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REVIEW

Laser Acupuncture for the Pain of Knee Osteoarthritis: A Systematic Review and Meta-Analysis of Randomized Controlled Trials

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Purpose: Knee joint pain severely affects patients' quality of life and mental health and is a major factor in their seeking medical treatment. Given the increasing interest in non-invasive and complementary therapies for knee osteoarthritis, we conducted a systematic literature review and a meta-analysis of randomized clinical trials (RCTs) to evaluate the analgesic efficacy of laser acupuncture for knee osteoarthritis.

Methods: Data were searched from Cochrane CENTRAL, PubMed, EMBASE, MEDLINE, and three Chinese databases from inception to September 10, 2024, for RCTs of acupuncture for KOA. Paired reviewers independently extracted data and assessed the risk of bias. We used random effects models for all meta-analyses and the GRADE approach to assess the certainty of evidence.

Results: We included 5 RCTs (293 participants, 57% females). Low certainty evidence suggested that laser acupuncture may have no or little effects on reducing pain intensity compared to exercise (weighted mean difference [WMD] −0.84 cm on a 10 cm Visual Analogue Scale [VAS], 95% CI −1.12 to −0.56 cm; laser acupuncture may reduce more pain intensity compared to placebo laser acupuncture (WMD −2.33 cm, 95% CI −3.57 to −1.09 cm). Low evidence showed that laser acupuncture may improve the knee functioning of KOA patients compared to placebo acupuncture on 240-point WOMAC (WMD −39.06, 95% CI −63.79 to −14.32).

Conclusion: Based on the low-certainty evidence from our meta-analysis, the effects of laser acupuncture on pain intensity compared to exercise are uncertain. However, compared to placebo laser acupuncture, laser acupuncture may lead to greater pain reduction and improved knee functioning in KOA patients. Due to the limited number of included studies and the low certainty of evidence, further high-quality RCTs are needed to confirm these findings.

Keywords: laser acupuncture treatment, KOA, RCT, systematic review

Introduction

Knee osteoarthritis (KOA) stands as a widespread chronic joint condition,[1,2] affecting a vast number of individuals worldwide and placing a considerable economic strain on health-care systems, with substantial annual costs incurred globally. The pain associated with KOA is often described as a deep, aching discomfort that worsens with movement, weight-bearing activities, and prolonged standing, severely affecting patients' daily lives. As KOA progresses, patients often experience debilitating pain and functional limitations. Conventional treatments include intra-articular corticosteroids and nonsteroidal anti-inflammatory drugs (NSAIDs)[3]. This has fueled interest in non-invasive and complementary therapies, particularly laser acupuncture (LA), which integrates traditional Chinese medicine (TCM) principles with modern laser technology.[4] In TCM, KOA is attributed to "qi and blood stagnation" and "imbalance of yin and yang" in the knee meridians, leading to pain and dysfunction. LA aims to restore this balance by stimulating specific acupoints. Both laser acupuncture (LA) and traditional acupuncture (TA) target acupoints to alleviate pain in knee osteoarthritis (KOA). LA offers distinct advantages in safety, convenience, and precision. By eliminating needle-related risks. Its shorter treatment sessions may enhance treatment adherence. The precision of laser beams further reduces variability in

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acupoint stimulation compared to manual needling. To evaluate the efficacy of LA for the pain, our study employed anchor-based minimal clinically important differences (MIDs), enabling readers to assess whether observed pain reductions are clinically meaningful beyond statistical significance.

Methods

Literature Search and Strategy

The librarian Wenbin Ma made search strategies from the inception to September 2024 without language restrictions and searched PubMed, Embase, Cochrane CENTRAL, Medline, Web of Science, FMRS, Ovid, Chinese National Knowledge Infrastructure (CNKI), Wanfang Database, and VIP Database for Chinese Technical Periodicals (VIP) (Appendix 1). We also searched Clinical Trials.gov using keywords including knee osteoarthritis and laser acupuncture. We reviewed the reference list of previous systematic reviews and found no additional studies that met the inclusion criteria. The protocol has been registered on PROSPERO (https://www.crd.york.ac.uk/PROSPERO/view/CRD42023481193).

