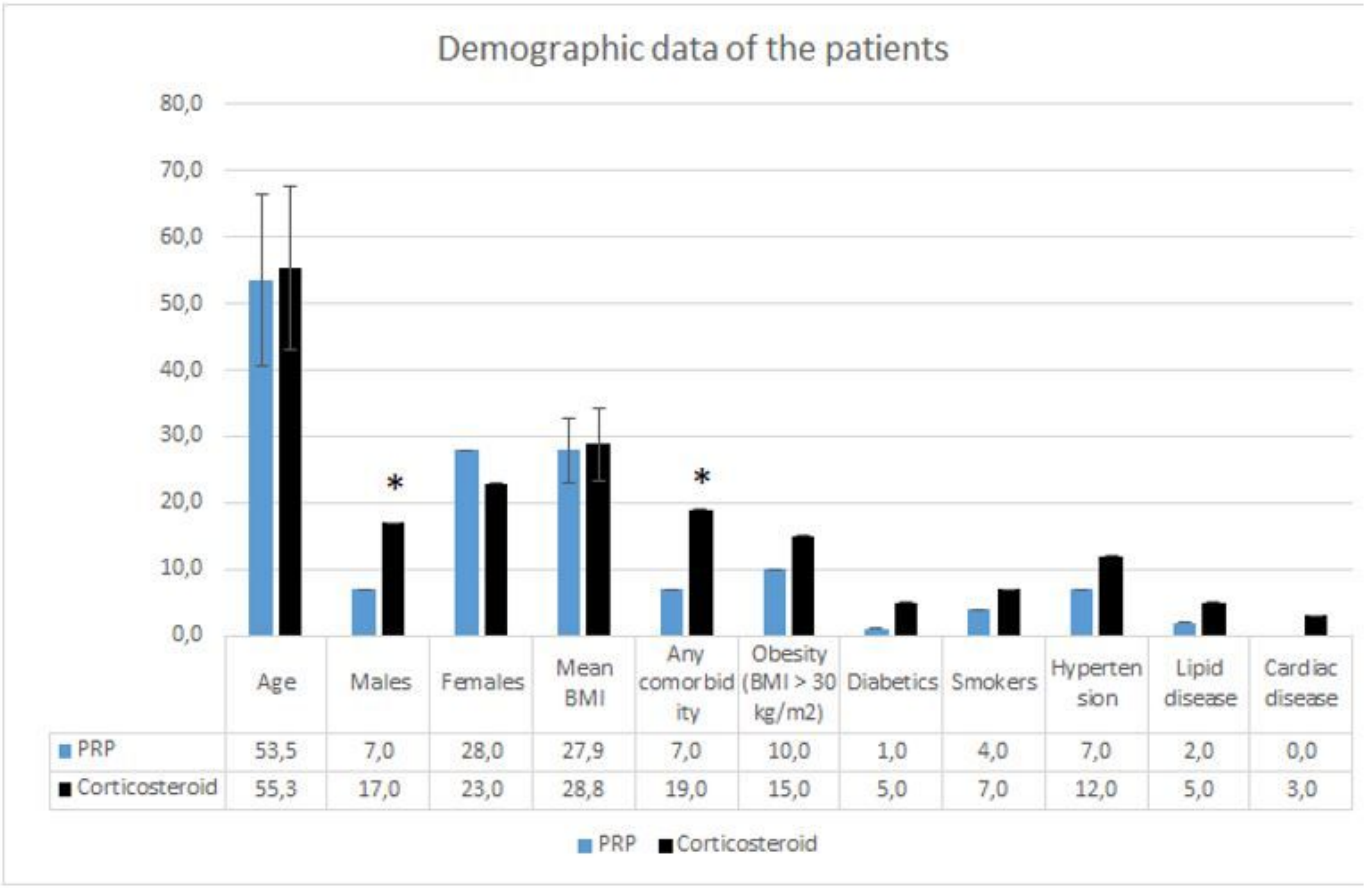

Figure 2

Demographic data of the patients at the time of study. Age and BMI expressed in mean values with 1 S.D. Asterisk (*) indicates significant statistical difference ($p < 0.05$) between the two groups

