ORIGINAL ARTICLE

Nr 2022;12 (3):411-421

Even Patients with Very Chronic Symptoms of Greater Trochanteric Pain Syndrome (GTPS) may Report Improvements Following Radial Extracorporeal Shockwave Therapy (rESWT), but no Single Baseline Factor Predicts Response

P. C. Wheeler[1,2,3]

[1] *Department of Sport and Exercise Medicine, University Hospitals of Leicester NHS Trust, Leicester, U.K.*
[2] *School of Sport, Exercise and Health Sciences, Loughborough University, Loughborough, U.K.*
[3] *National Centre of Sport and Exercise Medicine, Loughborough, U.K.*

CORRESPONDING AUTHOR:
Patrick Wheeler
Department of Sport and Exercise Medicine
University Hospitals of Leicester NHS Trust
Leicester General Hospital
Gwendolen Road
Leicester, U.K
LE5 4PW
E-mail: p.wheeler@lboro.ac.uk

DOI:
10.32098/mltj.03.2022.17

LEVEL OF EVIDENCE: 4

SUMMARY

Objective. Do any measures at baseline predict response from radial Extracorporeal Shockwave Therapy (rESWT) for patients with GTPS?

Methods. Setting: single UK NHS Sports Medicine Clinic. Patients: 260 patients following rESWT for GTPS. Mean age 60.0 ± 11.9 years, 81% female, mean duration of symptoms 44.5 ± 44.7 months (range: 3 months-20years). Interventions: participants received three sessions of rESWT plus structured home exercise programme (flexibility, strength, and balance). Main outcome measures: follow-up was 3-months, and 6-months. Outcome measures of self-reported "average pain", "worst pain", and VISA-G score. Baseline PROMS (Non-Arthritic Hip score, and Oxford Hip Score), pain (painDETECT, S-LANSS, CSI), "ability" (ODI, MSK-HQ), mood (HADS).

Results. Improvement in "average pain" of 30% at 3-months, and 37% at 6-months. VISA-G improved by more than 10% points at 3-months and 6-months. Several weak or very-weak correlations were identified, but no single baseline variable corelated strongly to the improvements seen at follow-up time-points.

Conclusions. There were clinical and statistically-significant improvements seen following rESWT for patients with GTPS, even in those with very long duration of symptoms, irrespective of age or symptom duration. There was a statistically significant difference for gender (greater benefit in female patients) which did not reach clinical significance. Greatest improvements in self-reported pain were seen in those with the worst baseline symptoms, particularly with variables more sensitive to non-arthritic hip pain (NAHS, VISA-G) than "arthritic pain" measures (OHS). Baseline measures such as Oswestry Disability Inventory or the MSK-HQ have weak correlations to improvements in some factors seen, with fewer correlations seen for markers of chronic, neuropathic, or centralised pain, or mood.

KEY WORDS

Extracorporeal shockwave therapy; tendons; outcome assessment; Greater Trochanteric Pain Syndrome

INTRODUCTION

Greater Trochanteric Pain Syndrome is a common cause of lateral hip pain, has an incidence of 1.8/1000 patients per year in primary care, affecting women more than men, most typically in their 50's and 60's (1-4). "Greater trochanteric pain syndrome" has held various names over the last few decades, indicating the ongoing confusion as to the pathological processes involved; for the purposes of this article

the phrase "greater trochanteric pain syndrome" (abbreviated to "GTPS") will be used, although the limitations of this terminology are recognised (3, 5, 6).

GTPS describes an area of reproducible lateral hip pain over the area of the greater trochanter, typically spreading to the buttock, upper lateral thigh, or occasionally further, which can overlap with symptoms from other conditions including hip joint, spinal, or radicular pathologies (3, 7). GTPS is more common in patients with pre-existing osteoarthritis of the knee or low back pain, with conflicting evidence as to whether it may be more common in overweight or obese patients (3, 8). Examination typically reveals maximal tenderness in the posterolateral area of the greater trochanter, but the majority of clinical tests have limited sensitivity and poorly differentiate GTPS from other causes of lateral hip pain (9, 10). Investigations can be useful in aiding diagnoisis, and 88% of patients with GTPS symptoms have evidence of gluteus tendinopathy on MRI compared to 50% of those with hip pain but without specific greater trochanteric symptoms (5, 11). However as gluteal tendinopathy can be often reported on MRI in those without specific GTPS-symptoms, rather than a diagnostic tool, investigations may be more useful in ruling out other conditions such as osteoarthritis of the hip, or tears of the gluteal tendons (11).

Radial extracorporeal shockwave therapy (rESWT), involves the use of inaudible high-energy sound waves which are generated externally to the body and spread aspherically into soft-tissue as a pressure wave, losing power as they pass deeper into tissue, but potentially covering a broad area (12). rESWT is most typically performed over three sessions, at weekly intervals, in order to promote a healing response alongside a structured rehabilitation programme (13). However the treatment numbers vary between studies with ongoing uncertainty as to "optimal treatment" (14), with evidence from a case-control study suggesting benefits of a single treatment session of rESWT in patients with GTPS (15), and another case series that used between one and eleven sessions (mean 5.6 sessions) of rESWT (16). Recent research however has questioned the protocol typically recommended, with equal benefit demonstrated in patients following 3 sessions of "maximum tolerated" *versus* "minimal dose" rESWT in a double-blinded RCT (17).

