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## Acta Orthopaedica et Traumatologica Turcica

journal homepage: <https://www.elsevier.com/locate/aott>

# Anterior reconstruction versus posterior osteotomy in treating Kümmell's disease with neurological deficits: A systematic review

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## ARTICLE INFO

## Article history:

Received 23 June 2017

Received in revised form

29 March 2018

Accepted 7 May 2018

Available online 24 May 2018

## Keywords:

Kümmell's disease

Neurological deficits

Anterior reconstruction

Posterior osteotomy

Postoperative outcomes

Systematic review

## ABSTRACT

**Objective:** This study aimed to conduct a systematic review of literature comparing the clinical effectiveness and safety between anterior reconstruction (AR) and posterior osteotomy (PO) in the treatment of Kümmell's disease with neurological deficits.

**Methods:** We systematically reviewed the literature in PubMed, EMBASE, Cochrane Database of Systematic Reviews, and the Web of Science for "spin\*", "surg\*", "Kümmell's disease," "Kummell's disease," "Kummell disease," "vertebral osteonecrosis," "vertebral pseudarthrosis," "intravertebral vacuum cleft," "delayed vertebral collapse," and "compression fracture nonunion". Quality was assessed using the Grading of Recommendations, Assessment, Development, and Evaluation method.

**Results:** A total of 10 publications involving 268 Kümmell's disease patients with neurological deficits were included in this review, with 7 studies of low- or very low-quality. There were 37.7% and 62.3% of patients receiving AR and PO, respectively. For clinical outcomes, AR group showed no significant differences in pain, neurological dysfunction, and imaging outcome improvements compared with patients who underwent PO. However, the incidence of implant-related complications including loose screw, screw fracture, screw disconnection, and plate dislodgment, was higher in AR group compared with PO group (21.6% vs. 14.3%). As another major complication, AR group more often required a second surgery.

**Conclusion:** This systematic review demonstrated that both AR and PO could improve pain, neurological dysfunction and imaging outcomes. However, serious comorbidities, multilevel corpectomies and/or severe osteoporosis highly required PO. Design discrepancies were found in the current studies, further higher-quality studies are warranted.

**Level of evidence:** Level III, therapeutic study.

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## Introduction

Kümmell's disease, first described by Dr Hermann Kümmell in 1891, is defined as avascular osteonecrosis and occurs after delayed posttraumatic vertebral collapse, mostly in an osteoporotic spine.<sup>1–3</sup> Currently, percutaneous vertebroplasty (PVP) and kyphoplasty (PKP) achieve pain relief and satisfactory deformity correction in Kümmell's disease without neurologic deficits.<sup>4,5</sup> However, in patients with neurological deficits, cement augmentation is inappropriate.<sup>6,7</sup> Due to complicated neurologic compromise, those cases have to receive open surgery for spinal cord decompression and spine stabilization.

Anterior reconstruction (AR) and posterior osteotomy (PO) have been proposed for the management of Kümmell's disease with

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Peer review under responsibility of Turkish Association of Orthopaedics and Traumatology.

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**Table 1**  
General results.

