Recommendations for use of extracorporeal shockwave therapy in sports medicine: an international modified Delphi study

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ABSTRACT

Objectives While extracorporeal shockwave therapy (ESWT) may be an efficacious adjunctive treatment option for musculoskeletal injuries, current research is limited by significant heterogeneity within treatment protocols. This study aims to establish international expert consensus recommendations on ESWT terminology, parameters, procedural considerations, contraindications and side effects in the application of ESWT to sports injuries.

Methods A systematic literature search was performed on the use of ESWT for musculoskeletal and sports medicine injuries to identify potential panellists, followed by the development of a steering committee-led questionnaire. A three-stage, modified Delphi questionnaire was provided to a panel of 41 international clinical and research experts across 13 countries. Panellists had the opportunity to suggest edits to existing statements or recommend additional statements in Round 1. Consensus was defined as≥75% agreement.

Results All 41 panellists completed Rounds 1, 2 and 3. Consensus was reached on 69/118 statements (58.5%), including recommendations on terminology and fundamental concepts, indications for use, procedural aspects for tendinopathy and bone pathologies, treatment correlations with imaging, periprocedural and postprocedural considerations, absolute and relative contraindications and potential side effects. Of the 49 statements that did not reach consensus, 17/49 (34.7%) were related to procedural aspects of bone pathology.

Conclusion This international panel presents recommendations on ESWT terminology, indications and treatment considerations to guide ESWT use and decision-making by sports medicine clinicians. While our panel supported the use of ESWT in the treatment of bone pathologies, certain procedural aspects of ESWT specific to these injuries did not reach consensus and require further investigation.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Increasing evidence supports the use of extracorporeal shockwave therapy (ESWT) in the treatment of musculoskeletal pathologies.
⇒ Current studies are limited given the variability in the types of treatment (radial and/or focused) and treatment parameters, as well as a lack of consensus on periprocedural and postprocedural recommendations.

INTRODUCTION

In 2020, musculoskeletal disorders were the second leading cause of non-fatal disability, impacting over 1.63 billion people globally, and are expected to increase in the coming decades.[1] This high burden of global musculoskeletal disorders suggests the need for evidence-based effective treatment options. One such intervention includes extracorporeal shockwave therapy (ESWT) with increasing evidence supporting its use in musculoskeletal and sports and exercise medicine for both recreational and high-level sports participants.[2] ESWT is used in the management of musculoskeletal injuries, including lateral epicondylopathy,[3] hamstring tendinopathy,[4] Achilles tendinopathy,[5] gluteal tendinopathy,[6] plantar fasciopathy[7] and bone pathologies such as bone stress injuries[8] and medial tibial stress syndrome.[9]

Two forms of ESWT are commonly used in practice. Focused shockwave therapy generates sound waves that can penetrate deeper structures at the site of application, while radial shockwave therapy produces pressure waves that primarily affect more superficial structures.[10] Radial shockwave does not deliver a high-amplitude shockwave and is sometimes referred to as radial pressure waves.[11] The proposed mechanisms of action for ESWT are based on the effects of energy propagation through tissues

WHAT THIS STUDY ADDS

⇒ A distinction should be made between the use of focused shockwave and/or radial pressure waves with their corresponding energy levels (low, medium, high).
⇒ Shockwave and/or pressure wave therapy is recommended as part of the treatment algorithm for various tendinopathies, plantar fasciopathy, bone stress injuries, delayed and non-union fractures, sesamoiditis and medial tibial stress syndrome.
⇒ Procedural recommendations include the use of clinical focusing without local anaesthesia, treatment intervals of 1–2 weeks with a total of 3–5 sessions, variable energy levels depending on the specific pathology and avoidance of Visual Analogue Scale pain scores greater than 6 and 7 for tendon and bone conditions, respectively.
⇒ Non-steroidal anti-inflammatory drugs should be avoided throughout the duration of treatment as well as a period of time after treatment dependent on the specific clinical context.
⇒ Following treatment, no range of motion restrictions or weight-bearing precautions are required for tendinopathies or fasciopathies, including for in-season athletes.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ This study may improve the procedural use and methodologic reporting of shockwave/pressure wave therapy to better guide clinical practice and research.
⇒ Further research is needed to strengthen specific recommendations as well as improve procedural considerations of shockwave and/or pressure waves for bone pathologies.
⇒ Increasing knowledge and evidence surrounding shockwave/pressure wave therapy may play an important role in guiding insurance companies to support future coverage of this treatment.

to stimulate interstitial and extracellular responses, which may increase collagen synthesis,[12] cellular proliferation[13] and neovascularisation.[14] Further, ESWT may also disrupt pain responses via central or peripheral mechanisms.[15 16]

Current literature demonstrates variable efficacy of ESWT for improving pain and function which, while it may reflect intrinsic factors that can be more challenging to quantify or control, may also reflect differences in published studies in the application of ESWT, including type (radial and/or focused), energy flux density, number of impulses, frequency and number of treatment sessions within a given musculoskeletal condition.[7] Other periprocedural and postprocedural aspects may also vary and influence outcomes, including the use of local or oral analgesics, exercise programme and return to activities or sports.[17]

The variability in patient characteristics, type and degree of musculoskeletal injury, stage of tendinopathy/disease and treatment protocols for ESWT limits our understanding of its best application, primarily through human subject research. The Delphi method represents an alternative strategy for establishing consensus on topics including ESWT application.[18] It uses a group facilitation technique to achieve consensus among a panel of experts through multiple rounds of structured anonymous questionnaires.[19] The Delphi method has been widely used in musculoskeletal and sports medicine and has recently been implemented in expert consensus exploration of certain treatments such as platelet-rich plasma (PRP) in lateral epicondylopathy,[20] rehabilitation following hamstring injuries[21] and physical therapy for biceps tendinopathy.[22] To date, no international consensus has been developed on the topic of ESWT application in musculoskeletal and sports medicine. Therefore, the purpose of this modified Delphi study was to attempt to reach a consensus on ESWT terminology, indications, ESWT parameters, procedural aspects for tendon and bone pathologies, periprocedural and postprocedural considerations, contraindications and side effects.

METHODS

Study design

This study employed a three-stage modified Delphi method, with an outline questionnaire provided through email to an expert panel from March 2024 to August 2024. The study reporting followed ACcurate COnsensus Reporting Document guidelines.[23 24] The study protocol was prospectively registered at the institutional review board (IRB) website prior to the initiation of the study. Informed consent was implied by voluntary completion of the surveys. Online surveys were completed using Research Electronic Data Capture (REDCap). Study data were collected and managed using REDCap electronic data capture tools hosted at the institution affiliated with the lead author. REDCap is a secure web-based software platform designed to facilitate data capture for research studies, offering: (1) a user-friendly interface for validated data collection; (2) audit trails to monitor data manipulation and export processes; (3) automated export features for easy data transfer to popular statistical programmes; and (4) tools for integrating and ensuring compatibility with external data sources.[25 26]

Steering committee

The lead and senior authors (HCR and AST) published a systematic review on the use of ESWT for in-season athletes and physically active individuals,[2] elected to perform this modified Delphi study and formed an initial steering group (HCR, MS, JSH and AST) to develop initial statements. These were further reviewed and refined by a multidisciplinary steering group (NM, AS, CL, LG, KQ, JSH and AST). The expert panel was selected based on the criteria described below.

Expert panel selection

Noting a wide range of experts recruited in prior Delphi studies ranging from 20 to 60,[19 27] the recruitment goal for this study was for a minimum of 25 experts composed of clinicians and/or researchers with nationally and internationally recognised training and experience in ESWT. The following criteria were established a priori and documented in the research protocol submitted to the IRB.

A systematic literature search using EMBASE and PubMed was conducted to identify systematic reviews, meta-analyses and randomised control trials (RCTs) related to ESWT with publication dates to June 2023 to identify potential panellists. The following terms were used in combination: shock wave therapy, shockwave therapy, ESWT, extracorporeal shockwave therapy, focused shockwave therapy, radial shockwave therapy, radial pressure wave therapy, tendinopathy, fasciopathy. Additional articles were identified through cross-referencing. Authors of these papers were identified and assigned a score using the following: one point was awarded to the first author (including co-first authors), corresponding author and/or last author.

