



## Update article

# Shockwave treatment for musculoskeletal diseases and bone consolidation: qualitative analysis of the literature<sup>☆</sup>



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## ABSTRACT

Shockwave treatment is an option within orthopedics. The exact mechanism through which shockwaves function for treating musculoskeletal diseases is unknown. The aim of this study was to make a qualitative analysis on the effectiveness of shockwave treatment among patients with musculoskeletal pathological conditions and pseudarthrosis. Searches were conducted in the Cochrane Library, Medline and Lilacs databases. Thirty-nine studies that reported using shockwave treatment for musculoskeletal diseases were found. Their results varied greatly, as did the types of protocol used. The studies that evaluated the effectiveness of shockwave treatment for lateral epicondylitis, shoulder tendinopathy, knee osteoarthritis, femoral head osteonecrosis and trochanteric bursitis reported inconsistent results for most of their patients. Those that evaluated patients with calcifying tendinopathy, plantar fasciitis, Achilles tendinopathy, patellar tendinopathy and pseudarthrosis showed benefits. Shockwave treatment is a safe and non-invasive method for chronic cases in which conventional techniques have been unsatisfactory and should be used in association with other treatment methods for tendinopathy. Further quality studies are needed.

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## Tratamento por ondas de choque nas doenças musculoesqueléticas e consolidação óssea – Análise qualitativa da literatura

## RESUMO

O tratamento por ondas de choque é uma opção na ortopedia. O mecanismo exato pelo qual funcionam as ondas de choque para tratar doenças musculoesqueléticas não é conhecido. O objetivo deste trabalho é fazer a análise qualitativa da efetividade do tratamento por ondas

## Palavras-chave:

Ondas de choque de alta energia

Doenças musculoesqueléticas

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Estudos de avaliação como assunto  
 Revisão por pares  
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 Pseudoartrose

de choque em pacientes com patologias musculoesqueléticas e pseudoartroses. A pesquisa foi feita nas bases de dados Cochrane Library, Medline e Lilacs. Encontrou 39 estudos que relatam o tratamento por ondas de choque de doenças musculoesqueléticas. Os resultados são muito variados, assim como os tipos de protocolo. Os estudos que avaliaram a efetividade do tratamento por ondas de choque para epicondilite lateral, tendinopatias do ombro, osteoartrose do joelho, osteonecrose da cabeça do fêmur e bursite trocanteriana relataram resultados inconsistentes para a melhoria dos pacientes. Os que avaliaram pacientes com tendinopatia calcária, fascite plantar, tendinopatia do tendão calcâneo e patelar e pseudoartrose mostraram benefício. O tratamento por ondas de choque é um método seguro e não invasivo para os casos crônicos em que os convencionais não tenham sido satisfatórios e deve ser associado aos outros métodos de tratamento das tendinopatias. Novos estudos de qualidade são necessários.

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## Introduction

The objective of this study was to qualitatively analyze the literature regarding the effectiveness of shockwave treatment for musculoskeletal diseases and bone consolidation.

Shockwaves applied to the musculoskeletal system started to be used in Brazil in 1998, with the arrival of the first urological lithotripsy machines, which were adapted for use on orthopedic lesions. This adaptation consisted of introducing new technology that made it possible to grade the depth to which and the strength with which shockwaves penetrate the human body.<sup>1</sup>

In the United States, this treatment was first approved by the Food and Drug Administration (FDA) in 2001. In Brazil, all the equipment is registered and authorized by the National Agency for Sanitary Surveillance (ANVISA).<sup>1</sup>

Studies have been developed with the aim of understanding the action of shockwaves on various human tissues, including the intensity, interval between applications, depth needed, side effects and efficacy.<sup>2</sup>

The action of shockwaves is determined through their penetration into tissues without skin, vessel or nerve lesions. When they reach the injured area, they promote mechanical stimulation that induces a series of biological effects, such as: increased production of prostaglandins relating to the tissue repair process; increased congestion and local blood microcirculation; and increased local concentration of nitric acid, with pain relief.<sup>3</sup>

Shockwave treatment for tendinopathy is indicated for patients with chronic pain for at least three months, who have already received medications, physiotherapy, infiltrations and orthoses without achieving any improvement and for whom a surgical procedure might be indicated. Shockwave therapy is not indicated for treating acute pathological conditions.<sup>4</sup>

