Whether the Unilateral Transverse Process-pedicle Approach has Advantages over the Traditional Transpedicle Approach: A Systematic review and Meta-analysis

Ob der unilaterale querverlaufende Prozess-Pedikel-Ansatz Vorteile gegenüber dem traditionellen Transpedikel-Ansatz hat: Eine systematische Überprüfung und Meta-Analyse

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ABSTRACT

Purpose To summarize the literature and compare the advantages and disadvantages of the unilateral transverse process-pedicle approach (UTPA) and conventional transpedicular approach (CTPA) vertebral augmentation in the treatment of osteoporotic vertebral compression fractures (OVCF).

Methods A single researcher performed a systematic literature review using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Online scientific databases were searched in September 2021 for English- and Chinese-language publications. A series of comparative studies were included, with UTPA as the main intervention and CTPA as the comparison indicator. A meta-analysis was performed for studies that reported clinical outcome indicators. The χ^2 was used to study heterogeneity between trials, and the I^2 statistic was calculated to estimate variation across studies.

Results A total of eight studies were included for meta-analysis, all of which were observational studies with mixed bias risk. There were 613 subjects in the UTPA group and 488 subjects in the CTPA group. The results of the meta-analysis showed that there was no difference between the UTPA group and the CTPA group in terms of visual analogue scale scores ($p = 0.31$), Oswestry Disability Index scores ($p = 0.50$), correction of kyphosis angle ($p = 0.65$), and the amount of bone cement ($p = 0.13$), but the UTPA group had a shorter operative time ($p < 0.001$), bone cement leakage rates ($p = 0.02$), and fluoroscopy times than the CTPA group ($p < 0.001$). Partial analysis results had a high risk of bias, and the most common source of bias was that there was high heterogeneity between studies, and the sensitivity can only be reduced by a random effect model, and some studies (four items) did not clearly describe the confounders that they controlled.

Conclusion The limited evidence obtained in this study proves that the new puncture method does not have more advantages than the traditional technique, so it is no longer meaningful to continue to obsess over the impact of the puncture method on surgical outcome.

ZUSAMMENFASSUNG

Zweck Um die Literatur zusammenzufassen und die Vor- und Nachteile der unilateralen Transversal-Prozess-Pedikel-Annäherung (UTPA) und der konventionellen transpedikulären Ansatz (CTPA)-Wirbelaugmentation bei der Behandlung von osteoporotischen vertebralen Kompressionsfrakturen (OVCF) zu vergleichen.

Methoden Ein einzelner Forscher führte eine systematische Literaturrecherche unter Verwendung der Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)-Richtlinien durch. Wissenschaftliche Online-Datenbanken wurden im September 2021 nach englisch- und chinesischsprachigen Publikationen durchsucht. Eine Reihe von Vergleichsstudien wurde eingeschlossen, mit UTPA als Hauptintervention und CTPA als Vergleichsindikator. Für Studien, die klinische Ergebnisindikatoren berichteten, wurde eine Metaanalyse durchgeführt. χ^2 wurde verwendet, um die Heterogenität zwischen den Studien zu untersuchen, und die I^2-Statistik wurde berechnet, um die Variation zwischen den Studien abzuschätzen.

Ergebnisse Insgesamt wurden acht Studien in die Metaanalyse eingeschlossen, die alle Beobachtungsstudien mit gemischtem Bias-Risiko waren. 613 Probanden in der UTPA-Gruppe und 488 Probanden in der CTPA-Gruppe. Die Ergebnisse der Metaanalyse zeigten, dass es keinen Unterschied zwischen der UTPA-Gruppe und der CTPA-Gruppe in Bezug auf VAS-Werte ($p = 0.31$), ODI-Werte ($p = 0.50$), Korrektur des Kyphosewinkels ($p = 0.65$) und die Menge an Knochenzement ($p = 0.13$), aber die UTPA-Gruppe hatte weniger Operationszeit ($p < 0.001$), Knochenzementaustrittsraten ($p = 0.02$) und Durchleuchtungszeiten als die CTPA-Gruppe ($p < 0.001$). Teilanalyseergebnisse wiesen ein hohes Risiko für Bias auf, und die häufigste Quelle für Bias war, dass zwischen den Studien eine hohe Heterogenität bestand und die Sensitivität nur durch das Zufallseffektmodell verringert werden kann und einige Studien (vier Elemente) dies nicht klar beschreiben Confounder, die sie kontrollierten.

Schlussfolgerungen Die in dieser Studie erhaltenen begrenzten Beweise belegen, dass die neue Punktionsmethode nicht mehr Vorteile als die traditionelle Technik hat, sodass es nicht länger sinnvoll ist, sich weiterhin mit den Auswirkungen der Punktionsmethode auf das Operationsergebnis zu befassen.

Introduction

Osteoporotic vertebral compression fracture (OVCF) is a common disease in the department of orthopedics. Due to long-term chronic pain and spinal deformity, the patient's daily activities are significantly limited [1]. Percutaneous vertebral augmentation (PVA), including percutaneous vertebroplasty and percutaneous kyphoplasty, is the main treatment for OVCF, and both percutaneous vertebroplasty and percutaneous kyphoplasty have shown promising results [2, 3]. By injecting bone cement into the vertebra, the operation can enhance the strength and stability of the patient's vertebra and avoid collapse, thus relieving the patient's pain and other clinical symptoms with definite effects. In order to reduce surgical trauma, reduce radiation exposure, and increase surgical safety, many scholars have carried out in-depth studies on puncture techniques and paths. Because a successful puncture can not only avoid complications, it also promotes the symmetrical distribution of bone cement after puncture [4]. Although many puncture methods have been designed, including pedicle, paravertebral, anterolateral, and posterolateral approaches, PVA with CTPA under the C-arm is the most commonly used approach [5, 6]. A unilateral pedicle approach can meet the surgical requirements at one time, but if the inclination is small, the cement usually deposits on one side of the vertebral body, and there is no force on the opposite side. If the angle of inclination is too large, the inner wall of the pedicle can be easily damaged, which can lead to serious complications such as intraoperative bone cement leakage, nerve root leakage, or spinal cord injury. Bilateral pedicle approaches can avoid these problems; however, an additional puncture increases the risk of nerve injury and radiation [7, 8]. It is a challenge to address these issues with a unilateral puncture approach without increasing the risk of surgery. Yan et al. [9] reported that the puncture point of the traditional pedicle approach is closer to the facet joint, which is highly likely to damage the facet joint and cause postoperative lumbago pain. Therefore, a unilateral trans transverse process-pedicle approach was proposed for PVA in the treatment of senile OVCF. While avoiding damage to the articular process, the operative time, bone cement injection amount, and leakage rate of unilateral PVA were significantly lower than that of the traditional pedicle approach. However, there is no medical-based evidence to confirm the safety and effectiveness of unilateral UTPA in the treatment of OVCF, and there are still clinical controversies about the therapeutic effects of different approaches.