Similar to other treatments and conditions, there appears to be great heterogeneity in response to rESWT for patients with GTPS. Benefits are typically seen in most, but not all, patients but this can take 3-months to 6-months for clinically appreciated benefits to occur (17, 18). To date there is no research looking to identify any specific factors at baseline which may be of value in predicting response to treatment and which may guide individualised pathways of care. This research seeks to identify if any self-reported measures at baseline may have value in predicting response to rESWT in patients with chronic GTPS.

MATERIALS AND METHODS

Procedure logs were examined from a single UK hospital outpatient clinic, which has a regional reputation for the management of patients with chronic tendinopathy. A total of 260 patients who had previously been treated with rESWT for symptoms of Greater Trochanteric Pain Syndrome (GTPS) were identified from procedure logs.

Baseline and outcome measurements

Baseline assessments were conducted prior to the rESWT procedure. There is no single "gold standard" for assessing patients with GTPS, therefore a 0-10 numerical rating scale of self-reported "average pain" and self-reported "worst pain" were used initially, alongside validated PROMS: the Oxford Hip Score (OHS) (19, 20), and the Non-Arthritic Hip Score (NAHS) (21, 22). Additional hip-specific measure of function was undertaken with participants partway through the longitudinal case series with the Victorian Institute of Sport Assessment - Gluteal Tendon questionnaire (VISA-G) (23) and the Musculoskeletal Health Questionnaire (MKS-HQ) (24) for global musculoskeletal functioning. These measures were recorded contemporaneously at baseline before rESWT treatment, and also at 3-months and 6-months after rESWT treatment.

Additional measurements were taken across a broad range of aspects of function to assess baseline function, with subsequent analysis undertaken to assess if measurements at baseline predicted subsequent outcome. These included validated measures of neuropathic pain or central sensitisation: painDETECT (25, 26), and Leeds Assessment of Neuropathic Symptoms and Signs (S-LANSS) (27, 28), or Central Sensitisation Inventory (CSI) (29, 30) respectively. Assessments of anxiety and depression symptoms were assessed through the Hospital Anxiety and Depression Scale (HADS) (31, 32) plus PHQ-4, GAD-7 & PHQ-9 (33-35). Markers of chronic pain were assessed via the Pain Catastrophising Scale (PCS) (36) and the Psychological Inflexibility in Pain Scale (PIPS) (37). Additional measures of global function and ability were assessed via EuroQol 5Dimensions (EQ-5D) (38, 39) and the Oswestry Disability Index (ODI) (40). These combined questionnaires took an average of 30 minutes to complete by the patient prior to treatment.

Interventions

Patients received three rESWT treatment sessions performed at weekly intervals of rESWT from a "Intelect" RPW ESWT machine (DJO Global Chattanooga), with

energy level controlled by the operator to the "maximum comfortably tolerated dose" for the individual patient in line with manufacturer instructions. The treatment protocol was for rESWT delivered at a frequency of 20 Hz with 2000 shocks per treatment session. The mean value of the pressure waves generated was 2.3 ± 0.2, 2.9 ± 0.3, and 3.4 ± 0.4 bar for the 1st, 2nd, and 3rd treatment sessions respectively.
In addition to the rESWT, all patients were given a structure home exercise programme and taught how to progress this programme alongside the rESWT treatment. This programme included components of mobilisation, stretching, balance and strengthening exercises and is documented in previous work (17). Patients were encouraged to start the HEP prior to rESWT and to continue this throughout the period of follow-up, progressing this as their symptoms allowed. They were all given written material to support their compliance with the HEP.

Follow-up

Patients were reviewed in routine clinics at three-months and at six-months following the final rESWT treatment procedure. Follow-up data for outcome measurements was recorded at the follow-up time-points, the patients' general progress was assessed, their compliance and ability with the home exercise programme was reviewed and further instruction given if appropriate.

Ethics statements

This specific project does not fulfil the criteria of research as stipulated by HRA, therefore formal NHS ethics approvals were not required for this project. This specific project, which examines data at baseline and compares these to outcomes seen following treatment is a part of a wider ongoing body of work examining different aspects of chronic tendinopathy which is fully registered with the hospital Trust and relevant authorities.

Statistical analysis

Anonymised data from the procedural logs were inputted into a bespoke Excel spreadsheet (MS Excel for Mac – current version 16.50) by the author. All data was anonymised prior to analysis and held/used in accordance with hospital procedures. From this, group values (including means, standard deviations, and ranges) were calculated for the patient group as a whole, and for different sub-groups. Most data collected were scale data, with some data recorded as either ordinal or nominal categories. Data were analysed with SPSS (v27) and the Shapiro-Wilk test was performed to assess normality. Most data were not normally distributed, therefore non-parametric testing was used throughout, typically Wilcoxon Signed-Rank or Chi-Square testing. Spearman's correlation was used to assess relationships between variables. Statistical significance was set at $p < 0.05$. Missing Value Analysis (MVA) was not undertaken.