Table 1 Participant demographics (Rounds 1, 2 and 3, N=41)

Gender	
Male	33 (80.49%)
Female	8 (19.51%)
Age (years)	
30–39	8 (19.51%)
40–49	8 (19.51%)
50–59	12 (29.27%)
60–69	11 (26.83%)
Prefer not to answer/no response	2 (4.88%)
Average age	51.49 years
Primary area of expertise	
Clinician only	15 (36.59%)
Researcher only	0 (0.00%)
Both clinician and researcher	26 (63.41%)
Experience	
Overall professional experience	21.50 years
Clinical experience with ESWT	11.49 years
Research experience with ESWT	8.56 years
Highest professional degree	
MD	22 (53.66%)
DO	2 (4.88%)
MD PhD	3 (7.32%)
DPM	7 (17.07%)
PhD	5 (12.20%)
Masters	1 (2.44%)
FRCSEd	1 (2.44%)
Country	
USA	27 (65.85%)
Taiwan	2 (4.88%)
Germany	2 (4.88%)
Argentina	1 (2.44%)
Austria	1 (2.44%)
China	1 (2.44%)
Colombia	1 (2.44%)
Israel	1 (2.44%)
Japan	1 (2.44%)
Netherlands	1 (2.44%)
Saudi Arabia	1 (2.44%)
Singapore	1 (2.44%)
UK	1 (2.44%)
Practice setting	
Academic	19 (46.34%)
Private	13 (31.71%)
Both	4 (9.76%)
Other	5 (12.20%)
Current role	
Non-operative physician	22 (53.66%)
Orthopaedic surgeon	9 (21.95%)
Podiatrist	7 (17.07%)
Physical therapist	2 (4.88%)
Researcher	1 (2.44%)

DO, Doctor of Osteopathic Medicine; DPM, Doctor of Podiatric Medicine; ESWT, extracorporeal shockwave therapy; FRCSEd, The Fellow of the Royal College of Surgeons of Edinburgh; MD, Doctor of Medicine; PhD, Doctor of Philosophy.

Scores for the systematic review and meta-analysis cohort ranged from 1 to 4. Three individuals had scores of 4, 3 had scores of 3 and 14 had scores of 2 (1 of whom was excluded from the final analysis due to their passing). Overall, a total of 20 authors were identified here with scores ranging from 2 to 4 points.

Scores for the RCTs ranged from 14 to 1. Authors already included from the prior systematic review/meta-analysis were not duplicated. Authors with scores of ≥2 points were invited for participation. No scores of 1 were included across any article type.

Expert clinicians were required to have specialty training in musculoskeletal-related fields and have at least 5 years of practice experience. Members of The International Society of Medical Shockwave Treatment (ISMST) were identified. The expert clinicians were also invited through snowball recruitment.[28]

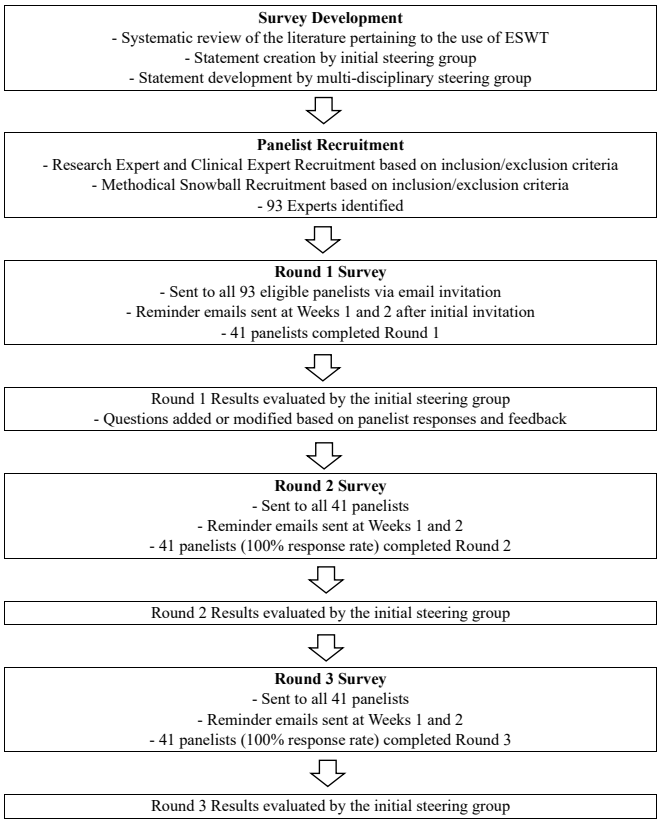

Figure 1 Modified Delphi process. ESWT, extracorporeal shockwave therapy.

Modified Delphi process

A multidisciplinary steering group of clinical experts (NM, AS, LG, CL, KQ, JSH and AST) created a Delphi questionnaire for Round 1. This included 98 items related to ESWT: terminology and concepts (n=5); musculoskeletal indications (n=29); procedural aspects for tendon (n=13), procedural aspects for bones (n=23); periprocedural considerations (n=8); postprocedural considerations (n=8); contraindications for radial pressure waves and focused ESWT (n=8); and side effects (n=4).

Each clinical expert received an email invitation to participate in the modified Delphi panel with a REDCap link to the questionnaire. Depending on the type of question or statement, responses were collected using a 5-point scale from 1 to 5 (1=contraindicated to 5=strongly recommend), a 3-point scale from 1 to 3 (1=do not agree, 2=neutral and 3=agree), a binomial response (yes or no) or multiple-choice options. Given the varied clinical backgrounds of the experts, a 'not within my

Table 2 Consensus on shockwave therapy terminology and concepts

Statement	Agreement	Neutral	Disagreement	Round achieved
Shockwave therapy's exact mechanism of action remains unknown but is best thought to be through cellular mechanotransduction where mechanical stimuli lead to cellular migration and proliferation, increased vascularity in addition to acting on pain pathways to decrease pain.	97.6% (41/42)	2.4% (1/42)	0% (0/42)	1
Focused shockwaves should be referred to as extracorporeal shockwave therapy (ESWT).	88.1% (37/42)	4.76% (2/42)	7.14% (3/42)	1
Focused shockwave therapy and radial pressure waves should not be referred to as high or low energy shockwaves.	88.1% (37/42)	4.76% (2/42)	7.14% (3/42)	1
In common practice, ESWT is used to describe both focused and radial shockwaves. However, only focused ESWT generates a true shockwave. Therefore, radial ESWT should be referred to as 'pressure wave therapy' or 'radial pressure wave therapy'. (Statement modified in Round 2)	80.5% (33/41)	9.8% (4/41)	9.8% (4/41)	2
Energy levels of shockwave therapy are defined as: Low (< 0.10 mj/mm2), Medium (0.10–0.28 mj/mm2), High (≥0.29 mj/mm2).	78% (32/41)	19.5% (8/41)	2.4% (1/41)	2

Colouring indicates full consensus (■), consensus with one or more disagreement (■) and failure of consensus (■).
Consensus was defined a priori by ≥75% agreement or disagreement.
mj/mm2, millijoules per square millimetre.

practice/expertise' option was an answer choice provided for each question. During Round 1, participants had the opportunity to suggest edits to the statements or recommend additional statements using an open text box.

A threshold of 75% agreement or disagreement was used as a prior cut-off based on the previous studies,[29 30] and the statements that reached consensus were removed from subsequent rounds. Suggestions made by participants were discussed within the initial steering group, and statements or questions were added or modified for clarity. Open-ended questions were also added to capture any clinically relevant responses.[27] Following Rounds 1 and 2 of voting, participants received individualised feedback reports and a summary of the panel scores for each statement. Participants could reflect on and adjust their scores, if necessary, while maintaining anonymity. The same types of responses were used as Round 1. Throughout the entire process, except for the initial steering group, all other invited participants were blinded to the identity of the other experts.