Methods

Search strategy

The Cochrane Library, PubMed, and Embase databases were searched to September 2021 for all the qualified studies in order to analyze the effect of UTPA versus CTPA in the treatment of OVCF. Literature was also identified by tracking reference lists from papers and Internet searches. Two investigators independently extracted data, and a third investigator was involved when a disagreement occurred.

Study selection

To be included in the meta-analysis, studies should meet the following criteria:

1. Comparative studies: randomized controlled trails (RCT), prospective or retrospective case-control study, or cohort study.
2. The included patients had OVCF, and severe back pain was related to OVCF.

3. The test group was UTPA, and the control group was treated with CTPA.
4. Studies qualified when at least one of the following outcomes were given: improvement on the visual analogue scale (VAS) and the Oswestry Disability Index (ODI), kyphotic wedge angle, and incidence of cement leakage.
5. The publications were available in English or Chinese.
6. Study design: RCTs and prospective clinical trials were regarded as eligible in the present study.

The following studies were excluded from the review:
1. Case reports, theoretical research, conference report, systematic review, meta-analysis, expert comment, and economic analysis.
2. The outcomes were not relevant.

Data extraction

Two reviewers determined study eligibility independently. A third investigator was involved to reach an agreement. The analyzed data were extracted from all the included studies and consisted of two parts: basic information and main outcomes. The first part was about the basic information: the authors' name, the publication year, study design, sample size of each group, surgical options, and percentage of gender, age, and follow-up time. The second part was the clinical outcomes: VAS scores, ODI, kyphotic wedge angle, and incidence of cement leakage. The studies were performed by two reviewers independently. Any arising difference was resolved by discussion.

Quality assessment

The included studies were evaluated according to the Newcastle-Ottawa Quality Assessment Scale (NOS) recommended by the Cochrane Non-randomized Research Center. The NOS scale scoring system evaluates the literature in three parts (maximum score is 9), which are:
1. Selection of research objects (4 points)
2. Comparability between groups (2 points)
3. Determination of exposure factors and outcome indicators in case-control and cohort studies (3 points)

A score of 0 ~ 3 points was considered low-quality research, 4 ~ 6 points as medium quality research, and 7 ~ 9 as high-quality research. Literatures with NOS scores of 6 and above were eligible for meta-analysis [10].

Data analysis

Statistical analysis was performed using RevMan5.3 software provided by the Cochrane collaboration. Standard mean difference (SMD) or weighted mean difference (WMD) and relative risk (RR) were used as effect analysis statistics for continuous variables and dichotomous variables, respectively. The corresponding 95 % confidence interval (CI) of the two types of variables was calculated. The χ^2 test was used for heterogeneity analysis (test standard was set as $\alpha = 0.05$), and I^2 was used for quantitative judgment of heterogeneity. When $p < 0.05$ or $I^2 > 50\,\%$, significant heterogeneity between studies was considered and a random effect model was used; otherwise, a fixed effect model was used to synthesize the results of various studies. A funnel plot was used to analyze potential publication bias. If the symmetry is good, the possibility of publication bias is small.

Results

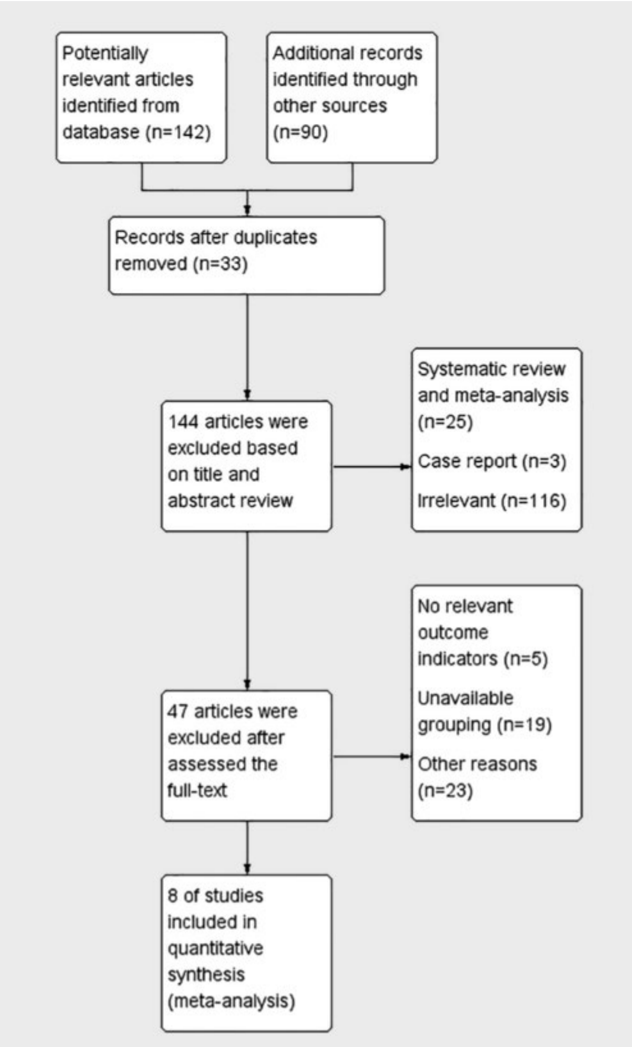
Characteristics of the included studies

By searching multiple databases and sources, we identified 199 articles by the index words. After screening titles and abstracts, 144 articles were excluded, leaving 55 articles for further evaluation. During full-text screening, 45 articles were excluded due to the following criteria: for having no clinical outcome (n = 5), unavailable grouping (n = 15), and theoretical research or review (n = 23). Finally, 8 studies were included in the meta-analysis, with 613 subjects in the UTPA group and 488 subjects in the CTPA group. The selection process is presented in ▶ **Fig. 1**.

