Comparing the effectiveness of medium- and high-dose extracorporeal shockwave therapy against calcific tendonitis of the rotator cuff

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Abstract. High-dose Extracorporeal Shock Wave Therapy (ESWT) effectively reduces calcium deposit size and pain scores and restores joint movement scope (JMS); however, it is frequently associated with pain as a side effect. There are no reports that medium-dose ESWT is as effective as high-dose ESWT. This was a double-blind, randomized clinical trial to compare the effectiveness of medium-dose ESWT with that of high-dose ESWT in patients with rotator cuff calcific tendonitis. Patients tendonitis aged 30–70 years, with visual analog scale scores of ≥4 were included in the study and randomly assigned to receive high-dose or medium-dose ESWT. ESWT was administered twice at a 2-week interval, and patients were evaluated at 4, 8, and 12 weeks after therapy. Both groups exhibited significant differences in calcium deposit size, pain score, and JMS before therapy, immediately after therapy, and at 4, 8, and 12 weeks after therapy (p < 0.05). There were no significant between-group differences in calcium deposit size, pain score, and JMS before therapy, immediately after therapy, and at all evaluation points thereafter (p > 0.05). All patients who received high-dose ESWT reported pain as a side effect, whereas 12.5% of patients who received medium-dose ESWT reported pain (p < 0.001). High-dose ESWT and medium-dose ESWT produce equivalent results; however, medium-dose ESWT was associated with fewer side effects.

1. Introduction

Rotator cuff calcific tendonitis is associated with the accumulation of calcium crystals on the tendons of the rotator cuff; however, its etiology remains unclear. This condition is frequently diagnosed based on medical history, physical examination, and radioimaging of calcium deposits. Almost 50% of patients with calcific tendonitis complain of shoulder pain, especially at night. Further, joint movement limitation (JML) associated with the condition adversely influences activities of daily life. Non-operative treatments are successful in 90% of patients and include non-steroidal anti-inflammatory drugs, subacromial corticosteroid injections, percutaneous needle aspiration, exercise therapy, and multimodal therapies such as ultrasound, transcutaneous electrical stimulation (TENS), and shock wave therapy [1,2].

Extracorporeal Shock Wave Therapy (ESWT) is a nonpharmacological treatment for calcific tendonitis first reported in Germany (1992) and Austria (1998). It significantly reduces calcium deposit size and pain scores, while improving JML for tendons associated with the rotator cuff [3-10].
Side effects of high-dose ESWT include local bleeding (petechiae, hematoma), pain, arrhythmia, hypertension, and peripheral nerve paresthesia [11]. Medium-dose ESWT may be associated with reduced side effects, yet no data have shown that medium-dose ESWT is as effective as high-dose ESWT for treating calcific tendonitis [12]. Thus, the purpose of this research was to compare medium- and high-dose ESWT on variables of interest, including pain, JML, and calcium deposit size in patients with rotator cuff calcific tendonitis.

2. Methods
This was a double-blind, randomized clinical trial focused on patients with rotator cuff calcific tendonitis. Research was conducted at the musculoskeletal clinic in the Medical Rehabilitation Department of Cipto Mangunkusumo Hospital Jakarta. The study was carried out between July and December 2016 and was approved by the Health Research Ethics Committee of Faculty of Medicine, Universitas Indonesia-Cipto Mangunkusumo Hospital. A sample size of 40 patients meeting the following inclusion criteria were included: age 30–70 years, diagnosis of rotator cuff calcific tendonitis with ultrasonography, presence of musculoskeletal problems with a visual analog scale (VAS) score of ≥4, and willingness to participate in the study and provide informed consent. Patients were excluded if they had blood clotting disorders, used pacemakers, were pregnant, had malignancies, had infections that caused shoulder joint pain, had partial or total shoulder joint rotator cuff rheumatism, had a history of shoulder joint surgery, had unstable shoulder joint, or were uncooperative. Outlier criteria were missing evaluations, delay in the administration of the second therapy, rotator cuff surgery during the evaluation period, and withdrawal of consent from the study by the patients. Data were analyzed using the SPSS program for Windows version 21.0.