There is still some controversy regarding the different types of equipment, which produce different types of waves. Some devices produce focal waves (more intense and deeper penetration), while others emit radial waves (less intense and more superficial). The treatment protocols may range from a single application, when more powerful focal wave generators are used, to three or four sessions at one-week intervals when

less powerful generators are used. The results from comparative studies have not shown any differences between these two types of protocol.<sup>5</sup>

## Methods

Systematic reviews and controlled clinical trials evaluating the use of shockwave treatment for musculoskeletal diseases and bone consolidation were included.

The databases used were the Cochrane Central Register of Clinical Trials (Central; Cochrane Library 2013, volume 2), Medline via PubMed (from 1966 until February 2013) and Lilacs via Bireme (from 1982 until February 2013). There were no restrictions based on language or publication status.

The strategy had the objective of finding randomized clinical trials and systematic reviews of randomized clinical trials.

## Results

The search initially found 525 references. Because of the large number of studies with level I evidence, only the findings from the systematic reviews were described here. Randomized clinical trials were evaluated in the absence of these studies.

The results were divided according to the main diseases than can be treated using shockwave therapy.

### Lateral epicondylitis

Buchbinder et al.<sup>6</sup> (2006) and Buchbinder et al.<sup>7</sup> (2009): nine randomized clinical trials (RCTs) with 1006 patients with lateral epicondylitis, which compared treatment versus placebo, and one RCT with 93 patients with lateral epicondylitis, which compared treatment versus local infiltration with corticosteroids. Based on the systematic review of nine RCTs, there is evidence that shockwave treatment provides little or no benefit in comparison with placebo, in terms of pain and function among patients with lateral epicondylitis. There was moderate evidence from just one RCT that reported that use of corticosteroid infiltration was more effective than applications of shockwaves.

Dingemans et al.<sup>8</sup> (2013): 20 RCTs and two systematic reviews that addressed this topic, with results similar to those of Buchbinder.

Rompe et al.<sup>9</sup> (2007): 10 RCTs. The studies included in this review concluded that there was no consensus with regard to differentiation between low-energy and high-energy shockwaves for treating lateral epicondylitis. This review indicated that there was some therapeutic benefit from shockwave treatment for the restricted condition of patients with recalcitrant chronic epicondylitis.

In summary, the systematic reviews included in this study present results that are inconsistent with use of shockwaves to treat patients with lateral epicondylitis. Only one study reported that shockwave treatment was effective for patients with recalcitrant chronic epicondylitis.

### **Patellar tendinopathy**

Wang et al.<sup>10</sup> (2007): quasi-randomized clinical trial that evaluated 27 patients (30 knees) who were treated with shockwaves, and 23 patients (24 knees) that were treated in the conventional manner. This study demonstrated favorable functional results for the group treatment with shockwaves. Ultrasonography examinations showed that there was a reduction in the thickness of the patellar tendon in the treated group and an improvement in blood circulation at that location, in comparison with the group that was treated conservatively.

Zwerver et al.<sup>11</sup> (2011): 62 athletes with patellar tendinopathy divided into 31 who were treated with shockwaves and 31 who received placebo treatment. The athletes maintained their competitive activity. The analyses did not demonstrate that the shockwave treatment was effective for the patients with patellar tendinopathy.

The studies included in the present review thus showed conflicting results regarding the effectiveness of shockwave treatment for patients with patellar tendinopathy.

### **Tendinopathy of the shoulder**

Lee et al.<sup>12</sup> (2011): a systematic review relating to the medium-term results from evaluating pain among patients who underwent shockwave treatment. The review found that there seemed to be a tendency for the treatment used to diminish the pain of patients treated using this method. However, the studies included presented severe methodological limitations relating to the assessment scores and dosages of the procedure used. It was concluded that there was a need for further studies with greater methodological efficacy.

Huisstede et al.<sup>13</sup> (2011): 11 studies relating to calcification and six to tendinopathy without calcification. The authors concluded that only the high energy of shockwaves was effective for calcareous tendinopathy and did not find any evidence for using shockwaves to treat non-calcifying tendinopathy or tendinosis.