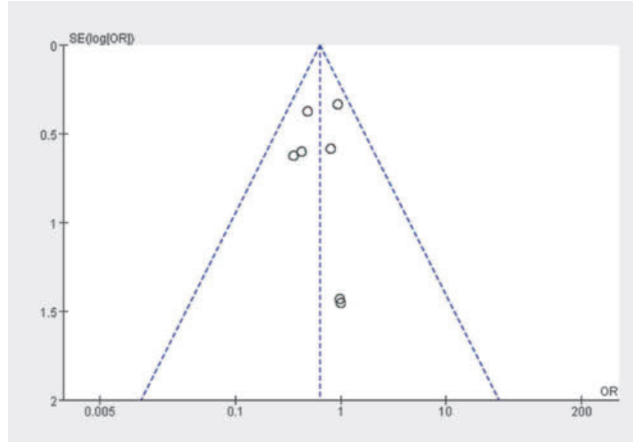
The main characteristics of the included studies are summarized in Table 1, with two prospective comparative studies, and eight retrospective comparative studies. The age of patients in the UTPA group and the CTPA group was more than 60 years. Other basic characteristics of the included studies are shown in ▶ **Table 1**.

▶ **Table 1** The general characteristic of the included studies.

Study	Years	Design	No. of UTPA	Sample CTPA	Surgery	Gender female/male	Age (mean)	Mean follow-up, mo
Yan [9]	2014	Prospective	158	151	PKP	220/89	71.9 ± 4.2	16.8
Yan [11]	2016	Prospective	55	53	PKP	39/15	68.9 ± 4.2	12
Jia [12]	2018	Retrospective	18	18	PVP	30/6	76.2 ± 10.6	18.3
Huang [13]	2020	Retrospective	48	47	PKP	80/15	66.91 ± 5.09	6
Lu [14]	2020	Retrospective	38	38	PKP	61/15	77.2 ± 3.9	12–24
Tao [15]	2021	Retrospective	135	101	PKP	314/133	76.6 ± 7.2	12
Lian [16]	2021	Retrospective	31	31	PVP	42/20	65.37 ± 5.14	3
Pan [17]	2021	Retrospective	44	49	PKP	57/36	68.8 ± 5.0	15.3



▶ **Fig. 1** The flow chart shows the process for identifying relative studies.



▶ **Fig. 2** Funnel plot to assess publication bias of the bone cement leakage rate.

▶ **Table 2** Quality evaluation according to the Newcastle-Ottawa Quality Assessment Scale.

Study	Selection 4	Comparability 2	Exposure 3	Total score 9
Yan [9]	4	1	3	8
Yan [11]	3	2	3	8
Jia [12]	2	2	3	7
Huang [13]	4	1	2	7
Lu [14]	3	2	3	6
Tao [15]	4	1	3	8
Lian [16]	2	2	3	7
Pan [17]	3	2	3	8

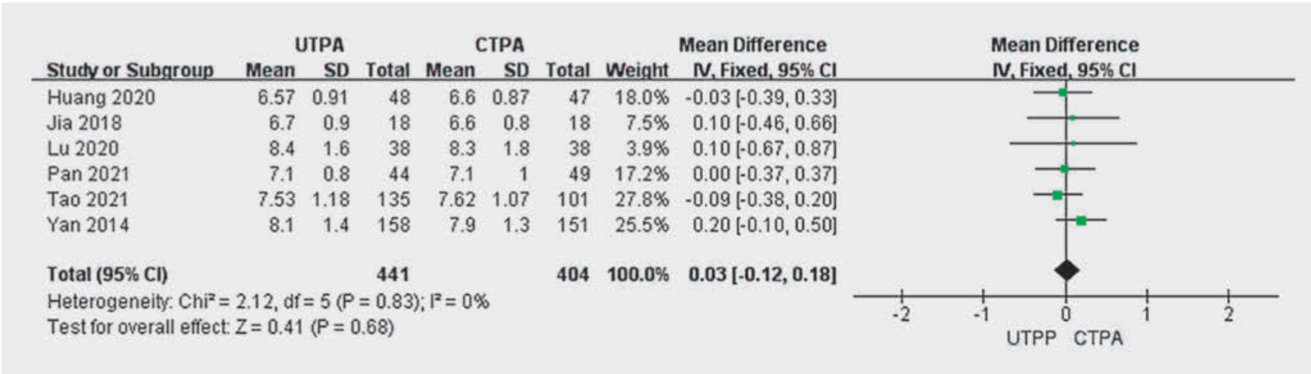
Quality assessment and potential bias

Based on the inclusion and exclusion criteria, eight articles were included in the meta-analysis. Quality and potential bias were assessed by a funnel plot. The funnel plot for log WMD in the bone cement leakage rate of the included studies was notably symmetrical, suggesting no significant publication bias (▶ **Fig. 2**). The results of the methodological quality evaluation showed that one article was of medium quality and seven articles were of high quality, all of which met the requirements of the meta-analysis. The specific scores are shown in ▶ **Table 2**.