Statistical analysis and reporting

Levels of agreement were summarised as percentage (%). Responses for 'strongly recommend' or 'recommend' were categorised as 'recommend'. Descriptive statistics were used to present the demographic information of the experts. Consensus was defined a priori as agreement or disagreement of ≥75% for each statement or question. While presenting the results, three levels of agreement were defined: (1) Full consensus: ≥75% of panellists agreed on the Delphi statement; no panellists disagreed. (2) Consensus with one or more disagreements: ≥75% of panellists agreed on the Delphi statement, but one or more panellists disagreed. (3) Failure of consensus: <75% of panellists agreed on the Delphi statement.

Equity, diversity and inclusion statement

Our research and author group represented a broad range of international experts using ESWT to treat musculoskeletal conditions. Our group was comprised of junior, mid-career and senior experts (ages ranging from 34 to 68 years old) from a variety of disciplines (22 non-operative musculoskeletal/sports medicine physicians, 9 orthopaedic surgeons, 7 podiatrists, 2 physical therapists). The panellists held a variety of professional degrees (MD, DO, PhD, MD/PhD and DPM) and a mix of academic (19), private practice (13) or hybrid (9) clinical settings. Our gender distribution was comprised of greater male (n=33) and female (n=8) experts from 13 different countries and 4 continents.

Patient, public and clinical expert involvement

Selected experts were asked to nominate other clinical experts who could contribute insights to participate in the study. Additionally, invited experts included the members of ISMST to ensure that the study included perspectives from experts involved in drafting recommendations for ESWT.

RESULTS

Participants

93 experts were identified and invited to participate in Round 1. 41 experts completed Round 1. All participants (n=41) subsequently completed Rounds 2 and 3 of voting. Participant demographics, including gender, mean age, primary area of expertise, clinical and research experience with ESWT, highest professional degree, geographical location, practice setting and current role are included in table 1. Figure 1 illustrates the progression between Rounds 1, 2 and 3 of the voting process.

Delphi rounds and consensus process

Responses by round for each Delphi statement are provided as online supplemental files 1–4. Agreement was reached on 46, 16 and 7 statements for the first, second and third round, respectively. Items that reached the consensus process were grouped by topic of ESWT: terminology and concepts (table 2), musculoskeletal indications (table 3), procedural aspects for tendon (table 4), procedural aspects for bone (table 5), periprocedural and postprocedural considerations (table 6), contraindications (table 7) and side effects (table 8).

Prior to round 2, after reviewing the responses for questions with 'range' answer choices as well as feedback from the expert panel, some of these 'range' answers were converted into short-answer questions to allow experts to provide specific numbers with the goal of identifying a number threshold that can reach consensus. Given the persistent variability of responses, the decision was made to present medians with IQRs for these questions.

DISCUSSION

The purpose of this modified Delphi study was to reach a consensus among experts on ESWT terminology, ESWT parameters, procedural aspects for tendon and bone

Table 3 Indications for shockwave or pressure wave therapy in sports medicine and musculoskeletal medicine

Conditions	Recommended	Neutral	Not recommended	Round achieved
Plantar fasciopathy	100% (42/42)	0%	0%	1
Insertional Achilles tendinopathy	100% (42/42)	0%	0%	1
Proximal hamstring tendinopathy	100% (38/38)	0%	0%	1
Common extensor tendinopathy	100% (35/35)	0%	0%	1
Patellar tendinopathy	97.4% (37/38)	2.6% (1/38)	0%	1
Medial epicondylopathy (Statement added in Round 2)	97.4% (37/38)	2.6% (1/38)	0%	2
Gluteal medius and minimus tendinopathy	97.1% (34/35)	2.9% (1/35)	0%	1
Calcific rotator cuff tendinopathy	97.1% (33/34)	0%	2.9% (1/34)	1
Midportion Achilles tendinopathy	95.2% (40/42)	4.8% (2/42)	0%	1
Delayed union fractures/bone stress injuries (>3 months of symptoms)	92.3% (36/39)	7.7% (3/39)	0%	1
Non-union fractures/bone stress injuries (>6 months of symptoms)	92.3% (36/39)	5.1% (2/39)	2.6% (1/39)	1
Medial tibial stress syndrome (Statement added in Round 2)	92.3% (36/39)	7.7% (3/39)	0%	2
Distal hamstring tendinopathy	91.9% (34/37)	5.4% (2/37)	2.7% (1/37)	1
Low-grade partial gluteus medius and minimus tear	91.4% (32/35)	8.6% (3/35)	0%	1
Greater trochanter pain syndrome	91.2% (31/34)	8.8% (3/34)	0%	1
Low-grade partial patellar tendon tear	89.5% (34/38)	5.3% (2/38)	5.3% (2/38)	1
Radial pressure wave therapy for low-grade partial tendon tear (Statement added in Round 2)	87.8% (36/41)	4.9% (2/41)	7.3% (3/41)	3
Bone stress injury	87.2% (34/39)	12.8% (5/39)	0%	1
Sesamoiditis (Statement added in Round 2)	86.8% (33/38)	10.5% (4/38)	2.6% (1/38)	2
Low-grade partial common extensor tendon tear	86.1% (31/36)	13.9% (5/36)	0%	1
Low-grade partial insertional Achilles tendon tear	85.7% (36/42)	9.5% (4/42)	4.8% (2/42)	1
Low-grade partial midportion Achilles tendon tear	85.7% (36/42)	9.5% (4/42)	4.8% (2/42)	1
Low-grade partial proximal hamstring tendon tear	83.8% (31/37)	13.5% (5/37)	2.7% (1/37)	1
Partial plantar fascia tear	81% (34/42)	11.9% (5/42)	7/1% (3/42)	1
Focused ESWT for low-grade partial tendon tear (Statement added in Round 2)	76.9% (30/39)	15.4% (6/39)	7.7% (3/39)	2
Non-calcific rotator cuff tendinopathy	76.5% (26/34)	17.6% (6/34)	5.9% (2/34)	1
Knee osteoarthritis	68.6% (24/35)	28.6% (10/35)	2.9% (1/35)	3
Focused ESWT for high-grade partial tendon tear (Statement added in Round 2)	45% (18/40)	35% (14/40)	20% (8/40)	3
Radial pressure wave therapy for high-grade partial tendon tear (Statement added in Round 2)	34.1% (14/41)	17.1% (7/41)	48.8% (20/41)	3
Focused ESWT for chronic full-thickness tendon tear (Statement added in Round 2)	25% (10/40)	20% (8/40)	55% (22/40)	3
Radial pressure wave therapy for chronic full-thickness tendon tear (Statement added in Round 2)	17% (7/41)	22% (9/41)	61% (25/41)	3
High-grade partial midportion Achilles tendon tear	Statement removed after Round 1			
High-grade partial insertional Achilles tendon tear				
High-grade partial common extensor tendon tear				
High-grade partial proximal hamstring tear				
High-grade partial patellar tendon tear				
High-grade partial gluteus medius and minimus tear				

Colouring indicates full consensus (■), consensus with one or more disagreement (■) and failure of consensus (■).
Consensus was defined a priori by ≥75% agreement or disagreement.
ESWT, extracorporeal shockwave therapy.

pathologies, periprocedural and postprocedural considerations, contraindications and side effects, with the aim of promoting best practices in applying shockwave in sports medicine and related disciplines. A total of 41 experts from diverse backgrounds participated in all three rounds and reached a consensus on 69 statements. 49 statements did not reach a consensus, including those related to procedural aspects of bone pathologies (n=17), indicating areas that warrant future research.