Rompe et al.<sup>14</sup> (2001): a randomized clinical trial that compared the use of shockwaves with conventional surgery for treating calcareous tendinopathy of the rotator cuff. After one year of follow-up, the calcification was found to have been eliminated in 85% of the surgical group and 47% of the shockwave group. Both groups improved their clinical scores.

Liu et al.<sup>15</sup> (2012): a randomized clinical trial versus placebo among patients with tendinopathy of the long head of the biceps. Seventy-nine patients were randomized and the results were favorable toward shockwave treatment. The authors concluded that conservative treatment using shockwaves enabled good results.

Kim et al.<sup>16</sup> (2012): a randomized clinical trial in which 71 patients with rotator cuff injuries were studied. They underwent arthroscopic repair with the aim of evaluating whether shockwave treatment would stimulate healing. The study did not prove that this method would stimulate tissue repair and diminish the incidence of postsurgical recurrence of the injury.

Krasny et al.<sup>17</sup> (2005): a randomized clinical trial that compared dry needling accompanied by ultrasonography and shockwave treatment, among 40 patients with calcareous tendinopathy of the rotator cuff who presented indications for arthroscopic treatment. Both groups presented improvements in the constant score. The calcification was seen to have disappeared in 60% of the group that underwent needling, versus 32.5% of the group that underwent shockwave therapy.

Galasso et al.<sup>18</sup> (2012), Engebretsen et al.<sup>19</sup> (2011) and Schofer et al.<sup>20</sup> (2009): these studies evaluated shockwave treatment in comparison with conventional treatment for tendinopathy of the shoulder without calcification. Galasso et al.<sup>18</sup> (2012) concluded that over the short term, shockwave treatment presented better results than those of the placebo group. On the other hand, in a comparative study with 140 patients, Engebretsen et al.<sup>19</sup> (2011) did not find any evidence that use of shockwaves promoted better results after one year of follow-up among patients with subacromial impact syndrome of the shoulder. Schofer et al.<sup>20</sup> (2009) did not find any differences in treatments using two different types of shockwaves.

Hsu et al.<sup>21</sup> (2008), Albert et al.<sup>22</sup> (2007), Cacchio et al.<sup>23</sup> (2006), Sabeti-Aschraf et al.<sup>24</sup> (2005), Pleiner et al.<sup>25</sup> (2004), Cosentino et al.<sup>26</sup> (2003) and Loew et al.<sup>27</sup> (1999): these authors evaluated use of shockwaves in comparison with conventional treatment for calcareous tendinopathy of the shoulder and concluded that use of high energy promoted improvement of the symptoms. Cacchio et al.<sup>23</sup> (2006) demonstrated that this was an effective and safe treatment method.

In summary, studies that have evaluated the effectiveness of shockwave treatment for patients with tendinopathy of the shoulder have presented conflicting evidence. Some studies have reported beneficial effects in cases of calcareous tendinopathy.

### **Plantar fasciitis**

Chang et al.<sup>28</sup> (2012): 12 studies, all randomized. Shockwave treatment was shown to be effective for the symptoms of plantar fasciitis.

Rompe et al.<sup>29</sup> (2007): 17 papers. These studies were considered heterogeneous: there was a preponderance of good results and the authors concluded that the shockwave treatment method should be considered only when the traditional methods fail.

Crawford et al.<sup>30</sup> (2003): 19 randomized studies, from which there was conflicting evidence regarding the efficacy for

reducing nocturnal pain, pain while resting and pain due to short-term pressure.

Kearney et al.<sup>31</sup> (2010): 11 studies. The current evidence favored eccentric exercises and shockwaves, although with limited evidence for judging their effectiveness.

Ogden et al.<sup>32</sup> (2002): eight studies. The results suggested that shockwave therapy should be considered before any surgical procedure and might be preferable to corticoid infiltration.

In summary, shockwave treatment is an option for cases that are resistant to the usual treatments for plantar fasciitis.

### **Knee arthrosis**

Laufer et al.<sup>33</sup> (2012): seven studies. The results regarding the effect of shockwave treatment were inconsistent in comparison with the placebo effect, and the authors suggested that further studies on this subject were necessary.