3. Results
Eighteen patients met the criteria for inclusion in the study, two of whom met the outlier criteria. Thus, in total, 16 patients were analyzed. Patient characteristics are explained in detail in Table 1

| Characteristics                      | Treatment Group | P value |
|--------------------------------------|-----------------|---------|
|                                     | Medium-dose (n = 8) | High-dose (n = 8) | |
| Age (years)*                         | 65.8±5.5        | 60.4±3.7        | 0.037 |
| Sex**                                |                 |                    |       |
| Male                                 | 3 (37.5)        | 4 (50)           | 0.614 |
| Women                                | 5 (62.5)        | 4 (50)           |       |
| Shoulder location**                  |                 |                    |       |
| Right                                | 6 (75.5)        | 4 (50)           | 0.301 |
| Left                                 | 2 (25)          | 4 (50)           |       |
| Calcium deposit location**           |                 |                    |       |
| Supraspinatus                        | 7 (87.5)        | 6 (75)           | 0.521 |
| Infraspinatus                        | 1 (12.5)        | 2 (25)           |       |
| Calcium deposit number**             |                 |                    |       |
| 1                                    | 7 (87.5)        | 6 (75.5)         | 0.521 |
| >1                                   | 1 (12.5)        | 2 (25.5)         |       |

Note: numerical data with normal distribution (*) are presented as mean (±SD), categorical data (**) are presented as n (%).

This study measured the calcium deposit size (in mm) using ultrasound before therapy and at 4, 8, and 12 weeks after therapy. Before therapy, there were no significant between-group differences (p = 0.060). For the medium-dose ESWT group, median calcium deposit size before therapy was 4.15 mm and shrank to 3.25 mm 4 weeks after therapy. The calcium deposit size continued to shrink through 8 and 12 weeks after therapy (and eventually reached 1.05 mm). For the high-dose ESWT group, median calcium deposit size before therapy was 5.35 mm and shrank to 3.85 mm 4 weeks after therapy.
therapy. As with the medium-dose group, the deposits continued to shrink through 8 and 12 weeks after therapy (eventually reaching 1.1 mm) (Table 2).

**Table 2. Changes in calcium deposit size in both groups**

| Calcium deposit size | Medium-dose ESWT group (n = 8) | High-dose ESWT group (n = 8) | p value |
|----------------------|-------------------------------|-----------------------------|---------|
| Before therapy       | 4.15 (2.7–7.5)                | 5.35 (3.6–8.4)              | 0.066   |
| 4 weeks after therapy| 3.25 (1.8–6.3)                | 3.85 (2.5–7.6)              | 0.494   |
| 8 weeks after therapy| 2.1 (1–5.1)                   | 2.2 (1.2–6.4)               | 0.599   |
| 12 weeks after therapy| 1.05 (0–1.5)                  | 1.1 (0.2–1)                 | 0.392   |

NB: Numerical data with abnormal distributions are presented as median (minimum value–maximum value).

In both treatment groups, there were significant changes in calcium deposit size before therapy and at 4, 8, and 12 weeks after therapy (p = 0.000). There were no differences between group in the magnitude of these changes (ANCOVA tests, p = 0.291).

Pain was assessed using VAS scores of 0–100 before therapy and at 4, 8, and 12 weeks after therapy. Before therapy, both groups exhibited VAS scores of >50 (53 for medium-dose ESWT group, 51 for high-dose ESWT groups). After therapy and at the next evaluation, the medium-dose group had a median VAS score of >30, whereas the high-dose group had a median VAS score of >20; by 12 weeks after therapy, both groups showed median values of >10 (Table 3).

**Table 3. Changes in VAS for both groups**

| VAS | Medium-dose ESWT Group (n = 8) | High-dose ESWT Group (n = 8) | p value |
|-----|-------------------------------|-----------------------------|---------|
| Before therapy | 53 (35–70) | 51 (25–77) | 0.746   |
| After therapy  | 38 (30–60) | 25 (10–45) | 0.148   |
| 4 weeks after therapy | 33 (20–40) | 25 (10–45) | 0.184   |
| 8 weeks after therapy | 33 (20–40) | 20 (10–30) | 0.045   |
| 12 weeks after therapy | 33 (10–40) | 15 (10–30) | 0.075   |

NB: numeric data with abnormal distributions are presented as median (minimum value–maximum value).