Study, year	Study type	Operation	Patients	Age (years)	Hospitalized time (Days)	Operation time (min)	Blood loss (ml)	Follow-up (Months)
Wang et al <sup>11</sup> 2015	Cohort	AR	13	68.4 (57–79)	5 (3–12)	81.6 ± 21.5	185 ± 52	24.3 (6–37)
		PO	17	69.6 (56–79)	4 (3–10)	65.4 ± 17.6	178 ± 47	23.2 (8–32)
Kashii et al <sup>12</sup> 2013	Cohort	AR	27	73.6 ± 6.9	NR	360 (360 ± 81)	950 (1420 ± 1464)	NR
		PO	36	74.6 ± 65.9	NR	348 (387 ± 113)	1207 (1377 ± 1054)	NR
Uchida et al <sup>13</sup> 2010	Cohort	AR	30	71.4 ± 5.3	NR	NR	NR	4.5 ± 1.9 Years
		PO	25	69.3 ± 7.5	NR	NR	NR	4.7 ± 2.1 Years
Zhang et al <sup>14</sup> 2015	Case series	PO	12	64 (55–75)	NR	148 (100–220)	625 (450–850)	33 (26–43)
Patil et al <sup>6</sup> 2013	Case series	PO	10	67.3 (48–85)	NR	NR	NR	25.4 (12–38)
Kanayama et al <sup>17</sup> 2010	Case series	AR	31	70.8 (57–87)	NR	193 (150–285)	436 (100–1350)	30.8
Long et al <sup>18</sup> 2009	Case series	PO	16	64.6 ± 3.5	NR	197 ± 39	766 ± 46	29 (12–54)
Saita et al <sup>16</sup> 2008	Case series	PO	13	75.2 (63–83)	NR	279 (220–340)	917 (390–1850)g	36.4 (6–71)
Li et al <sup>9</sup> 2007	Case series	PO	24	72 ± 8	4.5 ± 2.2 (3–10)	70.4 ± 17.2 (45–90)	150 ± 72 (100–450)	48 (30–76)
Kim et al <sup>15</sup> 2003	Case series	PO	14	67 (62–72)	NR	217 (150–300)	682 (420–1210)	36 (24–54)

neurological deficits. AR could resect the retropulsed bony fragments directly and provide anterior column support.<sup>8</sup> Meanwhile, PO is currently a common treatment with the advantages of dissecting the retropulsed posterior cortex by posterior spinal shortening osteotomy and correction of kyphotic deformity.<sup>9</sup> However, these major surgical interventions are challenging because of patients' advanced age, numerous comorbid medical complications, and frequent instrumentation failure secondary to severe osteoporosis.<sup>10</sup> With regard to the advantages and disadvantages of AR and PO, it remains unclear which of these procedures is optimal. In addition, to date, an absence of systematic literature reviews on comparing these two surgical procedures in the treatment of Kümmell's disease with neurological deficits provides the impetus for this systematic review.

We therefore performed a systematic review of the literature to comprehensively evaluate the evidence for the clinical and imaging outcomes as well as complications of AR and PO, respectively, for Kümmell's disease with neurological deficits, comparing these two surgical procedures.

## Methods

The two clinically relevant questions below were determined by consensus among a panel of spine experts, and a systematic review of related literature was conducted. Specific clinical questions were as follows:

- 1 In patients with Kümmell's disease and neurological deficits, what is the impact of different surgical approaches (AR versus PO) on pain relief and functional outcomes?
- 2 In patients with Kümmell's disease and neurological deficits, what is the impact of different surgical approaches (AR versus PO) on complications?

Search terms including “spin\*”, “surg\*”, “Kümmell's disease”, “Kummell's disease”, “Kummell disease”, “vertebral osteonecrosis”, “vertebral pseudarthrosis”, “intravertebral vacuum cleft”, “delayed vertebral collapse”, and “compression fracture nonunion” were used to search literature from PubMed, EMBASE, Cochrane Database of Systematic Reviews, and the Web of Science. We screened the references of the obtained articles for any additional studies. The inclusion criteria were: Kümmell's disease with neurological deficits; detailed description of the neurological status; detailed description of AR or PO procedure; length of the follow-up period; report of any peri/postoperative complications associated with surgery; statistical analysis of postoperative outcomes. NonEnglish articles, technical notes, letters to the editors, abstracts only, conference presentations,

commentaries, case reports, and narrative and quantitative reviews were excluded. Due to the limited evidence available on the topic, case series were included in this study.

Initial database searches retrieved 1876 studies. The respective abstracts were independently reviewed by 3 investigators (F.L., Z.C., and C.L.), and all relevant articles were read in full. Stringent exclusion criteria were applied, finally, 10 articles<sup>6,9,11–18</sup> were considered eligible for the study, including 3 articles reporting results from cohort study, and 7 articles reporting results from case series (Table 1). Among the 10 articles, 4 assessed AR, while 9 evaluated PO.