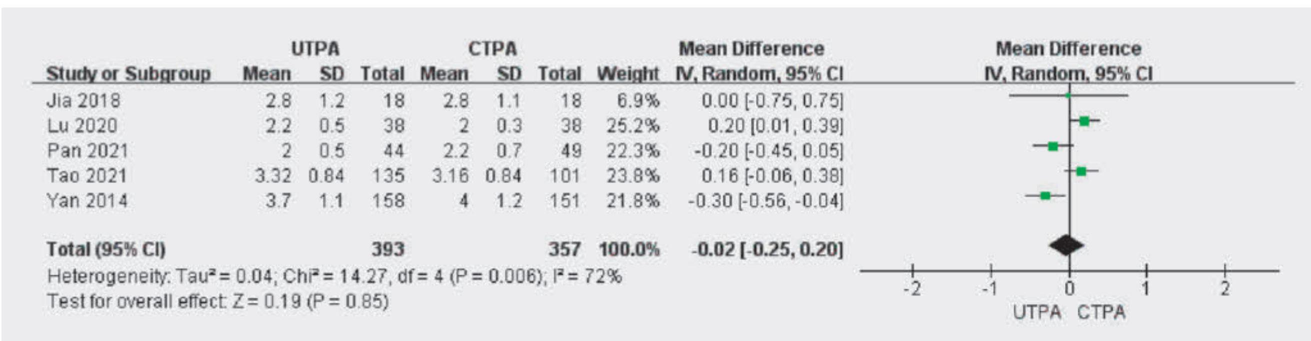
Results of Meta-analysis

VAS score

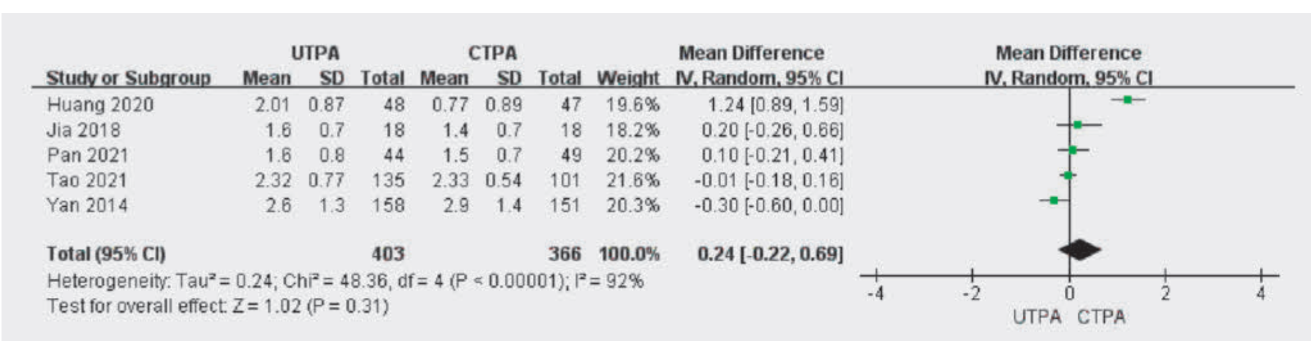
Preoperative VAS scores were compared in six studies (441 patients in the UTPA group and 404 patients in the CTPA group) without significant heterogeneity ($I^2 = 0\%$). The results showed that there was no statistically significant difference between the preoperative VAS scores of the two groups (MD = 0.03, 95 % CI [–0.12, 0.18], p = 0.68) (▶ **Fig. 3**); the two groups were comparable. Five literatures compared postoperative VAS scores (393 patients in the UTPA group and 357 patients in the CTPA group), showing heterogeneity ($I^2 = 72\%$), so the random effects model was used to the merge data. The results showed that there was no statistically significant difference in VAS scores between the two groups (MD = -0.02, 95 % CI [0.25, 0.20], p = 0.85) (▶ **Fig. 4**). VAS scores at the last follow-up were compared in five studies (403 patients in the UTPA group and 366 in the CTPA group) with heterogeneity ($I^2 = 92\%$). The results showed that there was no statistically significant difference in VAS scores between the two groups after data combination using a random effects model (MD = 0.24, 95 %



▶ **Fig. 3** Mean difference of preoperative VAS scores between the UTPA group and the CTPA group. CI = confidence interval, IV = inverse variance, SD = standard deviation.



▶ **Fig. 4** Mean difference of postoperative VAS scores between the UTPA group and the CTPA group.

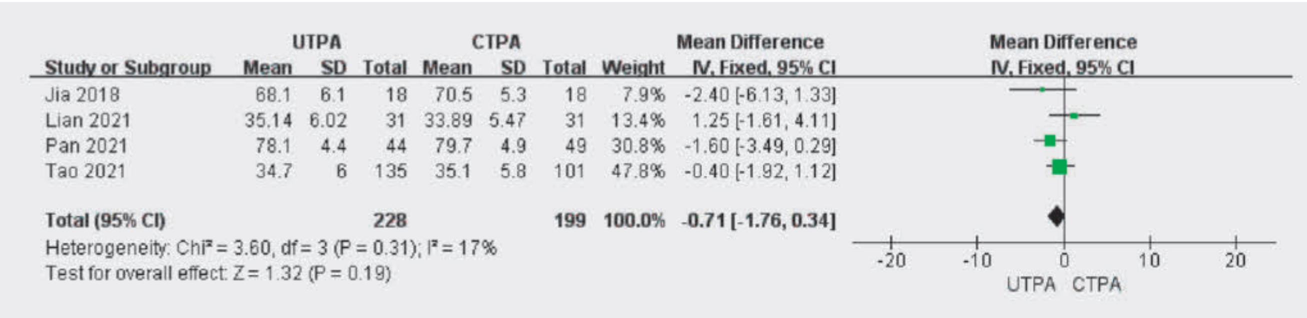


▶ **Fig. 5** Mean difference of the VAS scores at the last follow-up between the UTPA group and the CTPA group.