In both groups, VAS score significantly changed after therapy compared with that before therapy (p = 0.000). VAS scores after therapy were not significantly different compared with those at the next evaluation. There were no significant between-group differences in VAS score changes (ANCOVA tests, p = 0.427).

JML values were measured using a goniometer before therapy, immediately after therapy, and at 4, 8, and 12 weeks after therapy. We examined flexion, abduction, adduction, internal rotation, and external rotation. There was no significant between-group differences in JML values before therapy (p values are for flexion, abduction, adduction, internal rotation, and external rotation are p = 0.414, p = 0.414, p = 0.535, p = 0.662, p = 0.181, respectively) (Table 4).

**Table 4. Changes in the degree of JMS in both ESWT groups**

| JML   | Medium-dose ESWT Group (n = 8) | High-dose ESWT Group (n = 8) | p value |
|-------|-------------------------------|-----------------------------|---------|
| Flexion | Before therapy | 145 (100–180) | 160 (130–180) | 0.414   |
|       | After therapy   | 155 (130–180) | 170 (130–180) | 0.414   |
|       | 4 weeks after therapy | 160 (130–180) | 180 (140–180) | 0.228   |
|       | 8 weeks after therapy | 170 (130–180) | 180 (150–180) | 0.414   |
|       | 12 weeks after therapy | 173 (150–180) | 180 (150–180) | 0.662   |
Table 4. Continue

| JML               | Medium-dose ESWT Group (n = 8) | High-dose ESWT Group (n = 8) | p value |
|-------------------|--------------------------------|-------------------------------|---------|
| **Abduction**     |                                |                               |         |
| Before therapy    | 135 (90–180)                   | 160 (70–180)                  | 0.414   |
| After therapy     | 160 (100–180)                  | 170 (70–180)                  | 0.282   |
| 4 weeks after therapy | 160 (100–180)           | 175 (90–180)                  | 0.142   |
| 8 weeks after therapy | 160 (100–180)          | 175 (110–180)                 | 0.282   |
| 12 weeks after therapy | 170 (150–180)            | 175 (130–180)                 | 0.662   |
| **Adduction**     |                                |                               |         |
| Before therapy    | 45 (40–45)                     | 45 (40–45)                    | 0.535   |
| After therapy     | 45 (40–45)                     | 45 (45–45)                    | 0.317   |
| 4 weeks after therapy | 45 (40–45)                   | 45 (45–45)                    | 0.317   |
| 8 weeks after therapy | 45 (45–45)                   | 45 (45–45)                    | 1.000   |
| 12 weeks after therapy | 45 (45–45)                   | 45 (45–45)                    | 1.000   |
| **Internal rotation** |                              |                               |         |
| Before therapy    | 65 (20–90)                     | 55 (30–80)                    | 0.662   |
| After therapy     | 80 (45–90)                     | 70 (30–80)                    | 0.662   |
| 4 weeks after therapy | 70 (45–90)                   | 70 (30–80)                    | 0.755   |
| 8 weeks after therapy | 80 (60–90)                   | 75 (50–80)                    | 0.414   |
| 12 weeks after therapy | 85 (60–90)                   | 80 (50–90)                    | 0.345   |
| **External rotation** |                              |                               |         |
| Before therapy    | 70 (30–90)                     | 90 (60–90)                    | 0.181   |
| After therapy     | 90 (50–90)                     | 90 (60–90)                    | 1.000   |
| 4 weeks after therapy | 90 (50–90)                   | 90 (60–90)                    | 0.880   |
| 8 weeks after therapy | 90 (60–90)                   | 90 (70–90)                    | 0.808   |
| 12 weeks after therapy | 90 (80–90)                   | 90 (80–90)                    | 0.742   |

NB: numerical data with abnormal distributions are presented as median (minimum value–maximum value)

In both treatment groups, there were no significant changes in median JML on flexion (p = 0.059) and adduction (p = 0.251) before therapy, immediately after therapy, and at subsequent evaluation points. The magnitude of these changes did not significantly differ between the two groups for either flexion (p = 0.336) or adduction (p = 0.636) (Table 4).

Median JML abduction (p = 0.013), internal rotation (p = 0.022), and external rotation (p = 0.017) before therapy, immediately after therapy, and at subsequent evaluation points showed significant differences. The magnitude of these changes did not significantly differ between the two groups for either abduction (p = 0.210) or internal rotation (p = 0.969); however, there was a significant between-group difference in changes in external rotation (p = 0.025) (Table 4).