Literature Screening

Paired reviewers (DHZ, DNY, QQZ, YYL) screened titles, abstracts, and the full text of all potentially eligible articles using a pre-tested standardized form with detailed instructions, independently and in duplicate. Disagreements arising at any stage were resolved by discussion.

We included trials that: (1) enrolled adult patients with KOA, (2) randomized them to laser needle versus placebo laser, exercise therapy, or no treatment, (3) lasted for no less than 4 weeks, (4) reported at least one patient-important outcome ie, pain intensity, knee joint function, or adverse events. We excluded comparisons of laser needles versus other needle-penetrated therapies (eg, warm acupuncture, needling, and joint injections).

Data Extraction

Reviewers (DHZ, DNY, QQZ, YYL) abstracted data from each eligible trial into a pilot-tested form independently and in duplicate. Data were extracted (i) study characteristics (like authors, year of publication, study site/country, and source of funding); (ii) study population characteristics (ie, sample size, duration of disease, age, sex, body mass index, and duration of treatment); (iii) intervention and control details; (iv) co-interventions (for example, exercise); and (v) all of the patient outcomes listed above (like pain intensity, physical functioning, or mental functioning).

Risk of Bias (Quality) Assessment

Reviewers used REVMAN Manager 5.4.1 to assess the risk of bias. This tool includes three response options: “low risk of bias, unclear risk of bias, high risk of bias”. The evaluation encompassed several critical components: the methodology for generating the randomization sequence, the measures employed to ensure allocation concealment, the implementation of blinding for participants, health-care providers, and outcome assessors, thereby facilitating an unbiased assessment, and missing outcome data (more than 20% of missing data is considered a high risk of bias). Reviewer discrepancies regarding data extraction and bias risk or evidence quality assessment were resolved through discussion, and third-party (LL) adjudication was conducted when necessary. A bias summary table was generated (Figure 1).

Statistical Methods

Data Synthesis

We applied statistical analysis through STATA 18. For continuous outcomes, calculate the weighted mean difference (WMD) and its corresponding 95% confidence interval (CI) after converting all continuous outcome data to a uniform scale by domain:[10, 1] Pain intensity was transformed into a 10 cm visual analog scale (VAS) to measure pain; (2) Knee functioning was converted to a 240-point Western Ontario and McMaster University Osteoarthritis Index (WOMAC 3.1). To further optimize the interpretation, we modeled the risk difference (RD) of achieving at least the minimally important difference (MID) of 1 cm on the 10 cm VAS for pain intensity.

Figure 1 Risk of bias summary. (A.S. Al Rashoud 2014,[5] Dwi R. Helianthi 2016,[6] Fang-Yin Liao 2020,[7] Mei-Kin Li 2017,[8] MU Zhou-yan 2019.[9]

We calculate the relative risk (RR) and its corresponding 95% CI for dichotomous outcomes. The Q statistic and I^2 determined statistical heterogeneity. A meta-analysis was performed on all results utilizing the DerSimonian-Laird random effects model. Following Cochrane's guidance, we considered studies with an I^2 of 0–40% as "probably unimportant", 30–60% as "moderately heterogeneous", 50–90% as "substantial heterogeneity", and 75–100% as "considerable heterogeneity".

Certainty of Evidence

We applied the GRADE (Grading of Recommendations, Assessment, Development, and Evaluation) methodology to evaluate the certainty of evidence for every outcome. With GRADE, evidence from RCTs begins at high certainty. Still, it

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may be downgraded to moderate, low, or very low certainty based on considerations of risk of bias, consistency, directness, precision, and publication bias.[11] We considered pooled treatment effects on pain and knee functioning imprecise if the associated 95% CI included ½ the MID, and pooled effects for the VAS and adverse events as imprecise if the associated measure of precision included the null effect. We followed GRADE guidance to communicate our findings.[12]

Results

Description of Included Studies

Six thousand six hundred and fifty-five records were screened, and 5 trials were included involving 293 KOA patients (57% females). (Figure 2 and Table 1) The median average age of participants was 62.68 years (IQR 45.68 to 63.08 years), and all knee joints were assessed to be no less than grade II according to the Kellgren-Lawrence grading scale. Two trials were conducted in China,[7,9] and the remaining ones in Australia,[8] the UK,[5] and India.[6] Two studies reported their sources of funding.[5,8] Four trials compared laser acupuncture with placebo,[5–8] one study compared laser acupuncture with conventional exercise,[9] and the follow-up lasted at least 4 weeks (Table 1).