Ethical approvals

This project utilised anonymised data from questionnaires that patients who attended this outpatient department completed as a part of their routine clinical care. Patients were advised that these questions were designed to better understand their pain and the impact that their symptoms had on their quality of life, and they were free to choose not to complete the questionnaires if they wished, and gave permission for use of anonymised data. This specific project, which examines data at baseline and compares these to outcomes seen following treatment is a part of a wider ongoing body of work examining different aspects of chronic tendinopathy which is fully registered with the hospital Trust and relevant authorities. This specific project does not fulfil the criteria of research as stipulated by HRA, therefore formal NHS ethics approvals were not required for this project.

RESULTS

260 patients who had been treated with rESWT for GTPS were identified from procedural records who had follow-up recorded at either 3-months (n = 251/260) or 6-months (n = 229/260), or both (n = 219/260). There was a mean age of 60.0 ± 11.9 years, 81% (n = 211/260) were female, and there was a mean duration of symptoms of 44.5 ± 44.7 months (range: 3-240). These data are displayed in **table I**.
Baseline data were available for self-recorded values of "average pain" for all patients, and 256/260 patients for values of "worst pain". In addition, baseline values were available for the following PROMS: VISA-G (n = 213/260), NAHS (n = 256/260), OHS (n = 256/260) and MSK-HQ (n = 93/260).
Follow-up data for patients at 3-months showed a reduction in self-reported measures of "average pain" and "worst pain" of 30% and 25% respectively, and at 6-months these figures were 37% and 30%. There were statistically significant improvements in all outcome measures comparing baseline to 3-months, and baseline to 6-months (all $p < 0.001$), and these data are displayed in **table II**.

Table I. Demographics (n = 260 total).

Age	60.0 ± 11.9 years
Gender (%female/%male)	81% female/19% male (211 F/49 M)
Duration of symptoms	44.5 months ± 44.7 months (Range: 3-240 months)

Data are mean ± SD.

Table II. PROMs at baseline and follow-up.

	Baseline	3-month follow-up	6-month follow-up
Self-reported "average pain" (0-10)	6.3 ± 1.8 (n = 260)	4.4 ± 2.6* (n = 251)	4.0 ± 2.7* (n = 228)
Self-reported "worst pain" (0-10)	8.0 ± 1.5 (n = 256)	6.0 ± 2.7* (n = 241)	5.6 ± 2.9* (n = 226)
VISA-G	48.4% ± 16.2% (n = 213)	58.4% ± 19.1%* (n = 195)	61.3% ± 20.6%* (n = 197)
NAHS (total score)	43.0 ± 13.1 (n = 256)	51.4 ± 14.9* (n = 239)	53.0 ± 15.6* (n = 225)
Oxford Hip Score	25.7 ± 8.4 (n = 256)	32.1 ± 9.2* (n = 239)	33.0 ± 9.3* (n = 225)
MSK-HQ	31.0 ± 8.4 (n = 93)	36.2 ± 10.1* (n = 88)	37.8 ± 10.7* (n = 84)

Data are mean ± SD. Into brackets: number of patients with data. Asterisks (*) represent significant change from baseline value (all $p < 0.001$). VISA-G: Victoria Institute of Sports Gluteal Tendon score; NAHS: Non-Arthritic Hip Score (total score displayed); OHS: Oxford Hip Score; MSK-HQ: Musculoskeletal Health Questionnaire.

The presence of neuropathic pain as a component of pain has been suggested both as a concept, and has been found in previous cohort study across multiple different tendon conditions (26). Patients were categorised according to their baseline painDETECT score (n = 254/260) as to the likelihood of a neuropathic pain component. Overall, the painDETECT score was high enough to categorise as neuropathic pain was "likely" (painDETECT 19-38) in 22% of the patients (n = 55/254). Of the remainder, 23% (n = 58/254) scored in the "equivocal" category (painDETECT 13-18), and 56% (n =141/254) were identified as neuropathic pain was "unlikely" (painDETECT 0-12). Mean scores for self-reported average and worst pain calculated for those in each of these categories. These demonstrated that there were significant between-groups differences at baseline, with those who scored more highly on the painDETECT questionnaire at baseline (hence being more likely to have neuropathic pain) scoring higher on both 0-10 scales of "average pain" and "worst pain". However, these differences were not consistently seen at follow-up periods. These data are displayed in **table III**.

A further measure of neuropathic pain was used with the self-reported version of Leeds Assessment of Neuropathic Symptoms and Signs (S-LANSS, n = 93). Using this questionnaire, 27% (n = 31/93) scored highly enough to suspect the presence of neuropathic pain (S-LANSS score 12+). Additional baseline measures were taken for symptoms of central sensitisation using the Central Sensitisation Inventory (CSI, n = 201). Using this questionnaire 27% (n = 54/201) were judged to be more likely to have central sensitisation (CSI score > 40) at baseline.