We examined common side effects of ESWT including pain and petechiae/hematoma. Side effects were determined by direct interviews. Of the eight patients who received medium-dose ESWT, only one complained of pain (12.5%), whereas all patients who received high-dose ESWT complained of pain. There were significant between-group differences in pain scores (p < 0.001). We did not observe petechiae/hematoma as side effects with any of the patients (Table 5).

Table 5. Effects of medium- and high-dose ESWT

| Group | ESWT | p value |
|-------|------|---------|
|       | Medium-dose (%) | High-dose (%) |     |
| Pain  | 1 (12.5)      | 8 (100)      | <0.001 |
| Petechiae | 0 (0)     | 0 (0)       |    |

NB: categorical data presented in the form of n (%)
4. Discussion

4.1. Effectiveness of medium-dose ESWT and high-dose ESWT on calcium deposit size in patients with rotator cuff calcific tendinitis

To date, the definite mechanisms underlying the therapeutic effects of ESWT on calcification in patients with rotator cuff calcific tendinitis remains unclear. This study hypothesized that ESWT could cause fragmentation and cavitation in calcium deposits, causing the deposit to become disorganized and disintegrate. Calcium deposits likely occur secondary to subacromial bursa or because local soft tissue is absorbed (mechanical effect). Cavitation activates inflammatory responses at the microcellular level, including leukocyte induction, extravasations, and chemotaxis. This triggers the secretion of growth factors such as platelet-derived growth factor, transforming growth factor beta, insulin-like growth factor, vascular endothelial growth factor (VEGF), and nitric oxide synthase. These substances induce tendon healing (chemical effects) [5,8,13,14].

To cause tissue cavitation or microtrauma, adequate energy flux density (EFD) intake is required. EFD 0.12 mJ/mm² (medium-dose) damages the cell membrane and EFD 0.50 mJ/mm² (high-dose) damages the cell [8,13]. This theory was proven by previous research using high-dose ESWT. Gerdesmeyer et al. showed that 60% of calcium deposits were lost after 6 months and 86% after 12 months [7]. Albert et al. showed 15% calcium deposit loss after 3 months [6]. Loew et al. observed 60% calcium deposit loss after 3 months (p = 0.0009) [5]. Hsu found that calcium deposit size decreased from 11.9 ± 5.4 mm to 5.5 ± 6.3 mm (p < 0.001) after 12 months [10]. Pan et al. found that mean calcium deposit size decreased by weeks 4 (p = 0.003) and 12 (p = 0.002) [1].

Previous research that used medium-dose ESWT showed 87% calcium deposit loss after 6 months (significance levels not noted) [9]. Perlick et al. found that 33.7% of calcium deposits disappeared after 12 months (significance levels not noted) [8].

This study observed significantly reduced calcium deposit size in both groups between those before therapy and those at 4, 8, and 12 weeks after therapy (p = 0.00). Calcium deposit size reduction did not significantly differ between groups (p = 0.291).

4.2. Effectiveness of medium and high-dose ESWT on VAS scores in patients with rotator cuff calcific tendinitis

Chronic pain occurs in patients with rotator cuff calcific tendinitis [2] and is defined as pain that persists for 1–6 months or more. Chronic pain can be nociceptive, neuropathic, or mixed pain. Pain associated with musculoskeletal problems (e.g., tendinitis calcification) is nociceptive. Nociceptive pain appears if nociceptors are stimulated. Nociceptors in muscles and tendons are deep somatic nociceptors. Based on type of nociceptors, deep somatic includes into type of silent nociceptors which responds to inflammation [15].

ESWT therapy stimulates deep somatic nociceptors, causing deep pain in tissue and releases neuropeptide. Neuropeptides then stimulate fibroblast tendons to synthesize collagen and begin the process of healing tendons [16]. ESWT therapy also triggers the secretion of VEGF, which in turn stimulates angiogenesis (the formation of new blood vessels) to improve blood supply to the tissue and initiate repairs in chronically inflamed tissue through tissue regeneration [14,17].