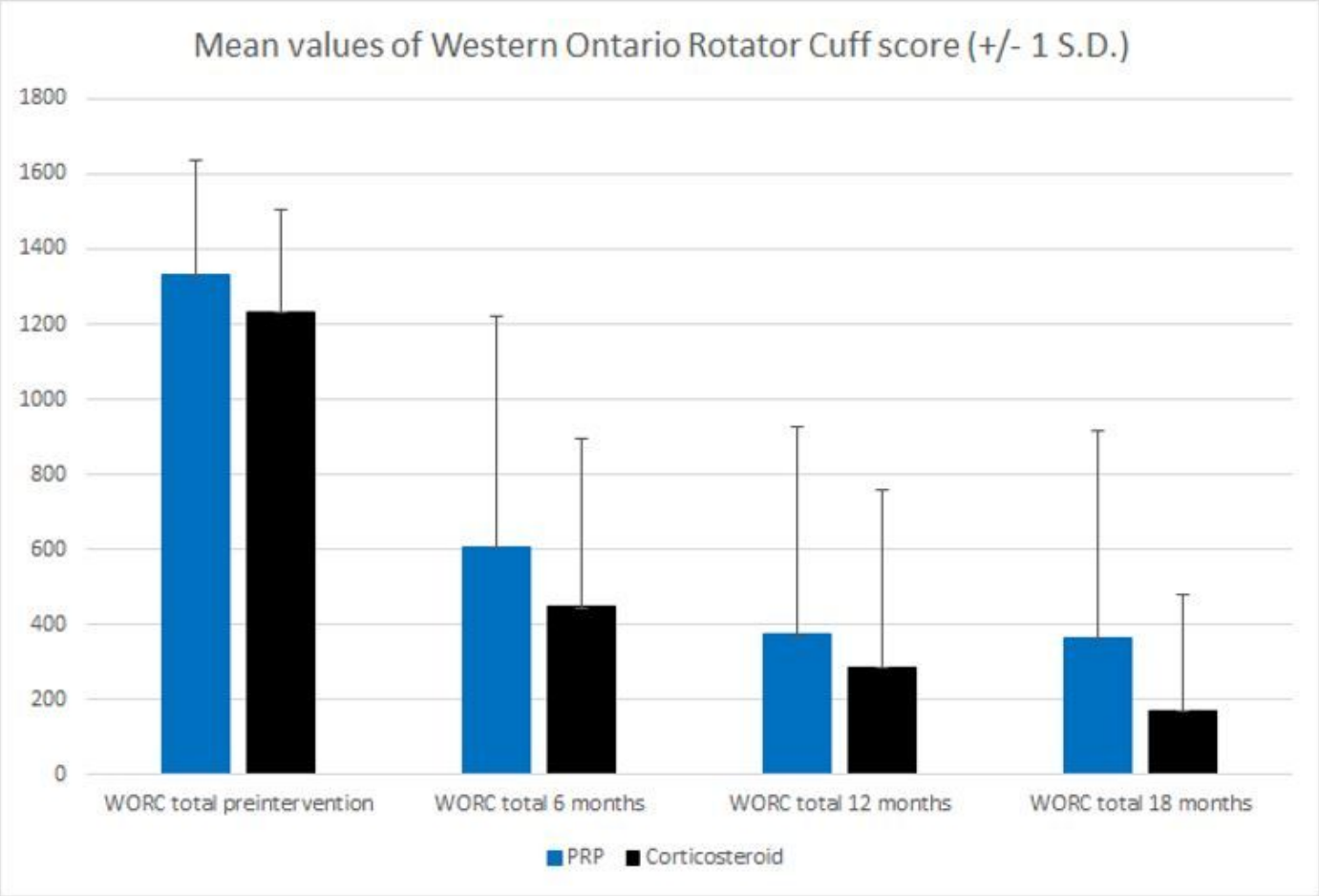

Figure 3

Mean values of Western Ontario Rotator Cuff total score during the follow-up between the corticosteroid group and the platelet-rich plasma group. No significant differences were detected between the two groups