The quality of evidence for each article was evaluated as high, moderate, low, or very low. The systematic review results and evidence quality rating were assessed by a group of multidisciplinary scientist, spine experts and methodologists. The group then went through a consensus-based decision making process using a modified Delphi technique to arrive at treatment recommendations related to the key clinical questions. This process and the strength of the recommendations were based on the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) method. All included articles were evaluated independently by the authors according to the GRADE criteria.<sup>19</sup>

## Results

### AR versus PO

Only 3 cohort trials<sup>11–13</sup> compared AR and PO for clinical and radiological data. These studies all found no significant differences between the two procedures with respect to pain relief, neurological and function improvement (Table 2). They found that postoperative kyphotic angle in both groups was significantly reduced in a comparison with the preoperative. Kashii et al<sup>12</sup> reported that AR showed a higher loss of correction rate at follow-up than PO but didn't reach a significant difference. Meanwhile, Uchida et al<sup>13</sup> reported an opposite result that PO showed a significant higher loss of correction rate than AR (Table 3). Kashii et al<sup>12</sup> also reported no significant differences between the two operations in the estimated mean blood loss and mean duration of surgery. However, Wang et al<sup>11</sup> reported overtly longer operation time and slightly increased blood loss in AR compared with PO (Table 1).

### AR: effectiveness and safety

One retrospective case series study<sup>17</sup> and 3 cohort studies were identified about the effectiveness and safety of AR. The data from

**Table 2**  
Clinical outcomes.

Study, year	Operation	Pain Grade			Neurological function			Function		
		Preoperation	Postoperation	Follow-up	Preoperation	Postoperation	Follow-up	Preoperation	Postoperation	Follow-up
Wang et al 2015	AR	VAS:8.2 ± 0.8	2.5 ± 1.4	2.0 ± 0.9	FC:5C,8D	5D,8E	NR	NR	NR	NR
	PO	8.3 ± 0.8	2.8 ± 1.2	2.1 ± 1.1	8C,6D,3E	6D,11E	NR	NR	NR	NR
Kashii et al 2013	AR	PS:1.2 ± 0.8	NR	2.0 ± 0.5	NC:3.1 ± 0.6	NR	4.8 ± 0.9	ADL:2.4 ± 1.4	NR	5.3 ± 1.6
	PO	1.3 ± 1.1	NR	1.9 ± 0.7	3.0 ± 0.7	NR	5.0 ± 1.0	2.1 ± 1.2	NR	4.8 ± 1.5
Uchida et al 2010	AR	VAS:7.8 ± 1.0	2.9 ± 1.3	2.7 ± 1.1	NC:7.3 ± 2.2	12.1 ± 1.8	11.8 ± 2.1	NR	NR	NR
	PO	7.8 ± 0.9	2.7 ± 1.2	2.4 ± 1.0	7.8 ± 1.5	11.8 ± 1.2	11.5 ± 1.4	NR	NR	NR
Zhang et al 2015	PO	VAS:7.17 ± 1.27 (5.0–9.0)	1.17 ± 1.03 (0–3)	NR	FC:8D,3C, 1B	1C,6D,5E	NR	NR	NR	NR
Patil et al 2013	PO	VAS:8.2	NR	2.8	FC:10 > E	10E	NR	ODI:65.4	NR	31.4
Kanayama et al 2010	AR	VAS: 58 ± 27	47 ± 28	21 ± 28	NR	NR	NR	JOA:10.3	24.8	22.7
Long et al 2009	PO	VAS:8.7 ± 0.6	2.7 ± 0.6	NR	FC:6C,10D	16D or E	NR	JOA:11.9 ± 3.1	26.2 ± 3.1	NR
Saita et al 2008	PO	NR	NR	NR	NR	NR	NR	NR	NR	11 cases were improved
Li et al 2007	PO	Denis pain scale: 10 P1; 7 P2; 1 P3; 2 P4; 1 P5	NR	0% P1 or P2 100% P4 and P5	FC:6C,9D,6E	NR	1D,20E	NR	NR	NR
Kim et al 2003	PO	VAS: 9.5	2.7	NR	FC:7C,7D	2D,11E	NR	NR	NR	NR