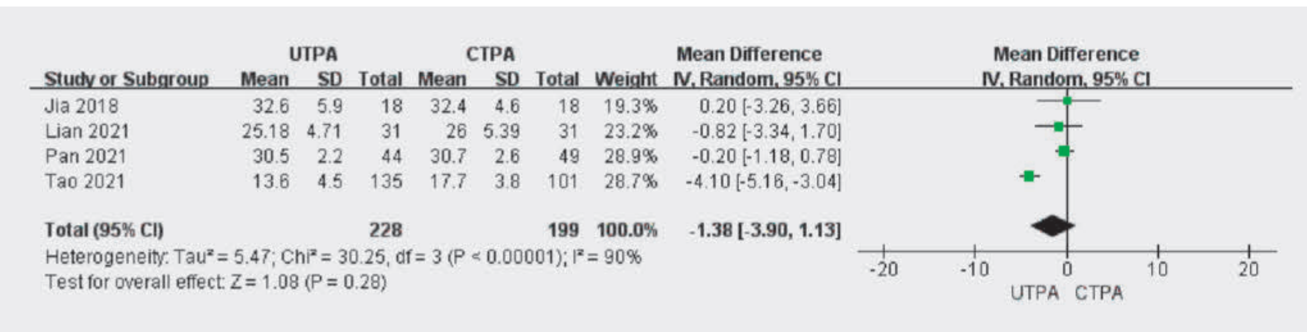
CI [−0.22, 0.69], p = 0.31) (▶ **Fig. 5**), indicating that the puncture method had no significant influence on short-term and long-term postoperative pain relief.

ODI score

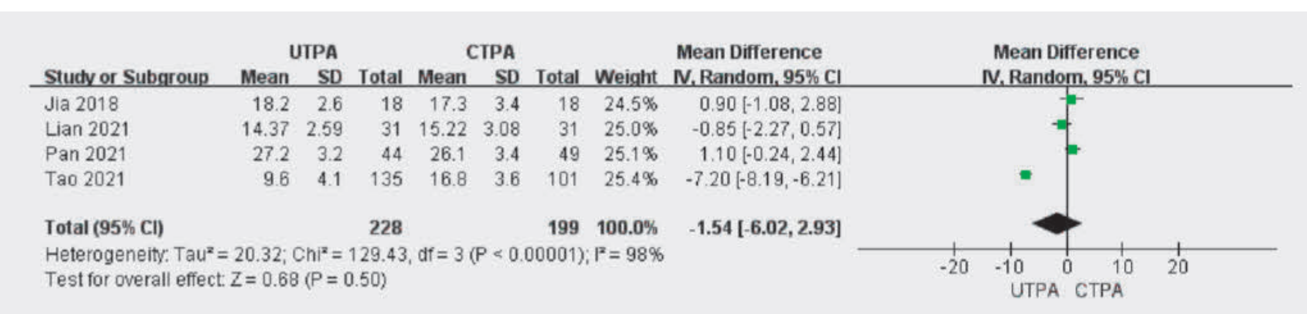
Preoperative ODI scores were compared in four studies (228 patients in the UTPA group and 199 patients in the CTPA group) without significant heterogeneity ($I^2 = 17\%$). The results showed that there was no statistically significant difference in preoperative ODI scores between the two groups (MD = −0.71, 95 % CI [−1.76, 0.34], p = 0.19) (▶ **Fig. 6**), indicating comparability. ODI scores were compared in four studies (228 patients in the UTPA group and 199 patients in the CTPA group) with significant heterogeneity ($I^2 = 90\%$). The results of the data combination by the random effect model showed that there was no significant difference in postoperative ODI score between the two groups [MD = −1.38, 95 % CI [−3.90, 1.13], p = 0.28) (▶ **Fig. 7**). ODI scores were compared in four studies at the last follow-up (228 patients in the UTPA group and 199 patients in the CTPA group) with significant heterogeneity ($I^2 = 98\%$). Data were combined by the random ef-



▶ **Fig. 6** Mean difference of preoperative ODI scores between the two groups.



▶ **Fig. 7** Mean difference of postoperative ODI scores between the UTPA group and the CTPA group.

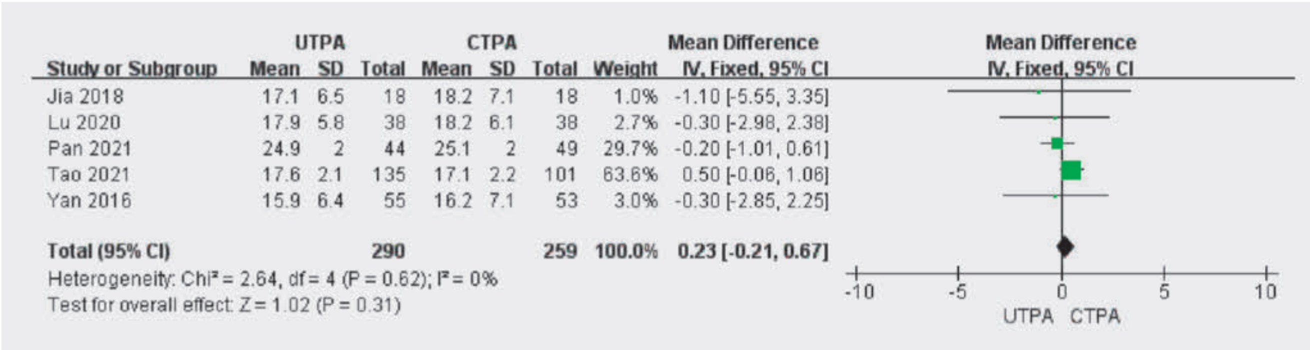


▶ **Fig. 8** Mean difference of the ODI scores at the last follow-up between the UTPA group and the CTPA group.