Pain in patients with rotator cuff calcific tendinitis sometimes become acute pain or subacute if using excessive force on the shoulders or stretching the shoulder suddenly [1]. Acute pain is temporary pain related to the existence of injury/tissue damage and lost along the healing process [15]. When patients using the shoulders on the repetitive movements, tendons produce crystal calcium, cause tissue damage and pain [18,19]. According to Wang, there was a correlation between reduced calcium deposit size and decreased pain in patients with calcific tendinitis [17]. Rompe et al. reported that tendon pain responses were affected by energy dosage, where doses >0.12 mJ/mm² (medium and high-dose) were more effective for overcoming pain, compared to doses <0.12 mJ/mm² (low) [20].

High-dose ESWT is effective for reducing pain in patients with calcific tendinitis, as observed by Gerdesmeyer who found VAS score reductions in the high-dose groups at 3, 6, and 12 months after therapy (p < 0.001) [7]. Hsu found a significant difference on VAS scores between the two groups (p < 0.05, ESWT high-dose) and the ESWT group resembled the value of a VAS score at the 3, 6, and 12 months after therapy (p < 0.001) [10]. Research by Pan determined that mean VAS scores significantly improve in patients who received high-dose ESWT, compared to those who received TENS, at 4 and 12 weeks after therapy (p = 0.001) [1].
This research showed similar results wherein the high-dose ESWT group exhibited reduced VAS scores after therapy compared with that before therapy (VAS 51 to VAS 25). Levels at 4, 8, and 12 weeks after therapy declined to under 25, although these changes did not rise to the level of statistical significance. Participants’ pain scale ratings, including mild pain, reportedly did not interfere with activities of daily living [21].

The use of the medium-dose ESWT therapy had not been much research done so that its effectiveness against pain in rotator cuff calcific tendonitis still unknown. Perlick et al. in 2003 and Peters et al. in 2004 tried to compare the high-dose ESWT and medium-dose, assessment of pain using the VAS score, said there are improvement of the VAS score in both treatment groups in this research, but the value of the significance was not listed. So also the value of the significance of the comparison of the change in VAS scores between the two groups was not listed [8,9].

This research showed that the use of the medium-dose ESWT statistically decreases VAS score between the VAS score before therapy and after therapy (VAS 53 decrease to a VAS 38). Then on evaluation the 4, 8, and 12 weeks after therapy although statistically showed no difference between the VAS score but still showed the VAS score of <30. The scale of pain still including mild pain, which does not interfere with the daily activities of the day [21].

4.3. Effectiveness of medium-dose and high-dose ESWT on JMS in patients with rotator cuff calcific tendonitis

In patients with rotator cuff calcific tendonitis, repetitive movements cause the tendons of the rotator cuff to produce crystal calcium, causing tissue damage and pain. This pain makes an affected patient reluctant to move his or her shoulder, and eventually the shoulder becomes rigid and joint movement decreases. Subacromial swelling (inflammation) may also accompany calcification in patients with rotator cuff tendonitis, causing loss of active and passive joint movement [19,22].

In this research, we examined flexion, abduction, adduction, and internal and external rotation. Before therapy, participants in both groups exhibited reduced JMS for all movements, with the exception of adduction. Immediately after ESWT therapy and at evaluation points 4, 8, and 12 weeks after therapy, we observed improved JMS for flexion, abduction, and internal and external rotation, in both groups. No improvements in JMS for adduction were noted in either group. This may be because, at baseline, JME for adduction was not reduced for either group.

Both groups demonstrated improved JMS for abduction, and internal and external rotation. These changes were significantly different between those before therapy and those after therapy and at 4, 8, and 12 weeks after therapy.

Improved flexion did not significantly differ between groups before and after therapy, and at 4, 8, and 12 weeks after therapy (p = 0.059). This might be because the rotator cuff (supraspinatus, infraspinatus, terrace minor, and subscapularis) is not responsible for shoulder joint flexion. Rather, the pectoralis major and deltoid anterior are responsible for shoulder joint flexion [23].

After ESWT therapy and at 4, 8, and 12 weeks after therapy, we did not see improvement in JMS for adduction, in either group (p = 0.251). This was likely because JMS for adduction was not decreased in either group at baseline. Should adduction is controlled by the subscapularis tendons, where no calcification was found [23].