Risk of Bias

Of the 5 eligible trials, 1 (20%) was judged to be at risk of bias in at least one domain. All 5 trials (100%) appropriately generated the randomisation sequence; 4 (80%) adequately concealed allocation; 4 (80%) blinded the participants; 2 (40%) blinded the health-care providers; 1 (20%) blinded the data collectors; and 4 (80%) blinded the outcome assessors. Additionally, 2 (40%) trials blinded the data analysts. All 5 trials had less than 20% missing outcome data (Figures 1 and 3).

Laser Acupuncture versus Exercise

Pain Intensity

Low evidence from one RCT (109 participants) showed that compared to exercise therapy, laser acupuncture had low-certainty evidence on reducing pain intensity (WMD −0.84 cm on a 10 cm VAS, modeled RD 6% for achieving the MID

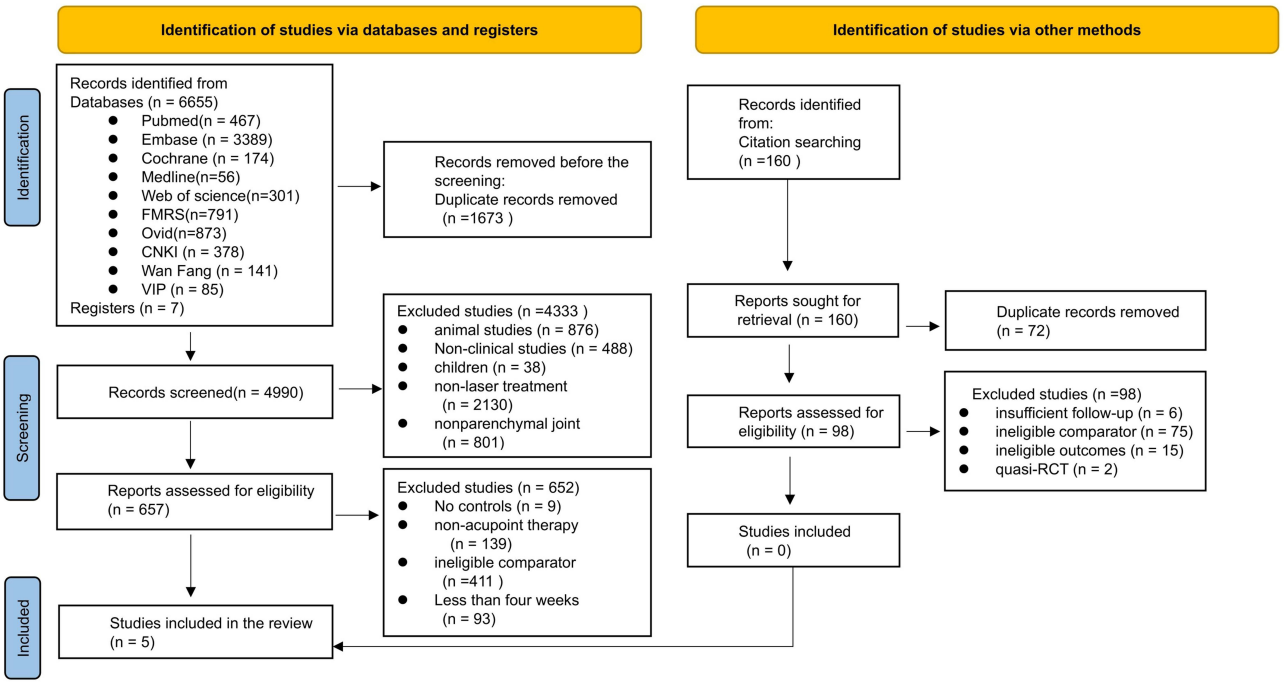

Figure 2 Selection of studies.