Shockwave therapy-related terminology and concepts

Despite specific definitions provided by various international shockwave therapy societies,[31] the term 'ESWT' is used to describe focused shockwaves and radial pressure

Table 4 Procedural aspects for tendon

Statement	Agreement	Neutral	Disagreement	Round achieved
Local anaesthesia is not recommended to be used when performing shockwave on patients.	100% (41/41)	0%	0%	1
The shockwave dose should start at a low energy level easily tolerated by the patient and then increase to patient tolerance and reach the goal therapeutic energy level.	92.9% (39/42)	2.4% (1/42)	4.8% (2/42)	1
Shockwave therapy treatment time interval between each session is recommended to be 1–2 weeks.	92.9% (39/42)	2.4% (1/42)	4.8% (2/42)	1
There is increased benefit to co-treating tendon pathology with combined use of physical therapy exercises and shockwave therapy. (Statement added in Round 3)	92.7% (38/41)	7.3% (3/41)	0%	3
Total recommended treatment sessions to accurately treat tendon issues vary, but typically between 3–5 sessions.	83.3% (35/42)	9.5% (4/42)	7.1% (3/42)	1
Low and medium energy levels are best used for treating tendon issues and fasciopathies.	78% (32/41)	12.2% (5/41)	9.8% (4/41)	2
Clinical focus as opposed to imaging guidance is recommended when performing shockwave on patients.	76.2% (32/42)	19% (8/42)	4.8% (2/42)	1
If available, it is recommended to use a combined approach of both radial and focused probes when performing shockwave on tendons.	75.7% (28/37)	16.2% (6/37)	8.1% (3/37)	2
There is increased benefit to co-treating tendon pathology with combined use of orthobiologics (ie, platelet-rich plasma) therapies and shockwave therapy, (Statement modified to replace 'cell-based (ie, platelet-rich plasma)' with 'orthobiologics (ie, platelet-rich plasma)' in Round 3)	52.5% (21/40)	32.5% (13/40)	15% (6/40)	3
	Multiple choice response			
For focused shockwave treatments, what is the average number of shocks you perform on the tendon in a single location?	500: 0% 0/39 1000: 5.1% (2/39) 1500: 10.3% (4/39) 2000: 69.2% (27/39) 2500: 7.7% (3/39) 3000: 7.7% (3/39) 3000+: 0% (0/39) Would not use: 0% (0/39)			3
For radial pressure wave treatments, what is the average number of strikes you perform on the tendon in a single location?	500: 2.5% (1/40) 1000: 2.5% (1/40) 1500: 5% (2/40) 2000: 47.5% (19/40) 2500: 7.5% (3/40) 3000: 20% (8/40) 3000+: 10% (4/40) Would not use: 5% (2/40)			3
	Free-text response			
During shockwave therapy procedures, pain will not exceed a VAS pain score of ___. (Statement modified to choose a range from 0 to 10 in Round 2)	Median 6 (IQR 5–7)			3
On average, it takes about ___ weeks for most patients to feel significant clinical benefit after initiation of shockwave therapy in tendon pathology or fasciopathy. (Statement modified to provide a number in Round 2)	Median 6 (IQR 4–6)			3
Patients can expect the effects of shockwave therapy to last at least ___ months in tendon conditions. (Statement modified to provide a number in Round 2)	Median 10 (IQR 6–12)			3

Colouring indicates full consensus (■), consensus with one or more disagreement (□) and failure of consensus (■).
Consensus was defined a priori by ≥75% agreement or disagreement.
VAS, Visual Analogue Scale.

waves in both the literature and clinical practice. As the form of shockwave and device settings can influence outcomes,[32] our panel proposes specific terminology be used both in research and clinical practice. Based on the consensus reached by the expert panel, we recommend not using the general term ESWT and advise explicitly reporting whether focused shockwave and/or radial pressure wave therapy had been used. Further, we propose reserving the term ESWT specifically for focused shockwaves.[31] The thresholds for categorising energy levels have varied in the literature, but our expert panel reached consensus on defining them as: low (<0.10 mj/mm2), medium (0.10–0.28 mj/mm2) and high (≥0.29 mj/mm2). This classification was adopted from one of the earliest animal studies investigating dose-related effects of shock waves on rabbit tendon Achilles[33] and supported by review of human subject research that low and medium energy levels may promote healing in soft tissue injuries and tendinopathies.[34]

Clinical implications: indications for shockwave or pressure wave therapy in clinical practice

Specific tendinopathies or fasciopathies that are appropriate to apply shockwave in clinical practice include plantar fasciopathy, midportion Achilles tendinopathy, insertional Achilles tendinopathy, non-calcific and calcific rotator cuff tendinopathy, common extensor of the elbow tendinopathy, proximal and distal hamstring tendinopathy, patellar tendinopathy, greater trochanter pain syndrome, gluteal tendinopathy, medial epicondylopathy and low-grade partial tendon tears. Among these conditions, plantar fasciopathy, insertional Achilles tendinopathy, common extensor tendinopathy and proximal hamstring tendinopathy all achieved 100% agreement. While prior studies

Table 5 Procedural aspects for bone

Statement	Agreement	Neutral	Disagreement	Round achieved
There is increased benefit to co-treating joint pathology with combined use of physical therapy exercises and shockwave therapy. (Statement added in Round 3)	92.3%(36/39)	5.1% (2/39)	2.6% (1/39)	3
Local anaesthesia is not recommended to be used when performing shockwave on patients.	89.5% (34/38)	7.9% (3/38)	2.6% (1/38)	1
It is recommended to use a focused probe when performing shockwave on osseous or joint pathology.	87.2% (34/39)	12.8% (5/39)	0%	1
Total recommended treatment sessions to accurately treat osseous and joint issues vary, but at least a minimum of 3–4 sessions.	83.4% (31/37)	8.1% (3/37)	8.1% (3/37)	2
The shockwave dose should start at a low energy level easily tolerated by patient and then be increased slowly to patient tolerance.	82% (32/39)	7.7% (3/39)	10.3% (4/39)	1
There is increased benefit to co-treating joint pathology with combined use of orthobiologics (ie, platelet-rich plasma) and shockwave therapy. (Statement modified to replace 'cell-based (ie, platelet-rich plasma)' with 'orthobiologics (ie, platelet-rich plasma)' in Round 3)	80.6% (29/36)	16.7% (6/36)	2.8% (1/36)	3
High energy levels (0.29 mj/mm2 or higher) are best used for treating disorders of osseous and joint pathology.	79.5% (31/39)	12.8% (5/39)	7.7% (3/39)	1
It is recommended to treat in one single session with focused high-energy shockwave therapy under sedation or general anaesthesia when treating osseous or joint pathology.	16.7% (6/36)	8.3% (3/36)	75% (27/36)	1
For central bone injuries treated with shockwave, MRI is preferred over CT scan to monitor healing with the goal to minimise ionising radiation to reproductive organs. (Statement modified in Round 2 to improve clarity)	72.7% (24/33)	3% (1/33)	24.2% (8/33)	3
Clinical focusing (described as treatment over areas of maximal pain reported by the patient) as opposed to imaging guidance is recommended when performing shockwave therapy on patients with acute bone stress injury (< 3 months of clinical presentation or radiological confirmation). (Statement modified in Round 2 to specify 'acute bone stress injury' and in Round 3 to clarify clinical focusing)	67.6% (25/37)	8.1% (3/37)	24.3% (9/37)	3
Clinical focusing (described as treatment over areas of maximal pain reported by the patient) as opposed to imaging guidance is recommended when performing shockwave therapy on patients with delayed union/non-union from bone stress injury (> 3 months). (Statement modified in Round 2 to specify 'delayed union/nonunion from bone stress injury' and in Round 3 to clarify clinical focusing)	56.8% (21/37)	8.1% (3/37)	3.5% (13/37)	3
Clinical focusing (described as treatment over areas of maximal pain reported by the patient) as opposed to imaging guidance is recommended when performing shockwave therapy on patients with acute traumatic fracture (< 3 months of clinical presentation or radiological confirmation). (Statement modified in Round 2 to specify 'acute traumatic fracture' and in Round 3 to clarify clinical focusing)	48.6% (17/35)	17.1% (6/35)	34.3% (12/35)	3
Clinical focusing (described as treatment over areas of maximal pain reported by the patient) as opposed to imaging guidance is recommended when performing shockwave therapy on patients with delayed union/non-union from traumatic fracture (> 3 months). (Statement modified in Round 2 to specify 'delayed union/nonunion from traumatic fracture' and in Round 3 to clarify clinical focusing)	44.4% (16/36)	11.1% (4/36)	44.4% (16/36)	3
Shockwave therapy treatment time interval between each session can be more frequent (closer together) than soft tissue indications.	32.4% (12/37)	37.8% (14/37)	29.7% (11/37)	3
If patients are receiving orthobiologics (ie, platelet-rich plasma), they should avoid shockwave therapy over the treatment area for at least 6 weeks. (Statement modified to replace 'cell-based (ie, platelet-rich plasma)' with 'orthobiologics (ie, platelet-rich plasma)' in Round 3)	24.2% (8/33)	12.1% (4/33)	63.6% (21/33)	3
	Multiple choice response			
For focused shockwave treatments, what is the average number of shocks you perform on bone in a single location (one specific area in bone)?	500: 0% (0/38) 1000: 5.3% (2/38) 1500: 7.9% (3/38) 2000: 44.7% (17/38) 2500: 13.2% (5/38) 3000: 26.3% (10/38) 3000+: 2.6% (1/38) Would not use: 0% (0/38)			3
For radial pressure wave treatments, what is the average number of shocks you perform on bone in a single location (one specific area in bone)?	500: 0% (0/37) 1000: 2.7% (1/37) 1500: 5.4% (2/37) 2000: 10.8% (4/37) 2500: 5.4% (2/37) 3000: 8.1% (3/37) 3000+: 2.7% (1/37) Would not use: 64.9% (24/37)			3