Additional measures of global ability/function were recorded with the Oswestry Disability Inventory (ODI, n = 206) and the EQ-5D %health measure (n = 254). Quantification of patient mood state for anxiety and depressive symptoms was made with Hospital Anxiety and Depression Scale (HADS, n = 252), PHQ-4 (n = 204), GAD-7 (n = 203), and PHQ-9 (n = 204). Measurement was also undertaken with the Pain Catastrophising Scale (PCS, n = 93) and Psychological Inflexibility in Pain Scale (PIPS, n = 93) as additional markers of interest. The baseline values for these different PROMs are displayed in **table IV**.

To attempt to identify possible predictors of outcome following rESWT, independent correlation analysis was undertaken between the different baseline values for the different PROMS and improvements in the self-reported values of "average pain", "worst pain", and the changes in the VISA-G score at 3-months and 6-months.

At 3-months weak or very weak correlations were found between a change in self-reported "worst pain" and baseline "average pain" (but not "worst pain"), MSK-HQ and ODI questionnaires. Improvements in the VISA-G score correlated with other hip function PROMS at baseline.

At 6-months follow-up, very weak correlations for improvements in self-reported "average pain" and 'worst pain" were found for baseline values of the ODI and painDETECT questionnaires. There were also found to be weak correlations between improvements in the VISA-G score and several of the other hip questionnaires (r_s all - 0.2 to - 0.4), but also a very weak negative correlation between improvements in the VISA-G score

Table III. Average/worst self-reported pain (0-10) for different categories of baseline painDETECT score.

	Self-reported "average pain"		
	Baseline	**3-month follow-up**	**6-month follow-up**
"Neuropathic pain unlikely" painDETECT (0-12) (n = 141)	6.0 ± 1.9	4.2 ± 2.6	4.1 ± 2.6
"Equivocal" painDETECT (13-18) (n = 58)	6.1 ± 1.7	4.2 ± 2.4	3.8 ± 2.6
"Neuropathic pain more likely" painDETECT (19-38) (n = 55)	7.2 ± 1.6	4.9 ± 2.7	4.4 ± 2.9
P-value	0.007 *	0.255	0.518
	Self-reported "worst pain"		
	Baseline	**3-month follow-up**	**6-month follow-up**
"Neuropathic pain unlikely" painDETECT (0-12) (n = 141)	7.7 ± 1.6	5.9 ± 2.7	5.7 ± 2.9
"Equivocal" painDETECT (13-18) (n = 58)	7.9 ± 1.4	5.8 ± 2.7	4.9 ± 2.9
"Neuropathic pain more likely" painDETECT (19-38) (n = 55)	8.7 ± 1.2	6.4 ± 2.7	6.1 ± 2.9
P-value	0.027*	0.452	0.013*

Data are mean ± SD; P-values demonstrate significance of difference within time-period group.

Table IV. Baseline PROMs.

Measure	PROM	Baseline value	n
Neuropathic pain	painDETECT	12.1 ± 7.2	254
	S-LANSS	9.1 ± 5.6	93
Central Sensitisation	CSI	32% ± 15%	201
Chronic pain	PCS	16.3 ± 11.3	93
	PIPS	60.1 ± 18.6	93
Global ability/function	ODI	34% ± 15%	206
	EQ-5D % health scale	68% ± 19%	254
Mental health (anxiety/depression)	HADS (anxiety scale)	5.8 ± 3.7	251
	HADS (depression scale)	4.9 ± 3.3	252
	PHQ-4	1.6 ± 2.2	204
	GAD-7	3.6 ± 3.9	203
	PHQ-9	5.2 ± 4.7	204

Data are mean ± SD.

at 6-months and the symptom duration (r_s = 0.160, p = 0.026*), n = 193, indicating those with shorter symptom duration may have had slightly greater improvements seen at 6-months.

These are described under the different sub-headings below, with key findings explored. All relevant data is shown in **table V** for the significance of any correlations at 3-months, and **table VI** for correlations at 6-months.

Table V. Correlations at 3-months.