Table 1 Characteristics of Included Studies

Study	Interventions	Funding	Country	No. of Participants at Baseline, n	Length of Follow-Up, Days	Mean Age (SD), Years	Female %
ZY M 2019[9]	Laser & exercise vs exercise	NA	China	109	28	54.00(8.04)	43%
AS Al R 2014[5]	Laser & exercise vs exercise and exercise	INDUSTRIAL	UK	49	Nine sessions[a]	53.90(10.09)	63%
DR H 2016[6]	Laser vs Placebo	NA	Indonesia	62	35	68.50(5.51)	68%
FY L 2020[7]	Laser vs Placebo	NA	China	33	28	70.10(6.79)	90%
MK L 2017[8]	Laser vs Placebo	INDUSTRIAL	Australia	40	28	62.20(10.65)	50%

Note: [a]Approximately 9 weeks, 63 days.
Abbreviation: NA, not reported.

of 1 cm, 95% CI −1.12 to −0.56).[9] While the statistical significance of the WMD (−0.84 cm) suggested a difference between groups, the small effect size and narrow clinical relevance (as indicated by the MID analysis) implied that laser acupuncture may not have offered substantial advantages over exercise therapy in terms of pain reduction.

Laser Acupuncture Compared to Placebo

Pain

Low evidence from 4 RCTs (184 subjects) showed that laser needle therapy may decrease KOA pain intensity compared to placebo (WMD −2.33 cm on a 10 cm VAS, 95% CI −3.57 to −1.09 cm, modeled RD 15% for achieving the MID of 1 cm, 95% CI 7% to 23%; Figure 4 and Table 2).

Until higher-quality evidence is available, laser acupuncture may be cautiously considered as a supplementary option for KOA pain management, but it should not replace evidence-based first-line therapies.

Knee Functioning

Low evidence from 3 RCTs (148 subjects) showed that laser needle might improve knee functioning compared to the placebo group (WMD −39.06 [95% CI −63.79, −14.32]; Figure 5, Table 2), suggest that the improvement in knee function scores was slightly greater in the laser acupuncture group compared to the placebo group.

Clinicians may consider laser acupuncture as a supplementary option for patients with knee dysfunction, particularly those who prefer non-invasive therapies or have contraindications to standard treatments.

Adverse Effects

Very low-certainty evidence from one RCT (59 participants) showed that laser acupuncture (RR 3.52, 95% CI 0.76 to 6.29).[6]

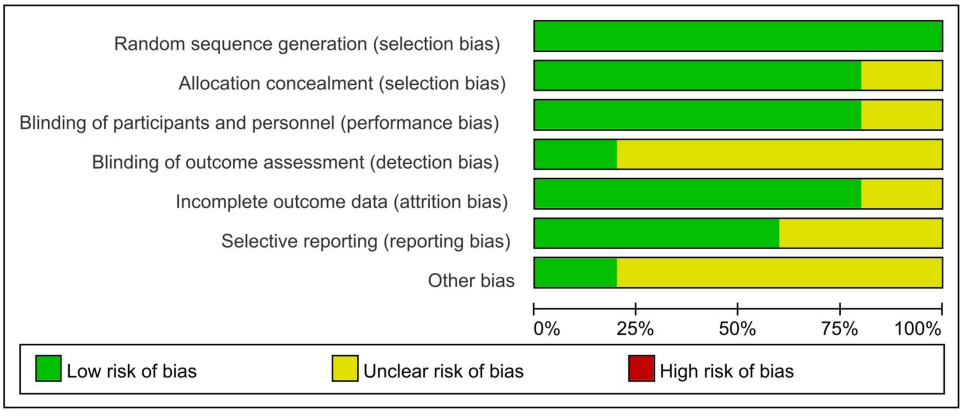

Figure 3 Risk of bias graph.