Continued

Table 5 Continued

Statement	Agreement	Neutral	Disagreement	Round achieved
For peripheral bone injuries, which of the following is the imaging study of choice for monitoring healing after shockwave therapy for acute traumatic fracture (< 3 months of clinical presentation or radiological confirmation). (Statement modified in Round 2 to specify 'acute traumatic fracture' and in Round 3 to state 'imaging of choice for monitoring healing')	X-ray: 65.9% (27/41) CT: 22% (9/41) MRI: 2.4% (1/41) N/A: 9.8% (4/41)			3
For peripheral bone injuries, which of the following is the imaging study of choice for monitoring healing after shockwave therapy for acute bone stress injury (< 3 months of clinical presentation or radiological confirmation). (Statement modified in Round 2 to specify 'acute bone stress injury' and in Round 3 to state 'imaging of choice for monitoring healing')	X-ray: 17.1% (7/41) CT: 24.4% (10/41) MRI: 48.8% (20/41) N/A: 9.8% (4/41)			3
For peripheral bone injuries, which of the following is the imaging study of choice for monitoring healing after shockwave therapy for delayed union/non-union from traumatic fracture (> 3 months). (Statement modified in Round 2 to specify 'delayed union/nonunion from traumatic fracture' and in Round 3 to state 'imaging of choice for monitoring healing')	X-ray: 29.3% (12/41) CT: 56.1% (23/41) MRI: 4.9% (2/41) N/A: 9.8% (4/41)			3
For peripheral bone injuries, which of the following is the imaging study of choice for monitoring healing after shockwave therapy for delayed union/non-union from bone stress injury (> 3 months). (Statement modified in Round 2 to specify 'delayed union/nonunion from bone stress injury' and in Round 3 to state 'imaging of choice for monitoring healing')	X-ray: 17.1% (7/41) CT: 53.7% (22/41) MRI: 19.5% (8/41) N/A: 9.8% (4/41)			3
For central bone injuries (ie, pelvic fracture, spine or hip fracture), which of the following is the imaging study of choice for monitoring healing after shockwave therapy for acute traumatic fracture (< 3 months of clinical presentation or radiological confirmation). (Statement modified in Round 2 to specify 'acute traumatic fracture' and in Round 3 to state 'imaging of choice for monitoring healing')	X-ray: 48.8% (20/41) CT: 14.6% (6/41) MRI: 9.8% (4/41) N/A: 26.8% (11/41)			3
For central bone injuries (ie, pelvic fracture, spine or hip fracture), which of the following is the imaging study of choice for monitoring healing after shockwave therapy for acute bone stress injury (< 3 months of clinical presentation or radiological confirmation). (Statement modified in Round 2 to specify 'acute bone stress injury' and in Round 3 to state 'imaging of choice for monitoring healing')	X-ray: 26.8% (11/41) CT: 17.1% (7/41) MRI: 29.3% (12/41) N/A: 26.8% (11/41)			3
For central bone injuries (ie, pelvic fracture, spine or hip fracture), which of the following is the imaging study of choice for monitoring healing after shockwave therapy for delayed union/non-union from traumatic fracture (>3 months). (Statement modified in Round 2 to specify 'delayed union/nonunion from traumatic fracture' and in Round 3 to state 'imaging of choice for monitoring healing')	X-ray: 19.5% (8/41) CT: 39% (16/41) MRI: 17.1% (7/41) N/A: 24.4% (10/41)			3
For central bone injuries (ie, pelvic fracture, spine or hip fracture), which of the following is the imaging study of choice for monitoring healing after shockwave therapy for delayed union/non-union from bone stress injury (>3 months). (Statement modified in Round 2 to specify 'delayed union/nonunion from bone stress injury' and in Round 3 to state 'imaging of choice for monitoring healing')	X-ray: 12.2% (5/41) CT: 34.1% (14/41) MRI: 29.3% (12/41) N/A: 24.4% (10/41)			3
	Free-text response			
During shockwave therapy procedures, pain will not exceed a VAS pain score of ___. (Statement modified to provide a number in Round 2)	Median: 7 (IQR 6–7)			3
On average, it takes about ___ weeks for most patients to have imaging findings that show healing on CT imaging after initiation of shockwave therapy treatment for acute traumatic fracture (< 3 months of clinical presentation or radiological confirmation). (Statement modified in Round 2 to provide a number and specify 'acute traumatic fracture' and in Round 3 replace 'radiographic findings' with 'imaging findings')	Median: 6 (IQR 6–8)			3
On average, it takes about ___ weeks for most patients to have imaging findings that show healing on CT imaging after initiation of shockwave therapy treatment for acute bone stress injury (< 3 months of clinical presentation or radiological confirmation). (Statement modified in Round 2 to provide a number and specify 'acute bone stress injury' and in Round 3 replace 'radiographic findings' with 'imaging findings')	Median: 8 (IQR 6–8)			3
On average, it takes about ___ weeks for most patients to have imaging findings that show healing on CT imaging after initiation of shockwave therapy treatment for delayed union/non-union from traumatic fracture (>3 months). (Statement modified in Round 2 to provide a number and specify 'delayed union/nonunion from traumatic fracture' and in Round 3 replace 'radiographic findings' with 'imaging findings')	Median: 8 (IQR 6–12)			3
On average, it takes about ___ weeks for most patients to have imaging findings that show healing on CT imaging after initiation of shockwave therapy treatment for delayed union/non-union from bone stress injury (>3 months). (Statement modified in Round 2 to provide a number and specify 'delayed union/nonunion from bone stress injury' and in Round 3 replace 'radiographic findings' with 'imaging findings')	Median: 8 (IQR 6–12)			3
On average, it takes about ___ weeks for most patients to have imaging findings that show healing on MRI after initiation of shockwave therapy treatment for acute traumatic fracture (< 3 months of clinical presentation or radiological confirmation). (Statement modified in Round 2 to provide a number and specify 'acute traumatic fracture' and in Round 3 replace 'radiographic findings' with 'imaging findings')	Median: 8.5 (6–12)			3