	% change in "average pain"	% change in "worst pain"	Change in VISA-G
Age	N	N	N
Gender	p = 0.028*	N	N
Symptom duration	N	N	N
Number of previous injections	N	(r_s = - 0.140, p = 0.034), n = 231	N
Rehab frequency (@3M)	N	N	N
Rehab regularity (@3M)	N	N	N
Baseline			
"Average pain" (0-10)	N	(r_s = - 0.135, p = 0.038*) n = 237	N
"Worst pain" (0-10)	N	N	N
VISA-G	N	N	(r_s = - 0.325, p < 0.001*), n = 195
NAHS	N	N	(r_s = - 0.227, p = 0.001*), n = 195
OHS	N	N	(r_s = - 0.220, p = 0.002*), n = 195
MSK-HQ	N	(r_s = 0.220, p = 0.046*), n = 83	N
ODI	N	(r_s = - 0.143, p = 0.049*), n = 190	N
EQ-5D %health	N	N	N
painDETECT (score)	N	N	N
painDETECT (category)	N	N	N
S-LANSS (score)	N	N	N
S-LANSS (category)	N	N	N
CSI (score)	N	N	N
CSI (category)	N	N	N
PCS	N	N	N
PIPS	N	N	N
HADS (Anxiety)	N	N	N
HADS (Depression)	N	N	N
PHQ-4	N	N	N
GAD-7	N	N	N
PHQ-9	N	N	N

N: non-significant statistical relationship; rs < 0.2 "very weak" correlation, > 0.2 "weak" correlation", > 0.4 "moderate" correlation" … (not seen in data set).

Table VI. Correlations at 6-months.

	% change in "average pain"	% change in "worst pain"	Change in VISA-G
Age	N	N	N
Gender	N	N	N
Symptom duration	N	N	(r_s = 0.160, p = 0.026 *), n = 193
Number of previous injections	N	N	N
Rehab frequency (at 6M)	N	N	N
Rehab regularity (at 6M)	N	N	N
Baseline			
"Average pain" (0-10)	N	N	N
"Worst pain" (0-10)	N	N	N
VISA-G	N	N	(r_s = - 0.308, p < 0.001*), n = 197
NAHS	N	N	(r_s = - 0.176, p = 0.013*), n = 197
OHS	N	N	N
MSK-HQ	N	N	N
ODI	(r_s = - 0.151, p = 0.037 *) n = 191	(r_s = - 0.175, p = 0.015*), n = 190	N
EQ-5D %health	N	N	N
painDETECT (score)	N	(r_s = 0.139, p = 0.039*) n = 221	N
painDETECT (category)	(p = 0.039*) n = 222	N	N
S-LANSS (score)	N	N	N
S-LANSS (category)	N	N	N
CSI (score)	N	N	N
CSI (category)	N	N	N
PCS	N	N	N
PIPS	N	N	N
HADS (Anxiety)	N	N	N
HADS (Depression)	N	N	N
PHQ-4	N	N	N
GAD-7	N	N	N
PHQ-9	N	N	(r_s = - 0.153, p = 0.035*), n = 189

N: non-significant statistical relationship. r_s < 0.2 "very weak" correlation, > 0.2 "weak" correlation", > 0.4 "moderate" correlation" … (not seen in data set).

Patient demographics

The patient age did not have any significant correlations with any of the changes in outcome measures seen at either 3-months or 6-months.

Patient gender was found to have a statistically significant difference in % change in self-reported "average pain" at 3-months. However, this is unlikely to have been clinically significant with female patients improving by 30% ± 38%

at 3-months, compared to male patients improving by 20% ± 55%, p = 0.028*. There were no statistically significant relationships between gender and changes in "worst pain" at 3-months (p = 0.127), nor changes in either variable at 6-months.

Symptom duration was found to have a statistically significant, but very weak correlation with improvements in the VISA-G score at 6-months (r_s = 0.160, p = 0.026*), n = 193, but not at 3-months (r_s = 0.075, p = 0.303), n = 190. There were no significant correlations with any changes in self-reported "average" or "worst" pain scales at either 3-months or 6-months.

Rehabilitation programme compliance

Although previous research has suggested that rESWT needs to be performed alongside a graded home exercise programme (13), there were no significant correlations seen identified either the self-reported frequency (how many times per day were the exercise undertaken), or how compliant patients were with the rehabilitation programme and any of the tracked improvements in pain or function at 3-months (**table V**) or 6-months (**table VI**). This may be limited by the accuracy of the self-reporting of this question.

Baseline pain and local hip function

Baseline assessments were undertaken with self-reported measures of "average" pain, "worst pain" and validated measures including VISA-G, NAHS, and OHS. None of these baseline measures correlated significantly with improvements in "average pain" measured at 3-months (**table V**) or 6-months (**table VI**). There were very weak negative correlations seen between baseline average pain, and improvements in self-related pain at 3-months, *i.e.*, those with highest levels of average pain at baseline reported the greatest % improvement in worst pain at 3-months, (r_s = - 0.135, p = 0.038*), n = 237. Similar correlation was not seen at 6-months which raises questions about any clinical significance of this.

Several weak or very weak correlations were seen for different baseline parameters and improvements in VISA-G scores seen at either 3-months (**table V**) and 6-months (**table VI**). This included baseline VISA-G score (3- and 6-months), NAHS (3-months), and OHS (3-months only). The data is displayed in **table V** (3-months) and **table VI** (6-months).

Global function

Baseline aspects of more global function was undertaken with the MSK-HQ, ODI, and EQ-5D-5L questionnaires. The baseline % health scale of EQ-5D did not have any statistically significant correlations with the three outcome measures studied at follow-up.