Improved JMS for flexion (p = 0.336), abduction (p = 0.636), adduction (p = 0.210), and internal rotation (p = 0.969), did not significantly differ between the two groups. Medium and high-dose ESWT share the same EFD, sufficient for the production of cavitation which destroys calcium deposits and stimulates inflammation and healing [8,13]. Rompe et al found a relationship between a 75% decline in the size of the calcium deposit and improved JMS function [24].

JMS improvements for external rotation were significantly different (p = 0.025) between the two groups, with the medium-dose ESWT group improving more than the high-dose ESWT group. This could because the calcium deposits of the tendons infraspinatus for the medium-dose ESWT were present in 12.5% (1 of 8 samples) and therefore subsequent reductions were found in 100% (3.1 cm to 0 cm). On the ESWT group high-dose calcium deposits in the tendons infraspinatus were found in 25% (2 of 8 samples) and the overall decrease in deposit size was 87.5% (samples a: 8.4 cm become 2.1 cm, samples b: 5.5 cm to 0 cm).

Thus, JMS was improved at 4, 8, and 12 weeks after therapy to functional levels for flexion (>170°), abduction (>170°), adduction (45°), internal rotation (>80°), and external rotation (90°) [23].
Gerdesmeyer et al. found significant improvements in JMS at 3, 6, and 12 months after therapy [7]. Albert et al. showed that JMS improved by 27.3% (p = 0.048) [6]. Loew et al. observed that in 71% of participants, JMS was within normal limits within three months of treatment [5]. Hsu et al. found that in 87.9% of participants JMS reached normal after three months (p < 0.001) [10]. Perlick et al. also found that medium-dose ESWT improved JMS [8].

4.4. Side effects of medium- and high-dose ESWT

Retrospective research about complications, side effects and contraindications associated with high-dose ESWT revealed that pain on administration and superficial hematomas occurred in 78.2% of 276 patients. Systemic complications such as arrhythmia (0.014%) and hypertension (0.010%) were very rare [25]. Gerdesmeyer et al. found that 20 of 48 patients (41.6%) complained of pain and eight patients (16.6%) complained of severe pain. Petechiae, haematoma and peripheral nerve disorders were not found [7]. Hsu et al. found pain and localized erythema in 9.1% [10]. Pan et al. found pain in 15.15%, arrhythmias in 3%, and no petechiae/haematoma [1]. Peters et al. observed pain in 13% of patients receiving medium-dose ESWT, and in 81% of patients with high-dose ESWT. They found that hematomas occurred in six percent of those who received medium-dose ESWT, and 19% of those who received high-dose ESWT [9]. Perlick et al. observed pain in 5% of their sample, and 100% of those who received high-dose ESWT demonstrated petechiae. Among those who received medium-dose ESWT, 2.5% experienced pain and 37.5% experienced petechiae [8].

This study collected data on the effects of ESWT include pain and petechiae/hematoma. Only one of the eight patients who received medium-dose ESWT complained of pain (12.5%), whereas all patients who received high-dose ESWT reported pain (100%). The side effects of petechiae/hematoma were not found in any patients. Our observed differences in stated means (p < 0.001) are line with those previously-reported.

5. Conclusion

Medium and high-dose ESWT were equally effective at reducing calcium deposit size, reduced pain, and improved JML in patients with rotator cuff calcific tendonitis; however, medium-dose ESWT was associated with fewer side effects. Medium- and high-dose ESWT appear equally effective. However, this research was unable to detect between-group differences for specific variables. We could only determine that there was, or was not, a difference. Hopefully this research can inform future research. Side effects were more prevalent in patients who received high-dose ESWT.