Continued

Table 5 Continued

Statement	Agreement	Neutral	Disagreement	Round achieved
On average, it takes about ___ weeks for most patients to have imaging findings that show healing on MRI after initiation of shockwave therapy treatment for acute bone stress injury (< 3 months of clinical presentation or radiological confirmation). (Statement modified in Round 2 to provide a number and specify 'acute bone stress injury' and in Round 3 replace 'radiographic findings' with 'imaging findings')	Median: 9 (IQR 6–12)			3
On average, it takes about ___ weeks for most patients to have imaging findings that show healing on MRI after initiation of shockwave therapy treatment for delayed union/non-union from traumatic fracture (>3 months). (Statement modified in Round 2 to provide a number and specify 'delayed union/nonunion from traumatic fracture' and in Round 3 replace 'radiographic findings' with 'imaging findings')	Median: 12 (IQR 8–12)			3
On average, it takes about ___ weeks for most patients to have imaging findings that show healing on MRI after initiation of shockwave therapy treatment for delayed union/non-union from bone stress injury (>3 months). (Statement modified in Round 2 to provide a number and specify 'delayed union/nonunion from bone stress injury' and in Round 3 replace 'radiographic findings' with 'imaging findings')	Median: 12 (IQR 8–12)			3

Colouring indicates full consensus (■), consensus with one or more disagreement (■), consensus by disagreement (■) and failure of consensus (■).
Consensus was defined a priori by≥75% agreement or disagreement.
mj/mm2, millijoules per square millimetre; VAS, Visual Analogue Scale.

have supported the efficacy of shockwave or pressure wave therapy for plantar fasciopathy,[7] common extensor tendinopathy[3 35] and proximal hamstring tendinopathy,[4] recent systematic reviews concluded that evidence to support the management of insertional Achilles tendinopathy is lacking.[36] Our panel also reached agreement for use of shockwave or pressure wave therapy for patellar tendinopathy while other reviews did not identify strong evidence to support use.[2 37] These discrepancies between research evidence and expert consensus suggest that there may be subsets of the patient population who could clinically benefit from shockwave or pressure therapy for these conditions. It is important to note that our panel supports shockwave or pressure wave therapy as an adjunctive treatment, rather than a replacement, for these conditions and as part of a larger, multimodal treatment approach.

While treatment of bone-related conditions has less research to support efficacy over tendinopathies or fasciopathies,[2] experts reached consensus that ESWT is appropriate for bone stress injuries, delayed union fractures, non-union fractures, sesamoiditis and medial tibial stress syndrome. Therefore, in cases of delayed healing from these pathologies, shockwave therapy may be considered to potentially expedite recovery. For indication questions, we used the general term 'ESWT' without specifying focused shockwave or radial pressure wave therapy because this would double the number of statements. Instead, we asked which device would be more appropriate for tendon versus conditions in the subsequent procedural aspects, which are discussed below.

Panellists identified differences in indication based on the degree of tendon tearing. While panellists reached consensus that focused ESWT or radial pressure wave therapy is appropriate for low-grade partial tendon tears, no consensus was reached to support their use in high-grade partial tendon tears and chronic full thickness tendon tears. However, the presence of high-grade partial tear or complete tear of tendon did not reach consensus for being a contraindication. Consequently, the clinical benefit of shockwave or pressure wave therapy for high-grade partial tendon tears or chronic full thickness tendon tears remains a clinical management decision that should be individualised as the current body of literature is insufficient to guide clinical management.

Procedural aspects for tendons and bones

For both tendon and bone pathologies, the panellist recommended that shockwave therapy begin at a low energy level that is easily tolerated by the patient, gradually increasing the patient's tolerance to reach the goal of therapeutic energy level. During the procedures, pain should not exceed a Visual Analogue Scale pain score of 6 for tendon conditions and 7 for bone conditions, based on the medians calculated by the experts proposed (for tendons, median 6 with IQR 4–6 and for bones, median 7 with IQR 6–7). Local anaesthesia is not recommended during treatment. While the total number of recommended treatment sessions may vary, the expert panel reached consensus on performing 3–5 sessions, with 1–2 weeks interval between them. Further, consensus was reached to recommend co-treating tendon and joint pathology with both physical therapy exercises and shockwave therapy.

For tendon conditions and fasciopathies, clinical focusing—defined as treatment over areas of maximal pain reported by the patient—is recommended over imaging guidance when performing shockwave procedures. Experts also recommended using low to medium energy levels and, if available, a combined approach of both radial and focused probes when treating tendon conditions. While the average number of shocks for tendon conditions did not reach consensus, 2000 shocks were the most common response for either focused shockwave or pressure wave therapy.

For bone conditions, experts recommended using focused ESWT and high energy levels for a minimum of 3–4 sessions. Panellists did not recommend performing a single session of focused high-energy shockwave therapy under sedation or general anaesthesia, despite prior reports of use for efficacy.[38] Notably, earlier studies used shockwave devices that were larger, performed in operating room/procedure room settings, and other considerations may have influenced these early reports. Unlike tendon conditions, the expert panel agreed that there is increased benefit in co-treating joint pathology with a combined approach of orthobiologics (eg, PRP) and shockwave therapy. These recommendations are in contrast to a review on bone stress injury from 2022 that concluded insufficient evidence supports the use of cell-based or PRP injections and ESWT in bone conditions, specifically in bone stress injuries.[39] There was

Table 6 Shockwave therapy periprocedural and postprocedural considerations

Statement	Agreement	Neutral	Disagreement	Round achieved
Acetaminophen or other non-NSAID medication could be used for pain management throughout the duration of shockwave treatment.	95.2% (40/42)	2.4% (1/42)	2.4% (1/42)	1
There are no range of motion restrictions or precautions necessary post shockwave therapy treatment of tendon or fasciopathy.	95.2% (40/42)	4.8% (2/42)	0%	1
There are no weight-bearing precautions necessary post shockwave therapy when treating tendon conditions with low-grade partial tears. (Statement was added in Round 2.)	85% (34/40)	7.5% (3/40)	7.5% (3/40)	2
NSAIDs should be avoided throughout the duration of shockwave treatments.	78.6% (33/42)	11.9% (5/42)	9.5% (4/42)	1
There are no weight-bearing precautions necessary post shockwave therapy treatment for tendon or fasciopathy.	78.6% (33/42)	9.5% (4/42)	11.9% (5/42)	1
Fluoroquinolones should be avoided throughout the treatment window of shockwave therapy.	77.8% (28/36)	16.7% (6/36)	5.6% (2/36)	1
The use of radial pressure wave application on tendons does NOT require additional activity restrictions outside best practice for the injury being treated. (Statement was added in Round 3 instead of asking 'When do you recommend patients to return to sports after radial pressure wave therapy' in Round 1 and 'When do you recommend patients to return to activities as tolerated after radial pressure wave therapy for tendons?' in Round 2.)	77.5% (31/40)	10% (4/40)	12.5% (5/40)	3
Radial pressure wave therapy can be performed while the patient is on direct anticoagulants.	67.6% (25/37)	10.8% (4/37)	21.6% (8/37)	3
Focused ESWT can be performed while the patient is on direct anticoagulants.	66.7% (26/39)	15.4% (6/39)	17.9% (7/39)	3
The use of focused ESWT application on tendons does NOT require additional activity restrictions outside best practice for the injury being treated. (Statement was added in Round 3 instead of asking 'When do you recommend patients to return to sports after focused or combined shockwave therapy' in Round 1 and 'When do you recommend patients to return to activities as tolerated after shockwave therapy' for bone pathologies in Round 2.)	65% (26/40)	17.5% (7/40)	17.5% (7/40)	3
The use of radial pressure application on bones does NOT require additional activity restrictions outside best practice for the injury being treated. (Statement was added in Round 3 instead of asking 'When do you recommend patients to return to sports after radial pressure wave therapy for tendons' in Round 1 and 'When do you recommend patients to return to activities as tolerated after radial pressure wave therapy' for bone pathologies in Round 2.)	64.7% (22/34)	26.5% (9/34)	8.8% (3/34)	3
The use of focused ESWT application on bones does NOT require additional activity restrictions outside best practice for the injury being treated. (Statement was added in Round 3 instead of asking 'When do you recommend patients to return to sports after focused or combined shockwave therapy' in Round 1 and 'When do you recommend patients to return to activities as tolerated after shockwave therapy' for bone pathologies in Round 2.)	62.5% (25/40)	17.5% (7/40)	20% (8/40)	3
Icing the treatment area should be avoided for the duration of shockwave therapy treatments.	46.3% (19/41)	22% (9/41)	31.7% (13/41)	3
There are no weight-bearing precautions necessary post shockwave therapy when treating tendons with high-grade partial tears. (Statement was added in Round 2.)	37.5% (15/40)	12.5% (5/40)	50% (20/40)	3
	Multiple choice response			
Non-steroidal anti-inflammatory drugs should be avoided prior to initiation of shockwave treatment at least ___. (NSAIDs were defined as non-steroidal anti-inflammatory drugs in Round 2.)	Not at all: 9.8% (4/41) 2 days: 14.6% (6/41) 4 days: 4.9% (2/41) 1 week: 58.5% (24/41) 2 weeks: 12.2% (5/41)			3
What is the recommendation for how many days aspirin 81 mg should be held prior to initiation of shockwave treatment? (Statement was changed to multiple choice questions in Round 2.)	Not at all: 56.1% (23/41) 2 days: 12.2% (5/41) 4 days: 2.4% (1/41) 1 week: 24.4% (10/41) 2 weeks: 4.9% (2/41)			3
Excessive alcohol consumption (> 24 to 36 grams per day or 2 to 2.5 standard drinks per day) has been shown to negatively affect tendon healing. How do you commonly educate patients surrounding alcohol intake surrounding shockwave sessions? (This statement was changed into a multiple-choice question in Round 2.)	Don't commonly educate patients on alcohol intake in regards to shockwave: 47.5% (19/40) Do not find it affects shockwave outcomes: 7.5% (3/40) Recommend avoiding through the duration of shockwave sessions: 15% (6/40) Recommend minimising through the duration of shockwave sessions: 30% (12/40)			3
How long after the final planned shockwave session should you hold use of non-steroidal anti-inflammatory drugs? (NSAIDs were defined as non-steroidal anti-inflammatory drugs in Round 2.)	No days: 17.1% (7/41) 1 week: 12.2% (5/41) 2–6 weeks: 53.7% (22/41) 6–12 weeks: 14.6% (6/41) >3 months: 2/4% (1/41)			3