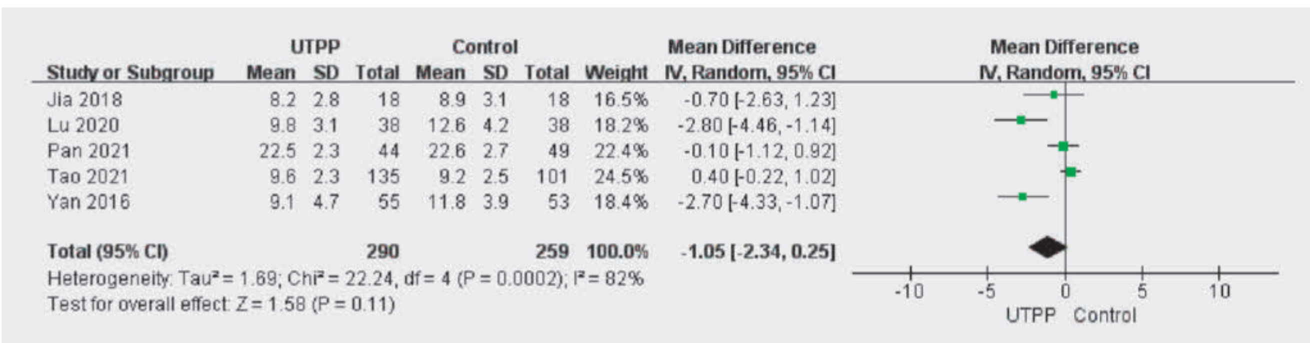
fects model and the results showed that there was no significant difference in postoperative ODI score between the two groups (MD = -1.54, 95 % CI [–6.02, 2.93], p = 0.50) (▶ **Fig. 8**), indicating that there was no significant difference in the impact of the puncture method on postoperative short-term and long-term spinal function.

Kyphosis angle

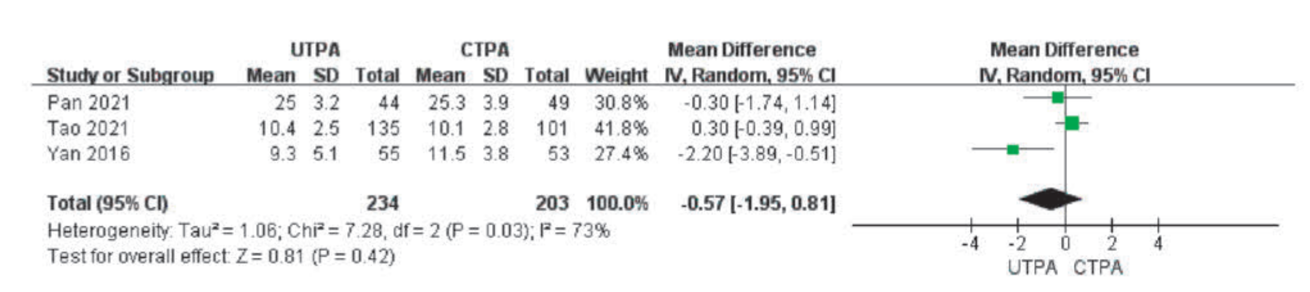
Preoperative kyphosis angle was compared in six studies (425 patients in the UTPA group and 470 in the CTPA group) without significant heterogeneity ($I^2 = 0\%$). The results showed that there was no statistically significant difference in the preoperative kyphosis angle between the two groups (MD = 0.22, 95 % CI [–0.12, 0.55], p = 0.20) (▶ **Fig. 9**), which was comparable. The postoperative kyphosis angle was compared in six studies (425 patients in the UTPA group and 470 in the CTPA group) with heterogeneity ($I^2 = 78\%$). The random effects model was used to combine data and the results showed that there was no significant difference in postoperative kyphosis angle between the two groups (MD = – 0.79, 95 % CI [–1.69, 0.11], p = 0.08) (▶ **Fig. 10**). The angles of kyphosis at last follow-up were compared in four studies (369 patients in the UTPA group and 414 in the CTPA group) without significant heterogeneity ($I^2 = 59\%$). There was no statistically significant difference in the kyphosis angle between the two groups at the last follow-up (MD = –0.10, 95 % CI [–0.52, 0.32], p = 0.65) (▶ **Fig. 11**). The results showed that the puncture method had no significant influence on the correction of kyphosis.



▶ **Fig. 9** Mean difference of the preoperative kyphosis angle between the two groups.



▶ **Fig. 10** Mean difference of the postoperative kyphosis angle between the UTPA group and the CTPA group.



▶ **Fig. 11** Mean difference of the kyphosis angle at the last follow-up between the UTPA group and the CTPA group.

Operative time

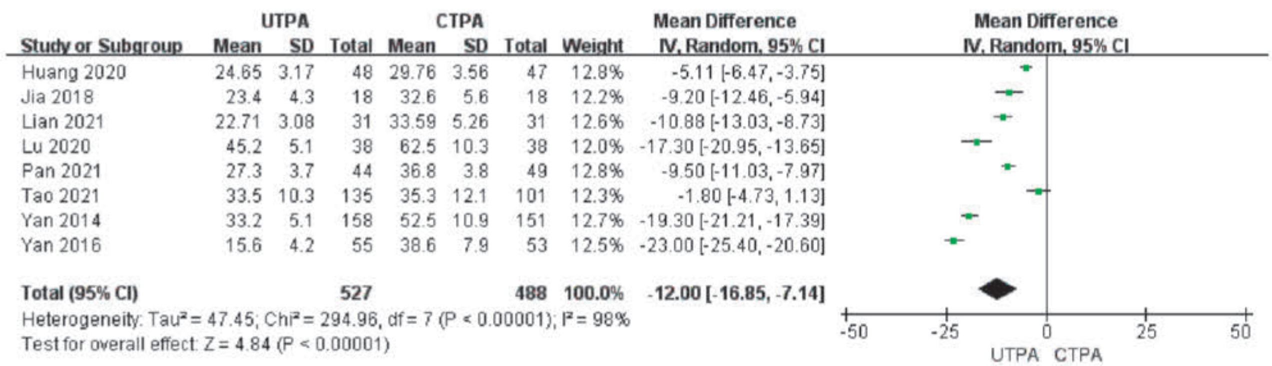
Eight studies compared the duration of surgery (527 patients in the UTPA group and 488 patients in the CTPA group) with significant heterogeneity ($I^2 = 98\%$). Therefore, the random effects model was used to combine the data, and the results showed that the UTPA group took significantly less time than the CTPA group (MD = –12.00, 95 % CI [–16.85, –7.14], p < 0.001) (▶ **Fig. 12**).