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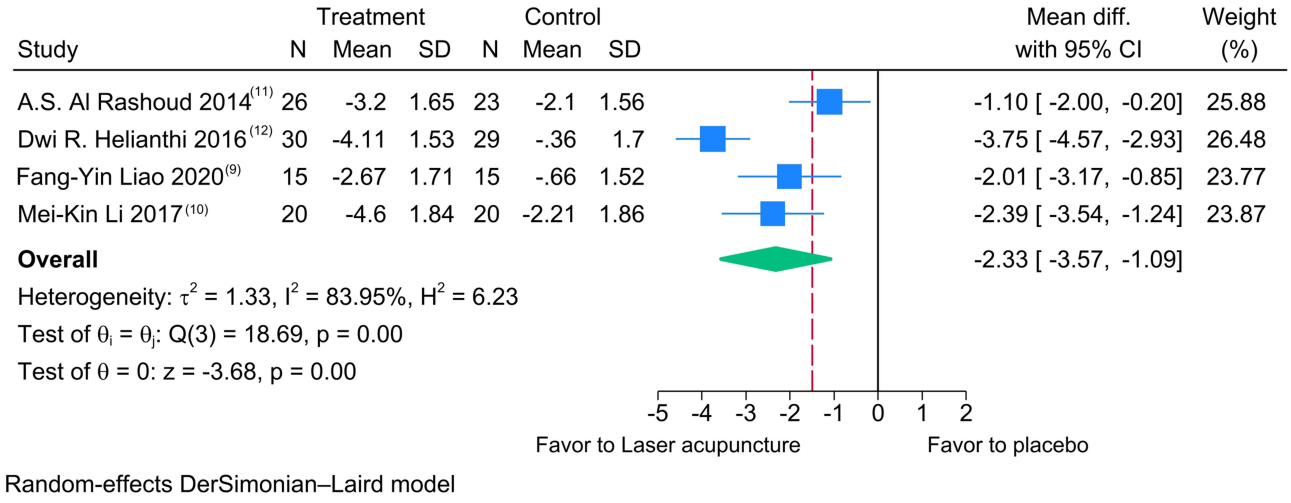

Figure 4 Pain intensity on a 10 cm VAS among patients with osteoarthritis of the knee who received Laser acupuncture compared to placebo control.

Discussion

Overall Findings

Compared to exercise therapy, laser acupuncture had little to no effect on reducing pain intensity in patients with knee osteoarthritis (KOA). However, compared to patients receiving placebo laser acupuncture, those receiving actual laser acupuncture may reduce pain intensity, improve knee joint function, and have fewer adverse reactions, based on low-certainty evidence. Despite a high heterogeneity level (I^2 = 83.95%), the direction of the effect size across the studies remained consistent. All studies showed that the pain scores in the laser acupuncture treatment group were notably lower compared to the control group, and this high heterogeneity did not compromise the validity of the results.

Table 2 Grade the Evidence Profile of Laser Acupuncture versus Exercise or Placebo Laser Acupuncture for People with KOA

(No. of Patients)	Risk of Bias	Inconsistency	Indirectness	Imprecision	Publication Bias	Treatment Association (95% CI)		The OVERALL Quality of the Evidence
						Laser Acupuncture	Control	
Pain: 0 to 10 cm VAS for pain; lower is better; MID = 1 cm								
5(293)	Serious [a,b]	NA	Not serious	Not serious	Not serious	66.6% achieved at least 1 cm pain reduction	51.7% achieved at least 1 cm pain reduction	Low
						Modeled RD 15% (7%, 23%)		
						WMD −2.33 cm (−3.57, −1.09 cm)		
Physical functioning: 0 to 240 points WOMAC for knee function; Lower is better;								
4(257)	Serious [a,b]	Moderate I^2= 60.48%	Not serious	Not serious	Not serious	WMD −39.06[−63.79, −14.32]		Low
Adverse effects								
1(59)	Moderate	NA	Not serious	Not serious	Not serious	RR 3.52 (0.76, 6.29)		Low

Notes: a, blinding of outcome assessors; b, I^2 > 70%.
Abbreviation: NA, not available.