Colouring indicates full consensus (■), consensus with one or more disagreement (■) and failure of consensus (■).
Consensus was defined a priori by≥75% agreement or disagreement.
ESWT, extracorporeal shockwave therapy; NSAID, non-steroidal anti-inflammatory drug.

Table 7 Contraindications for shockwave or pressure wave therapy

Statement	Agreement	Neutral	Disagreement	Round achieved
Malignancy is a contraindication to focused shockwave therapy treatment.	85.3% (35/41)	9.8% (4/41)	4.9% (2/41)	1
Focused shockwave therapy should not be performed with the lung in the treatment area.	77.8% (28/36)	11.1% (4/36)	11.1% (4/36)	1
Malignancy is a contraindication to radial pressure wave therapy.	76.9% (30/39)	23.1% (9/39)	0%	1
	Multiple choice response			
Radial pressure wave therapy should not be performed within ___ weeks of a local corticosteroid injection.	1 week: 5% (2/40) 2 weeks: 12.5% (5/40) 6 weeks: 60% (24/40) 3 months: 15% (6/40) N/A: 7.5% (3/40)			3
Radial pressure wave therapy should not be performed within ___ weeks of a corticosteroid injection in a different body part. (Statement was added in Round 2.)	1 week: 7.5% (3/40) 2 weeks: 32.5% (13/40) 6 weeks: 15% (6/40) 3 months: 0% (0/40) N/A: 45% (18/40)			3
Radial pressure wave therapy should not be performed within ___ weeks of systematic steroid treatment. (Statement was added in Round 2.)	1 week: 7.9% (3/38) 2 weeks: 39.5% (15/38) 6 weeks: 34.2% (13/38) 3 months: 2.6% (1/38) N/A: 15.8% (6/38)			3
Focused shockwave therapy should not be performed within ___ weeks of a local corticosteroid injection. (Statement was added in Round 2.)	1 week: 7.5% (3/40) 2 weeks: 12.5% (5/40) 6 weeks: 55% (22/40) 3 months: 17.5% (7/40) N/A: 7.5% (3/40)			3
Focused shockwave therapy should not be performed within ___ weeks of a corticosteroid injection in a different body part. (Statement was added in Round 2.)	1 week: 7.5% (3/40) 2 weeks: 35% (14/40) 6 weeks: 15% (6/40) 3 months: 0% (0/40) N/A: 42.5% (17/40)			3
Focused shockwave therapy should not be performed within ___ weeks of systematic steroid treatment. (Statement was added in Round 2.)	1 week: 10.3% (4/39) 2 weeks: 30.8% (12/39) 6 weeks: 41.0% (16/39) 3 months: 2.6% (1/39) N/A: 15.4% (6/39)			3
Absolute contraindications to radial pressure wave therapy				
Active systemic infection (24, 58.5%), active local infection (30, 73.2%), **active malignancy near treatment area (40, 97.6%)**, active malignancy not near treatment area (8, 19.5%), pregnancy (treating an area not close to belly) (15, 36.6%), major nerve in treatment area (ie, ulnar, radial, sciatic) (8, 19.5%), lung/rib in treatment area (12, 29.83%), cardiac pacemakers or other electrical implantable devices (23, 56.1%), epiphyseal plate in treatment area (12, 29.3%). Free-text responses: coagulopathy, open wound				
Absolute contraindications to focused ESWT				
Active systemic infection (26, 63.4%), active local infection (28, 68.3%), **active malignancy near treatment area (41, 100.0%)**, active malignancy not near treatment area (11, 26.8%), pregnancy (treating an area not close to belly) (19, 46.3%), major nerve in treatment area (ie, ulnar, radial, sciatic) (8, 19.5%), lung/rib in treatment area (24, 58.5%), cardiac pacemakers or other electrical implantable devices (26, 63.4%), epiphyseal plate in treatment area (20, 48.8%). Free-text responses: fetus in the treatment area, coagulopathy, open wound				
Relative contraindications to radial pressure wave therapy				
Active systemic infection (13, 31.7%), active local infection (12, 29.3%), active malignancy near treatment area (10, 24.4%), active malignancy not near treatment area (18, 43.9%), pregnancy (treating an area not close to belly) (17, 41.5%), major nerve in treatment area (ie, ulnar, radial, sciatic) (17, 41.5%), lung/rib in treatment area (13, 31.7%), cardiac pacemakers or other electrical implantable devices (14, 34.1%), epiphyseal plate in treatment area (12, 29.3%). Free-text responses: subcutaneous hardware, anticoagulation				
Relative contraindications to focused ESWT				
Active systemic infection (12, 29.3%), active local infection (12, 29.3%), active malignancy near treatment area (10, 24.4%), active malignancy not near treatment area (15, 36.6%), pregnancy (treating an area not close to belly) (17, 41.5%), major nerve in treatment area (ie, ulnar, radial, sciatic) (18, 43.9%), lung/rib in treatment area (12, 29.3%), cardiac pacemakers or other electrical implantable devices (10, 24.4%), epiphyseal plate in treatment area (9, 22.0%). Free-text responses: brain or spinal cord in the treatment area, subcutaneous hardware, anticoagulation				
Colouring indicates full consensus (■), consensus with one or more disagreement (■) and failure of consensus (■). In Round 2, contraindications were provided in multiple choices, and experts were allowed to select all that applied. In Round 3, contraindications were further divided into absolute and relative contraindications. Consensus was defined a priori by ≥75% agreement or disagreement. ESWT, extracorporeal shockwave therapy.				

varying agreement on the time frame and imaging modalities to monitor healing after acute traumatic fractures, acute bone stress injuries, delayed union/non-union from traumatic fractures and delayed union/non-union from bone stress injuries. While the average number of shocks did not reach consensus, 2000 shocks were again the most common response for focused shockwave therapy. Panellists agreed for general use of ESWT for bone pathologies as noted in