Bone cement leakage rate

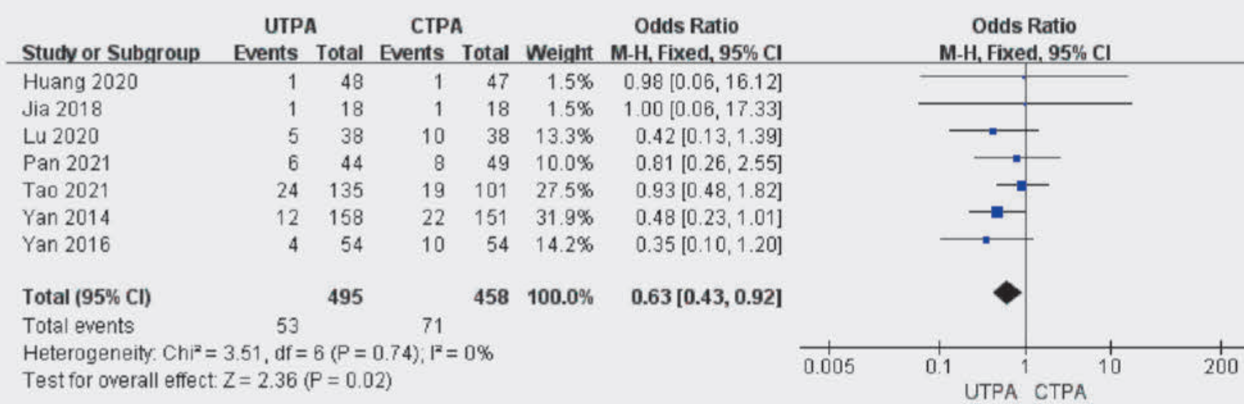
Bone cement leakage rates were reported in five studies (495 patients in the UTPA group and 458 patients in the CTPA group) without significant heterogeneity ($I^2 = 0\%$). The results showed that the bone cement leakage rate in the UTPA group was significantly lower than that in the CTPA group (MD = 0.62, 95 % CI [0.42, 0.92], p = 0.02) (▶ **Fig. 13**).

The amount of bone cement

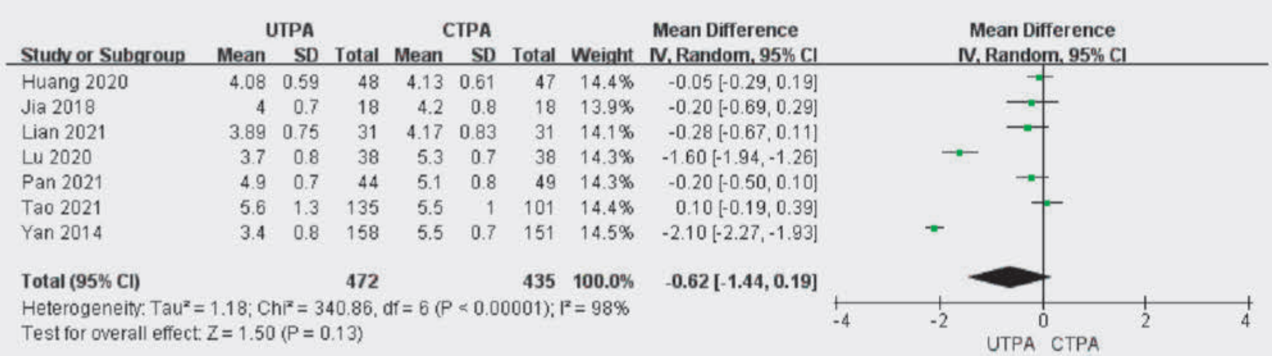
The perfusion dose of bone cement was reported in seven studies (472 patients in the UTPA group and 435 patients in the CTPA group) with significant heterogeneity ($I^2 = 98\%$). The results showed that there was no significant difference in the perfusion dose of bone cement between the two groups (MD = –0.62, 95 % CI [–1.44, 0.19], p = 0.13) (▶ **Fig. 14**).



► **Fig. 12** Mean difference of the operative time between the UTPA group and the CTPA group.



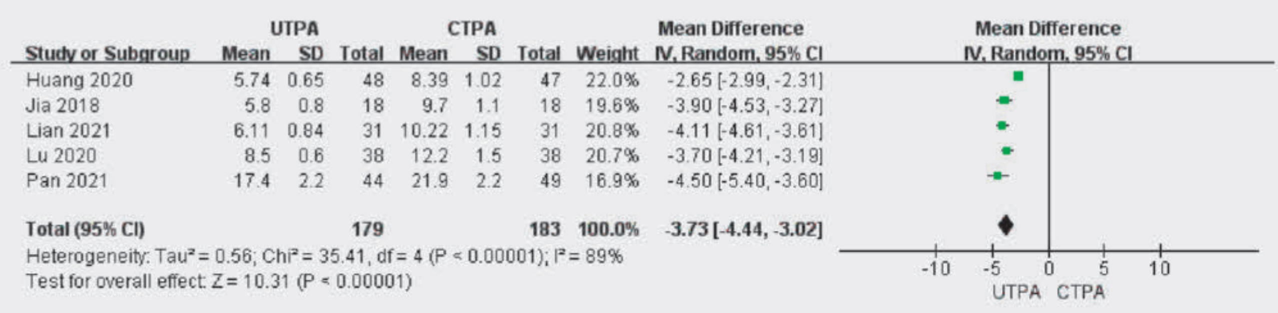
► **Fig. 13** Mean difference of the bone cement leakage rates between the UTPA group and the CTPA group.



► **Fig. 14** Mean difference of the amount of bone cement between the UTPA group and the CTPA group.