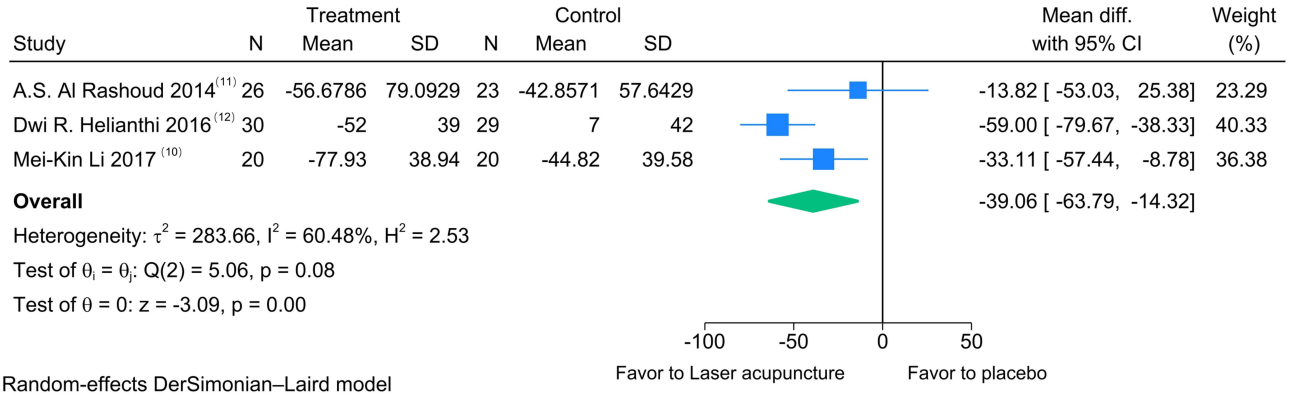

Figure 5 Knee joint functional score on a WOMAC (0–240, the higher the score, the worse the condition) among patients with KOA of the knee who received Laser acupuncture compared to placebo control.

Relationship to Other Studies

We manually searched for 12 other systematic reviews and included their references,[13–23] and there are no new references to add. The latest meta-analysis on knee osteoarthritis included 25 articles, of which 5 overlap with our included articles. The reasons for exclusion can be seen in Table 3. However, that review did not assess the certainty of evidence or contextualize the magnitude of effects by presenting the MID for outcomes.

We used the GRADE approach to rate the certainty of the evidence, and contextualized treatment effects by co-presenting available anchor-based MIDs. Pain intensity was uniformly converted to a 0–10 visual analog scale (VAS), while knee joint function was converted to a 0–240 WOMAC scale.

Strengths and Implications

Strengths of this review include a comprehensive search for eligible RCTs in any language and a focus on patient-reported outcomes. We used the GRADE approach to rate the certainty of evidence and contextualized treatment effects by co-presenting available anchor-based MIDs. To assist readers in making a more accurate interpretation of the results, we provided the minimal clinically important difference for the VAS scale as −1 cm.

The absence of studies with follow-ups longer than four months for laser acupuncture therapy in patients with knee osteoarthritis, due to research limitations, makes it difficult to evaluate its long-term effectiveness. Although some studies focusing solely on pain relief suggest that laser acupuncture may offer more significant therapeutic benefits than standard exercise, caution is warranted. An overestimation of laser acupuncture's effects may arise because the measurement of residual effects often relies on comparative studies, which may not fully account for long-term outcomes. To ensure a comprehensive assessment of long-term efficacy and safety, at least six months of follow-up (ideally up to a year) is necessary, thereby guaranteeing the practicality and durability of the study results.

Table 3 Reasons for the Exclusion of Literature in the Latest Meta-Analysis of Laser Acupuncture

Exclusion Reasons	Study
Data incomplete	Shen X 2009, Zhao L 2010, Mohammed N 2018, Hinman *RS* 2014[24–27]
Treatment time is less than 4 weeks	Yurtkuran M 2007, Mezaal AL 2019[28,29]
No comparison	Xi M 2008[30]
Comparison of Acupuncture and Laser Acupuncture	Zhao H 2018, Shi L 2012, Li X 2012, Suen LKP 2016, Qi H 2013[31–35]
Composite laser and red light irradiation	Ren X 2010,Liu H 2009, Shen XY 2008[36–38]
Moxibustion, not laser acupuncture	Ge J 2012, Lin L 2020, Zhao L 2021[39–41]
Ultrasound, not laser acupuncture.	Li Z 2016[42]
Knee joint replacement surgery	Huang CH 2021[43]

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Conclusion

Patients receiving laser acupuncture may experience a greater reduction in pain intensity compared to those receiving exercise therapy. Patients receiving laser acupuncture may experience less pain intensity and better knee joint function than those receiving a placebo.

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Author Contributions

All the authors contributed to the interpretation and edited draft versions of the manuscript. All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Disclosure

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