Table 8 Side effects associated with shockwave or pressure wave therapy

Statement	Agreement	Neutral	Disagreement	Round achieved
Potential side effects of radial pressure wave therapy include pain at the applicator site, skin erythema, skin bruising, haematoma formation, nerve irritation, superficial oedema and headache.	92.5% (37/40)	5% (2/40)	2.5% (1/40)	1
Potential side effects of focused shockwave therapy include pain at the applicator site, skin erythema, skin bruising, haematoma formation, nerve irritation, superficial oedema and headache.	90.5% (38/42)	7.1% (3/42)	2.4% (1/42)	1
There is a minimal risk of tendon rupture with the use of focused shockwave therapy.	85.7% (36/42)	7.1% (3/42)	7.1% (3/42)	1
There is a minimal risk of tendon rupture with the use of radial pressure wave therapy.	82.5% (33/40)	7.5% (3/40)	10% (4/40)	1
Side effects of radial pressure wave therapy include				
Pain at application site (41, 100.0%), skin erythema (39, 95.1%), skin bruising (38, 92.7%), haematoma formation (28, 68.3%), nerve irritation (27, 65.9%), superficial oedema (31, 75.6%), headache (9, 22.0%). Free-text response: tinnitus when applied at neck, skin injury				
Side effects of focused ESWT include				
Pain at application site (40, 97.6%), skin erythema (35, 85.4%), skin bruising (32, 78.0%), haematoma formation (25, 61.0%), nerve irritation (29, 70.7%), superficial oedema (28, 68.3%), headache (10, 24.4%). Free-text response: petechial haemorrhages, Achilles tendon rupture during running after pain relief, pneumothorax with high energy				
Other free-text responses include				
Increased pain or soreness, frozen shoulder when treating rotator cuff calcifications, oedema in the arm, tendon rupture, bone fractures, humeral head osteonecrosis, olecranon bursitis, vertigo, syncope, systemic inflammation, anxiety, tachycardia.				

Colouring indicates full consensus (■), consensus with one or more disagreement (□) and failure of consensus (■).
In Round 2, participants were given options to select (all that apply) from the side effects stated in Round 1 statement.
Consensus was defined a priori by ≥75% agreement or disagreement.
ESWT, extracorporeal shockwave therapy.

the indication section, but 64.9% of experts (n=24/37) indicated that they would not recommend radial pressure wave in the management of bone pathologies.

Periprocedural and postprocedural considerations

The expert panel reached consensus that non-steroidal anti-inflammatory drugs (NSAIDs) should be avoided throughout the duration of shockwave treatments and that acetaminophen or other non-NSAID medication could be used for pain management during this period. NSAIDs may interfere with the normal inflammatory pathway, required for normal tissue remodelling, such as soft tissue and bone.[40 41] Some experts recommended that NSAIDs should be held for 2–6 weeks after the final planned shockwave session, but this statement did not reach consensus. The questions also asked about the use of NSAIDs for shockwave in the general patient population; one report suggested the need to maintain patients with underlying rheumatological disease on stable disease-modifying antirheumatic drug regimen to avoid worsening or systemic inflammatory response.[42] Experts also agreed that fluoroquinolones should be avoided during the therapies. This recommendation is aimed at reducing the risk of tendon rupture associated with the use of fluoroquinolones, especially in patients with other risk factors for tendon ruptures.[43 44] Experts failed to reach consensus on when to discontinue NSAIDs before initiating shockwave or pressure wave therapy, or whether focused shockwave or radial pressure wave therapy can be performed while patients are on direct anticoagulants.

Consensus was reached regarding postprocedural precautions. Experts agreed that there are no range of motion restrictions or precautions necessary following shockwave therapy for tendinopathies or fasciopathies, and no weight-bearing precautions are required when treating low-grade partial tears. Furthermore, the use of radial pressure wave therapy on tendon does not require additional activity restrictions beyond the best practices for the injury being treated. One reported advantage of shockwave or pressure wave therapy is that it allows activities as tolerated, which may be particularly appealing to in-season athletes,[2] unlike other injection therapies such as PRP, which impose postprocedural activity restriction.[45] However, experts did not reach consensus on whether activity restrictions are required postprocedurally with radial pressure wave therapy for bone conditions, nor with focused ESWT for tendon and bone conditions. Consensus was also not reached regarding whether any precautions are needed post shockwave or pressure wave therapy when treating tendons with high-grade partial tears. This remains a clinical management decision that should be individualised for each patient. Consensus was additionally not reached on whether icing of the treatment area should be avoided.

Contraindications for shockwave or pressure wave therapy

For contraindications, the expert panel reached consensus that active malignancy near the treatment area is an absolute contraindication for both radial pressure wave therapy and focused ESWT and that focused ESWT should not be performed with lung in the treatment area. There were varying degrees of agreement on the following conditions as absolute or relative contraindications: active systemic infection, active local infection, active malignancy not near treatment area, pregnancy, major nerve in treatment area, lung/rib in treatment area, cardiac pacemakers or other electrical implantable devices, epiphyseal plate in treatment area.

No consensus was reached on the ideal timing to perform focused ESWT or radial pressure wave therapy following corticosteroid injections or following systemic steroid treatment.

Side effects associated with shockwave or pressure wave therapy

The expert panel reached consensus that potential side effects for focused ESWT and radial pressure wave therapy include pain at the applicator site, skin bruising, skin erythema, superficial oedema, haematoma formation, nerve irritation and headache. Panellists agreed that there is a minimal risk of tendon rupture with the use of either focused ESWT or radial pressure wave therapy.

When experts were allowed to vote on each of the side effects individually instead of the statement as a whole, experts reached

consensus only on pain at the application site, skin erythema and skin bruising. While these may represent more common side effects, it is important to be aware of other rare but serious complications mentioned in the free-text responses, including tendon ruptures, pneumothorax with high-energy focused ESWT, bone fractures and osteonecrosis, which have been rarely reported in the literature.[2]

Limitations

This was the first modified Delphi study aimed at reaching a consensus on various aspects of ESWT in sports medicine. While the Delphi method poses a risk for non-response error,[46] all 41 participants finished all three rounds. Despite this novelty and participation, our study has several limitations. First, our panel is comprised of regular users of ESWT, introducing the possibility of observer bias. Second, although the invited experts were unaware of each other's identities, the members of the steering group who generated the questions knew who was participating in this study and members who developed statements participated in rounds of voting. Third, one participant accidentally completed the Round 1 survey twice with slightly differing responses, and we included both sets of responses in our Round 1 results. Fourth, for the free-text questions where the experts provided specific numbers, due to the wide range of responses, we presented the data using medians and IQRs, which do not necessarily represent a consensus among the participating experts. We limited topics to radial pressure waves and focused shockwave therapy; recent devices including electromagnetic transduction therapy and 'unfocused' shockwave have been reported in clinical use.[47 48] Fifth, given that there is limited research evidence surrounding specific topics related to ESWT, such as procedural aspects for bone, it is a possibility that current expert consensus may be refuted in future rigorous research studies. Lastly, we are conscious that we did not involve patients or patient advocates who may have provided insights into the patient's experience and ensured that the outcomes of our endeavour would align with patients' needs and values. However, as this modified Delphi study aimed to reach consensus on ESWT that would require either clinical or research experience, we focused on recruiting clinical and research experts.

While the panellists reflected a wide range of clinical specialties and practice environments, there were gender imbalances and certain geographical locations were more highly represented. To account for this, our group sought to include experts from underrepresented geography and those of female gender. The cost of ESWT presents a significant barrier particularly in lower-income countries. These factors may limit access to ESWT for patients as well as the ability for sports medicine clinicians to obtain practice experience. These factors may contribute to an underrepresentation of perspectives from regions where ESWT is less accessible. By highlighting evidence and consensus supporting the use of ESWT, we may help to inform public policy to consider coverage or reduced costs for ESWT in order to improve accessibility and equity in case.

CONCLUSION

This modified Delphi study presents specific terminology, indications, procedural aspects, contraindications and side effects related to ESWT. The statements that reached consensus are intended to guide clinical decision-making for sports medicine clinicians in the treatment of tendon, fascia and bone pathologies. Future research will be needed to strengthen specific recommendations and to establish the best evidence-based clinical practices for ESWT.

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