The baseline MSK-HQ score was shown to have a weak correlation with improvements in "worst pain" at 3-months (r_s = 0.220, p = 0.046*), n = 83, but not with improvements in average pain or VISA-G at 3-months, or any of these markers at 6-months.

The baseline ODI questionnaire had a weak correlation with improvements in "worst pain" at 3-months (r_s = - 0.143, p = 0.049*), n = 190, but not with improvements in "average pain" or VISA-G at 3-months. At 6-months weak correlations were found with self-reported "average pain" (r_s = - 0.151, p = 0.037*) n = 191 and "worst pain" (r_s = - 0.175, p = 0.015*), n = 190 but not with changes in VISA-G.

Markers of chronic, neuropathic, and centralised pain

Markers of chronic, neuropathic, and centralised pain were undertaken at baseline with painDETECT, S-LANSS, CSI, plus PCS and PIPS. Of these baseline assessments, the only statistically significant correlation with outcome was at 6-months with weak correlations between the baseline painDETECT score and improvements in "worst pain" (r_s = 0.139, p = 0.039*) n = 221 and between baseline painDETECT category and improvements in "average pain" (p = 0.039*) n = 222.

Mental health/anxiety and depression scales

Baseline assessment of anxiety and depression symptoms was undertaken with HAD (anxiety and depression sub-scales), PHQ-4, GAD-7, PHQ-9. The only baseline variable that had a statistically significant correlation with outcomes measured was a weak negative correlation with improvement in VISA-G score at 6-months (r_s = - 0.153, p = 0.035*), n = 189.

DISCUSSION

This large case series of 260 patients with chronic GTPS has demonstrated statistically and clinically significant improvements in average pain, worst pain, and a number of validated hip-region PROMS at 3-months and 6-months. However, the nature of this case series data means that benefits seen cannot be ascribed solely to the rESWT intervention and other factors may have contributed, such as the nature of time itself. However, the long average duration of symptoms prior to rESWT-treatment, and the lack of correlation between duration of symptoms and benefits seen, may suggest that time-alone is not the leading cause of the symptom improvements that were seen in this case series. The

benefits seen in this study replicate benefits seen in other studies (2, 15, 18). However, outside this study group, previously published work has only investigated "hip-related" outcome measures, rather than assessing the wider aspects of function used here.

There were statistically significant correlations between multiple baseline factors in aspects of local pain, global function, neuropathic pain, and mental health function and improvements in measures of self-reported "average pain", "worst pain", or VISA-G score at either 3-months or 6-months. However, the majority of these were very weak strength correlations, limiting the clinical significance of these. It may be that multi-level regression may produce a model that could better predict response to treatment, but it is not clear how clinically useful such a complex model may be. Instead, these results demonstrate that no single baseline variable measured in this study had a meaningful value in predicting response to radial shockwave therapy in patients with chronic GTPS.

One of the important limitations of the findings from this study which may influence its generalisability was the duration of symptoms of the patients involved with this project. There was a mean ± SD of symptoms of 44.5months ± 44.7months with a range of 3-months to 20-years. This cohort represents a group of patients who have often had a very long duration of symptoms, and whilst were representative of the patients seen in this tertiary clinic, the outcomes may not be representative of patients with a shorter duration of symptoms, and previous studies have reported success in patients with symptoms of about 12-14months average (15). However, in this study the symptom duration had only a very-weak correlation with changes in VISA-G score at 6-months, and not at 3-months, and no statistically significant correlations with changes in markers of "average pain" or "worst pain" at either time-period studied. Further research could be undertaken with a cohort of patients with shorter duration of symptoms to see if the findings are replicated, or whether the findings from this research are as a result of the chronicity of symptoms.

A strength of this study is the large size of the cohort that were involved (n = 260 total) which gives weight to the findings that were presented here, and exceeds most published studies for this treatment in this condition. This is data from a pragmatic real-world clinic and different numbers of data were available for different measures studied, but the large overall group size has allowed the study of multiple baseline parameters and assessment as to value, if any, in predicting response to treatment. The patients' ages, gender, or duration of symptoms have not been consistently shown to affect outcomes seen. The influence of factors of chronic or centralised pain have not been shown to influence outcomes either positively or negatively, therefore these should not necessarily be barriers to considering rESWT. Local measures of hip pain did weakly correlate to outcome, with stronger correlations between VISA-G (23) and NAHS (21, 22) which may be representative of non-arthritic hip problems, than the OHS (19, 20) which may be more representative of symptoms from hip osteoarthritis. This could be the focus of further work.

CONCLUSIONS

In summary, the data presented here suggests that there is an average improvement in measure of "average" pain of about 30% at 3-months, and 37% at 6-months following rESWT. The improvement in measure of "worst pain" improved by 25% at 3-months, and 30% at 6-months. These reached statistical significance and exceeded the minimally important clinical difference (MCID) in a patient cohort with very long average duration of symptoms. Heterogenous outcomes were identified following rESWT, and no single factor was found to have a moderate or strong correlations with the outcome measures that were studied.