### **Osteonecrosis of the femoral head**

Alves et al.<sup>34</sup> (2009): these authors did not find any double-blind studies on the efficacy of treatments for osteonecrosis.

### **Tendinopathy of the calcaneal (Achilles) tendon**

Kearney et al.<sup>31</sup> (2010): 11 studies were reviewed and it was demonstrated that there was a consensus that functional treatment methods, including shockwaves, should be used before surgical methods for treating tendinopathy of the Achilles heel.

### **Trochanteric bursitis**

Del Buono et al.<sup>35</sup> (2012): 14 studies that provided low to moderate evidence for supporting the use of shockwaves for patients with trochanteric bursitis. Thus, these authors concluded that there was a need for better-conducted randomized studies.

### **Bone consolidation**

Schaden et al.<sup>36</sup> (2001) published the principles for using shockwaves for treating pseudarthrosis, in *Clinical Orthopedics*.

Furia et al.<sup>37</sup> (2010) compared the results from treating pseudarthrosis of fractures of the base of the fifth metatarsal between fixation using screws, from which 18 consolidations were obtained out of 20 patients, and shockwaves, from which 20 consolidations were obtained out of 23 patients, with a lower complication rate (comprising breakage of the synthesis material and infections).

Elster et al.<sup>38</sup> (2010) reported that 82.4% of their results were good, among 172 cases of pseudarthrosis of the tibia.

## **Discussion**

This study was motivated by a consultation that was sent to the Brazilian Society of Orthopedics regarding how shockwave treatment works, what its indications are and what results

are obtained. A committee of orthopedists was formed, which sought to make a detailed analysis of the literature on this type of treatment.

Although there is still some controversy regarding aspects of shockwave generation, the data in the literature indicate that they can be generated through hydraulic, magnetic, piezoelectric and pneumatic means. There are divergences among the authors investigated: Wang et al.<sup>3</sup> and Schaden et al.<sup>36</sup> preferred hydraulic devices, Fúria et al.<sup>37</sup> reported good results from magnetic devices and Gerdesmeyer et al.<sup>5</sup> and Rompe and Maffulli<sup>9</sup> used pneumatic devices. In Brazil, all of these methods are used, but especially pneumatic and hydraulic methods.<sup>2,3,5,9</sup>

Regarding the mechanism of action on tissue, all authors agree that the mechanical action induces biological action that alters cell permeability and promotes increased concentration of tissue regeneration factors and vascular regeneration factors at the site that is stimulated, as reported by Ogden et al.<sup>2</sup> and Wang et al.<sup>3</sup>

None of the authors found any side effects or important complications.

In relation to the indications analyzed according to pathological condition, the results from tendinopathy of the shoulder were favorable in relation to treatment of calcareous tendinopathy but not of non-calcareous tendinopathy. This is concordant with the results obtained within clinical practice. In the elbow, efficacy in relation to treating lateral epicondylitis was not proven, and there were divergences between the findings of Buchbinder and Rompe. In clinical practice, these divergences are repeated. Some patients report improvements in symptoms and are able to return to their activities without complaints around three months after the treatment, while others do not report improvements.<sup>6-9</sup> With regard to patellar tendinopathy and bursitis of the hip, there are still no studies proving its efficacy, even though some studies have shown favorable results, such as the study by Wang. The study by Zwerver was criticized because the athletes continued to take part in competitions during the treatment and the rest period was not respected, which should be for at least 30 days after the treatment has been applied. In cases of Achilles tendinopathy and plantar fasciitis, the studies by Furia, Ogden and Gerdesmeyer demonstrated favorable effects, which are confirmed in clinical practice, independent of the equipment used.<sup>5,10,11,29,32</sup>

Regarding the bone indications for knee arthrosis and for osteonecrosis of the femoral head, there are still no conclusive studies, although Wang reported good results. In relation to pseudarthrosis, Schaden, Furia and Elster demonstrated that shockwaves were effective and the clinical results were encouraging.<sup>34,36-38</sup>

## **Final remarks**

Despite the great variability of treatment protocols and the need for further studies, shockwave treatment is a safe and noninvasive method for chronic cases in which conventional treatments have not been satisfactory, and it should be used in association with other methods in cases of tendinopathy.



## Conflicts of interest

The authors declare no conflicts of interest.

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