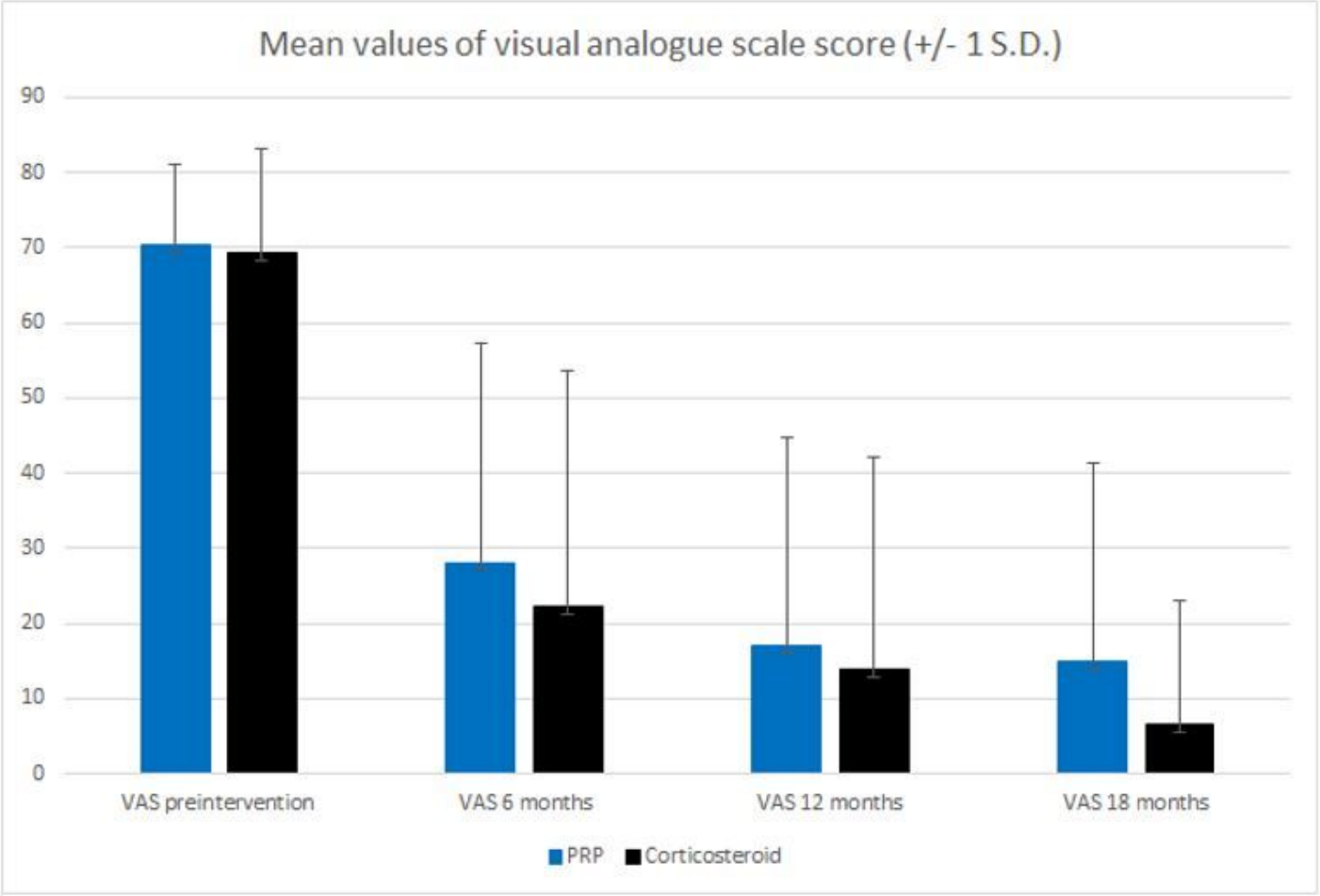

Figure 4

Mean values of Visual Analogue Scale during the follow-up between the corticosteroid group and the platelet-rich plasma group. No significant differences were detected between the two groups