FUNDINGS

None.

DATA AVAILABILITY

Data are available under reasonable request to the corresponding author.

CONTRIBUTIONS

The author collated and analysed the data, and wrote the manuscript.

CONFLICT OF INTERESTS

The author declares that he has no conflict of interests.

ACKNOWLEDGEMENTS

The author would like to offer their thanks to Ms. Chloe Dudson, Nurse Practitioner, who administered the rESWT treatment to many of the patients within this manuscript, and Mrs Rachel Calver, extended-scope physiotherapist, who provided clinic interim follow-up appointment for some of the patients in this manuscript. The assistance of both of these colleagues facilitated the delivery of the clinical service from which this data is obtained.

REFERENCES

1. Lievense A, Bierma-Zeinstra S, Schouten B, Bohnen A, Verhaar J, Koes B. Prognosis of trochanteric pain in primary care. Br J Gen Pract 2005;55(512):199-204.
2. Rompe JD, Segal NA, Cacchio A, Furia JP, Morral A, Maffulli N. Home training, local corticosteroid injection, or radial shock wave therapy for greater trochanter pain syndrome. Am J Sports Med 2009;37(10):1981-90.
3. Williams BS, Cohen SP. Greater trochanteric pain syndrome: a review of anatomy, diagnosis and treatment. Anesth Analg 2009;108(5):1662-70.
4. Stephens G, O'Neill S, Clifford C, *et al*. Greater trochanteric pain syndrome in the UK National Health Service: A multicentre service evaluation. Musculoskeletal Care 2019;17(4):390-8.
5. Kingzett-Taylor A, Tirman PF, Feller J, McGann W, *et al.* Tendinosis and tears of gluteus medius and minimus muscles as a cause of hip pain: MR imaging findings. Am J Roentgenol 1999;173(4):1123-6.
6. Silva F, Adams T, Feinstein J, Arroyo RA. Trochanteric Bursitis: Refuting the Myth of Inflammation. J Clin Rheumatol 2008;14(2):82-6.
7. Tortolani PJ, Carbone JJ, Quartararo LG. Greater trochanteric pain syndrome in patients referred to orthopedic spine specialists. Spine J 2002;2(4):251-4.
8. Segal NA, Felson DT, Torner JC, *et al*. Greater Trochanteric Pain Syndrome: Epidemiology and Associated Factors. Arch Phys Med Rehabil 2007;88(8):988-92.
9. Fearon AM, Scarvell JM, Neeman T, Cook JL, Cormick W, Smith PN. Greater trochanteric pain syndrome: defining the clinical syndrome. Br J Sports Med 2013;47(10):649-53.
10. Woodley SJ, Nicholson HD, Livingstone V, *et al*. Lateral Hip Pain: Findings From Magnetic Resonance Imaging and Clinical Examination. J Orthop Sports Phys Ther 2008;38(6):313-28.
11. Blankenbaker DG, Ullrick SR, Davis KW, De Smet AA, Haaland B, Fine JP. Correlation of MRI findings with clinical findings of trochanteric pain syndrome. Skeletal Radiol 2008;37(10):903-9.
12. Gerdesmeyer L, Maier M, Haake M, Schmitz C. [Physical-technical principles of extracorporeal shockwave therapy (ESWT)]. Orthopade 2002;31(7):610-7.
13. Schmitz C, Császár NBM, Milz S, *et al*. Efficacy and safety of extracorporeal shock wave therapy for orthopedic conditions: a systematic review on studies listed in the PEDro database. Br Med Bull 2015;116(1):115-38.
14. Lohrer H, Nauck T, Korakakis V, Malliaropoulos N. Historical ESWT Paradigms Are Overcome: A Narrative Review. Biomed Res Int 2016;2016:2016:3850461.
15. Furia JP, Rompe JD, Maffulli N. Low-Energy Extracorporeal Shock Wave Therapy as a Treatment for Greater Trochanteric Pain Syndrome. Am J Sports Med 2009;37(9):1806-13.
16. Seo K-H, Lee J-Y, Yoon K, *et al*. Long-term outcome of low-energy extracorporeal shockwave therapy on gluteal tendinopathy documented by magnetic resonance imaging. Plos one 2018;13(7):e0197460.
17. Wheeler P, Dudson C, Calver R, *et al*. Three sessions of radial-Extra-Corporeal Shockwave Therapy (rESWT) gives no additional benefit over "minimal-dose" rESWT for patients with chronic greater trochanteric pain syndrome (GTPS), a double-blinded randomised controlled trial. Trial. Clin J Sport Med 2022;32(1):e7-e18.
18. Wheeler PC, Tattersall C. The role of Extra-Corporeal Shockwave Therapy (ESWT) plus rehabilitation for patients with chronic Greater Trochanteric Pain Syndrome (GTPS), a case series assessing effects on pain, sleep quality, activity and functioning. Int Musculoskelet Med 2016;38(1):27-35.
19. Murray DW, Fitzpatrick R, Rogers K, *et al*. The use of the Oxford hip and knee scores. J Bone Joint Surg Br 2007;89(8):1010-4.
20. Nilsdotter A, Bremander A. Measures of hip function and symptoms: Harris Hip Score (HHS), Hip Disability and Osteoarthritis Outcome Score (HOOS), Oxford Hip Score (OHS), Lequesne Index of Severity for Osteoarthritis of the Hip (LISOH), and American Academy of Orthopedic Surgeons (AAOS) Hip and Knee Questionnaire. Arthritis Care Res (Hoboken) 2011;63(S11):S200-S7.
21. Christensen CP, Althausen PL, Mittleman MA, Lee J-a, McCarthy JC. The Nonarthritic Hip Score: Reliable and Validated. Clin Orthop Relat Res 2003;406(1):75-83.
22. Tijssen M, van Cingel R, van Melick N, de Visser E. Patient-Reported Outcome questionnaires for hip arthroscopy: a systematic review of the psychometric evidence. BMC Musculoskelet Disord 2011;12(1):117.
23. Fearon AM, Ganderton C, Scarvell JM, Smith PN, Neeman T, Nash C, *et al*. Development and validation of a VISA tendinopathy questionnaire for greater trochanteric pain syndrome, the VISA-G. Man Ther 2015;20(6):805-13.
24. Hill JC, Kang S, Benedetto E, Myers H, Blackburn S, Smith S, *et al*. Development and initial cohort validation of the Arthritis Research UK Musculoskeletal Health Questionnaire (MSK-HQ) for use across musculoskeletal care pathways. BMJ Open 2016;6(8):e012331.
25. Freynhagen R, Baron R, Gockel U, Tölle TR. painDETECT: a new screening questionnaire to identify neuropathic components in patients with back pain. Curr Med Res Opin 2006;22(10):1911-20.
26. Wheeler PC. Neuropathic pain may be common in chronic lower limb tendinopathy; a prospective cohort study. Br J Pain 2017;11(1):16-22.
27. Bennett MI, Smith BH, Torrance N, Potter J. The S-LANSS score for identifying pain of predominantly neuropathic origin: Validation for use in clinical and postal research. J Pain 2005;6(3):149-58.
28. Weingarten TN, Watson JC, Hooten WM, *et al*. Validation of the S-LANSS in the community setting. Pain 2007;132(1):189-94.
29. Coronado RA, George SZ. The Central Sensitization Inventory and Pain Sensitivity Questionnaire: An exploration of construct validity and associations with widespread pain sensitivity among individuals with shoulder pain. Musculoskelet Sci Pract 2018;36:61-7.
30. Wheeler PC. Up to a quarter of patients with certain chronic recalcitrant tendinopathies may have Central Sensitisation – a prospective cohort of more than 300 patients. Br J Pain 2019;13(3):137-44.
31. Snaith RP, Zigmond AS. The Hospital Anxiety and Depression Scale manual. Windsor, Berkshire (UK): Nfer-Nelson; 1994.