References
[1] Pan P J, Chou C L, Chiou H J, Ma H L, Lee H C and Chan R C 2003 Extracorporeal shock wave therapy for chronic calcific tendinitis of the shoulders: a functional and sonographic study Arch. Phys. Med. Rehabil. 84 988-E93
[2] Diehl P, Gerdesmeyer L, Gollwitzer H, Sauer W and Tischer T 2011 Calcific tendinitis of the shoulder Orthopade. 40 733
[3] Haake M, Deike B, Thon A and Schmitt J 2002 Exact focusing of extracorporeal shock wave therapy for calcifying tendinopathy Clin. Orthop. Relat. Res. 397 323
[4] Cosentino R, De Stefano R, Selvi E, Frati E, Foreign S, Frediani B and Marcolongo R 2003 Extracorporeal shock wave therapy for chronic tendinitis of the shoulder: single blind study Ann. Rheum. Dis. 62 248
[5] Loew M, Daecke W, Kusnierczak D, Rahamanzadeh M and Ewerbeck V 1999 Shock-wave therapy is effective for chronic calcifying tendonitis of the shoulder. J. Bone Joint Surg. Br. 81 863
[6] Albert J D, Meadeb J, Guggenbuhl P, Marin F, Benkalfate T, Thomazeau H and Chalès G 2007 High energy extracorporeal shock-wave therapy for calcifying tendinitis of the rotator cuff: a randomised trial. J. Bone Joint Surg. Br. 89 335
[7] Gerdesmeyer L et al 2003 Extracorporeal shock wave therapy for the treatment of chronic calcifying tendonitis of the rotator cuff: a et al. trial JAMA 290 2573
[8] Perlick L, Luring C, Bathis H, Perlick C, Kraft C and Diedrich O 2003 Efficacy of extracorporeal shock-wave treatment for calcific tendinitis of the shoulder: experimental and clinical results J. Orthop. Sci. 8 777
[9] Peters J, Luboldt W, Schwarz W, Jacobi V, Herzog C, Vogl T J 2004 Extracorporeal shockwave therapy in calcific tendinitis of the shoulder Skeletal Radiol. 33 712
[10] Hsu C J, Wang D Y, Tseng K F, Fong Y C, Hsu H C and Jim Y F 2008 Extracorporeal shock wave therapy for calcifying tendinitis of the shoulder J. Shoulder Elbow Surg. 17 55
[11] Bannuru R, Flavin N, Vaysbrot E, Harvey E and McAlindon T 2014 High-energy extracorporeal shock-wave therapy for particular chronic calcific tendonitis of the shoulder. Ann. Intern. Med. 160 542
[12] Huisstede B M, Gebremariam L, Sande R, Hay E M and Koes B W 2011 Evidence for effectiveness of extracorporeal shock-wave therapy (ESWT) to treat calcific and non-calcific rotator cuff tendinosis—a systematic review J Manual Therapy 16 419
[13] Notarnicola A and Moretti B 2012 The biological effects of extracorporeal shock wave therapy (eswt) on tendons tissue Muscles Ligaments Tendons J. 2 33
[14] Funk and Lennard 2007 Tendons healing mechanobiology Muscles Ligaments Tendons J. 2 33
[15] Morgan G E, Michael M S and Murray M J 2013 Pain Management 5th ed (New York: McGraw-Hill Medical) pp 359–361
[16] Schmitz C, Császár N B, Milz S, Schieker M, Maffulli N, Rompe J D and Furia J P 2015 Efficacy and safety of extracorporeal shock wave therapy for orthopedic conditions: a systematic review on studies government ministries in the PEDro database Br. Med. Bull. 116 115
[17] Wang C J 2012 Extracorporeal shock wave therapy in musculoskeletal disorders J. Orthop. Surg. 7 11
[18] Uhthoff H K and Loehr J W 1997 Calcific tendinopathy of the rotator cuff: Pathogenesis, diagnosis and management J. Am. Acad. Orthop. Surg. 5 183
[19] Hatch J 2014 Shoulder pain, diagnosis and treatment of common conditions J. Arth. Surg. 6 1
[20] Rompe J D, et al.1997 Extracorporeal shockwave therapy: experimental basis, clinical application Orthopade 26 215
[21] World Health Organization 2013 Pain Step Ladder (Malta: World Health Organization)
[22] Burbank K M, Stevenson J H, Gregory R, Czarneck I and Dorfman J 2008 Chronic shoulder pine tree: Part I. evaluation and diagnosis J. Am. Fam. Phy. 77 453
[23] Lynn L S 2006 Clinical Kinesiology and Anatomy, 4th ed. (Philadelphia: E.A. Davis Company)
[24] Rompe J D, Birger R A, Hopf C and Eysel P 1998 Shoulder function after extracorporal shock wave therapy for calcific tendonitis. J. Shoulder Elbow Surg. 7 505
[25] Sistermann R and Katthagen B D 1998 Complications, side effects and contraindications in the use of the medium and high-energy extracorporeal shock-in orthopedics Z. Orthop. Ihre Grenzgeb. 136 175.