X-ray fluoroscopy

The frequency of fluoroscopy was reported in five studies (179 patients in the UTPA group and 183 patients in the CTPA group), with significant heterogeneity ($I^2 = 89\%$). The random effects model was used to combine data and the results showed that the number of fluoroscopies in the UTPA group was significantly lower than that in the CTPA group (MD = –3.73, 95 % CI [–4.44, –3.02], $p < 0.001$) (► **Fig. 15**).



▶ **Fig. 15** Mean difference of the frequency of fluoroscopy between the UTPA group and the CTPA group.

Discussion

PVA is widely used in the treatment of painful OVCFs. Traditional unilateral and bilateral transpedicular approaches provide effective and safe treatment for patients with painful OVCFs. However, the operation of a unilateral transpedicular approach often fails to make bone cement evenly and sympathetically distributed in the affected vertebrae, resulting in a series of complications, such as refracture. Therefore, PVA via a bilateral pedicle approach is more commonly used in clinical practice [18]. Different from the traditional transpedicular puncture, a trans transverse process-pedicle puncture was performed at the midline of the transverse process 1–3 mm outside the projection edge of the pedicle. According to the segment of the fractured vertebral body, the entry point of T11-L2 gradually moved outward, and the camber angle of puncture gradually increased [19]. The new approach is believed to have advantages over traditional methods. As is known to all, the ideal treatment for OVCF should have a quick and lasting analgesic effect and can correct kyphosis caused by fracture well and improve quality of life [20]. The results of this study showed that the puncture route had no significant effect on pain relief, which was reflected not only in short-term pain relief, but also in long-term pain relief. However, some scholars put forward a different view that the occurrence of postoperative PVA pain is clearly related to the puncture route. They suggested that it was possible that the puncture site of the traditional pedicle approach was closer to the facet joint, thus damaging the facet joint and causing postoperative low back pain. Sun et al. [21] reported that the unilateral trans transverse process-pedicle approach avoided facet injury, was more conducive to improving patients' symptoms and postoperative quality of life, and the short-term postoperative lumbago pain was significantly better than a bilateral puncture. However, our study cannot provide sufficient evidence to prove that PVA therapy for pain in OVCF patients is related to the puncture route.

In this study, it was found that the unilateral transverse process-pedicle approach reduced the operation time. The extension of operation time is accompanied by the increase of anesthetic maintenance drugs, which increases the risk of perioperative period for patients with a poor basic state and puts more economic burden on patients. However, in the traditional pedicle approach, the operation time with the bilateral approach takes longer than the unilateral approach, which is consistent with our research conclusions.

Cement leakage is the main complication of OVCF treatment, and this complication is really related to the puncture technique [22]. For the prevention of bone cement leakage, the key lies in the choice of puncture route and the amount of bone cement infusion dose, which was also proved in our study, namely, the leakage rate through the unilateral transverse process-vertebral pedicle approach was significantly lower than that through the traditional bilateral pedicle approach. In addition, in our study, there was no significant relationship between the infusion dose of bone cement and puncture route, which was also consistent with clinical reality. The filling dose of bone cement should be more related to the size of the injured vertebra, the viscosity of bone cement, and the degree of fracture.

Long-term exposure to a large amount of radiation dose seriously harms the health of medical staff. In this regard, scholars at home and abroad agree that no matter how much and the duration of the radiation dose they receive, as long as the accumulated dose exceeds the limit, there is a risk of inducing diseases [23]. The risk of inducing cancer increases by 0.004 % for every 1 msV radiation dose received [24]. Percutaneous vertebral augmentation, however, exposes doctors to much higher radiation doses than other orthopedic procedures. Therefore, this aspect should be paid more attention. In our study, patients received a significant difference in radiation dose between traditional and new techniques. Traditional bilateral pedicle puncture results in patients receiving significantly more radiation doses than a transversal-pedicle puncture.

Liebschner et al. [25], through a three-dimensional finite element study, believed that unilateral puncture may lead to imbalanced filling of bone cement, thus causing spinal mechanic changes, and unilateral puncture is inferior to bilateral puncture in restoring vertebral stability. Although there are still controversies about the clinical efficacy of unilateral and bilateral puncture injection of bone cement and the effect of bone cement distribution on spinal biomechanics, many scholars have realized that once the puncture reaches or passes through the midline of the vertebral body and bone cement is distributed to the other side of the vertebral body, both sides of the vertebral body can be strengthened [26]. Wang et al. [27] reported that the transverse process-pedicle approach group presented with a more lateral entry point, larger puncture inclination angles, and higher success rates than that in the CTPA group. On the basis of reducing the risk of puncture, the unilateral transversal-pedicle approach is the best target site for PVA surgery, and bone cement can be diffused contralaterally, achieving the same satisfactory clinical results as the bilateral pedicle approach [28]. When performing a puncture operation, the puncture needle should exceed the midline of the vertebral body to maximize the uniform distribution of bone cement, so as to restore the height of the vertebral body, correct scoliosis, and reduce the risk of postoperative vertebral instability, bone cement leakage, and re-collapse of the injured vertebral body.

It is true that the precise location of the puncture is important in clinical events but it is all about the refinement of the puncture technique, not the choice of the puncture site.

Limitation

This study had some limitations. Due to the large inter-study heterogeneity of the included articles, the sensitivity can only be reduced through the random effect model in the statistical analysis so as to reduce a certain risk of bias. In addition, most studies have focused on pain relief and functional recovery, and complications such as recurrent fractures have not been mentioned. Therefore, further high-quality RCTs with a large sample size and long follow-up duration are warranted to offer more invaluable and convincing conclusions.

Conclusion

This study showed that PVA in both puncture methods relieved pain and significantly improved quality of life in patients with OVCF. There was no difference in the choice of surgical indications between the two methods. The new puncture method does not have any advantages over the traditional technique, so there is no point in continuing to obsess over the impact of the puncture method on surgical outcome. It is definitely important and necessary to carefully measure and compare imaging data before selecting the best puncture method for each individual and vertebral level.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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