32. Smarr KL, Keefer AL. Measures of depression and depressive symptoms: Beck Depression Inventory-II (BDI-II), Center for Epidemiologic Studies Depression Scale (CES-D), Geriatric Depression Scale (GDS), Hospital Anxiety and Depression Scale (HADS), and Patient Health Questionnaire-9 (PHQ-9). Arthritis Care Res (Hoboken) 2011;63(S11):S454-S66.
33. Löwe B, Decker O, Müller S, Brähler E, Schellberg D, Herzog W, *et al*. Validation and Standardization of the Generalized Anxiety Disorder Screener (GAD-7) in the General Population. Med Care 2008;46(3):266-74.
34. Kroenke K, Spitzer RL, Williams JBW. The PHQ-9. J Gen Intern Med 2001;16(9):606-13.
35. Löwe B, Kroenke K, Herzog W, Gräfe K. Measuring depression outcome with a brief self-report instrument: sensitivity to change of the Patient Health Questionnaire (PHQ-9). J Affect Disord 2004;81(1):61-6.
36. Sullivan MJL, Bishop SR, Pivik J. The Pain Catastrophizing Scale: Development and validation. Psychol Assess 1995;7(4):524-32.
37. Wicksell RK, Renöfält J, Olsson GL, Bond FW, Melin L. Avoidance and cognitive fusion – Central components in pain related disability? Development and preliminary validation of the Psychological Inflexibility in Pain Scale (PIPS). Eur J Pain 2008;12(4):491-500.
38. Herdman M, Gudex C, Lloyd A, Janssen MF, Kind P, Parkin D, *et al*. Development and preliminary testing of the new five-level version of EQ-5D (EQ-5D-5L). Qual Life Res 2011;20(10):1727-36.
39. Devlin NJ, Brooks R. EQ-5D and the EuroQol Group: Past, Present and Future. Appl Health Econ Health Policy. 2017;15(2):127-37.
40. Fairbank JCT, Pynsent PB. The Oswestry Disability Index. Spine 2000;25(22):2940-53.