VAS = Visual analog scale, FC = Frankel classification, NC = Neurological score, PS = Pain score, ADL = Activities of daily living, JOA = Japanese orthopedic association score, ODI = Oswestry disability index.

the above studies could not be pooled because of missing data and follow-up time intervals were not identical. Based on the identified non-experimental studies, improved vertebral height, pain, neurological deficits, functional disability, and corrected the angle of vertebral fractures were found during at least 6 months of follow-up (very low quality). Regarding safety, AR was described as a safe procedure in short-medium term; the incidence of infections (2 pulmonary and 2 surgical site infections) was 4.0%, and no patient died during follow-up. A total of 9/88 patients (10.2%) had vertebral fractures after surgery, and 16/74 patients showed implant-related complications (21.6%) (very low quality) (Table 4).

#### PO: effectiveness and safety

A total of 9 studies were reported on PO, including 6 case series<sup>6,9,14–16,18</sup> and 3 cohort studies. The data from these studies could also not be pooled. The imaging outcomes, pain, neurological deficits and functional disability were also improved during at least 12 months of follow-up after PO (very low quality). Regarding safety, the incidence of infections (2 pulmonary, 2 urinary tract, and 8 surgical site infections) was 7.6%. One patient died due to acute adrenal insufficiency during follow-up. Regarding other complications, 33/128 patients (25.8%) had vertebral fractures after surgery, and 15/121 subjects showed implant-related complications (12.4%) (very low quality). The PO procedure had the specific complication of dural tear (2.5%) (Table 4).

## Discussion

Kümmell's disease with neurological deficits is a relative contraindication for cement augmentation, and only amenable to major surgical interventions, such as AR and PO. These two procedures aim to decompress the spinal cord, restore the spinal physiological curvature of the spine, and maintain spinal stability. Some researches have discussed AR and PO surgical results for patients with Kümmell's disease with neurological deficits. However, to date, there is an absence of systematic literature review comparing clinical results for these two surgical procedures. In the present review, these two procedures were examined to ascertain which one provides the best surgical outcome in terms of effectiveness and safety.

The 10 selected studies have some heterogeneity that reduces the number of valid conclusions in some parameters. In the studies included, the operating time and blood loss were recorded in 72% of patients. The results showed that patients who underwent AR or PO had no significant difference in operative time and blood loss. In AR, operating time ranged from 81.6 ± 21.5 min to 360 ± 81 min, with blood loss between 185 ± 52 mL and 1420 ± 1464 mL. Meanwhile, operating time ranged from 65.4 ± 17.6 min to 387 ± 113 min, with blood loss between 178 ± 47 mL and 1377 ± 1054 mL in PO. Such important differences might mainly be due to heterogeneity in terms of operators and surgical methods.

Patients with Frankel B, C and D grades show a significant improvement in both AR and PO surgical procedures.<sup>11</sup> Similar results were found for the evaluation of neurosurgical score changes, and no statistically significant differences between AR and PO were reported by some studies.<sup>12,13</sup> These findings support the notion that AR and PO improve neurological function in Kümmell's disease patients with neurological deficits. We have further identified that patient-reported outcomes, including visual analog scale (VAS) scores, Japanese Orthopaedic Association (JOA) scores and Oswestry Disability Index (ODI) values, suggested equivalent medium-term clinical outcomes in patients undergoing AR and PO procedure.

Radiological outcomes assessed by the kyphotic Cobb's angle, wedge angle, or vertebral height were all improved by both procedures, while some studies reported no significant differences between the two groups at follow-up. For the kyphotic Cobb's angle, Kashii et al<sup>12</sup> reported that AR showed a higher loss of correction rate compared with PO, although with no statistical significance. Meanwhile, Uchida et al<sup>13</sup> reported an opposite result that PO showed a significantly higher loss of correction rate compared with AR. This discrepancy might be due to different numbers of posterior spinal fusion segments and fixation segments assessed in the two studies; these numbers were larger in Kashii et al.<sup>12</sup> Studies have demonstrated that fixation or fusion from two levels above the affected segment to two levels below the lesion provide greater stability and maintain correction of the kyphotic angle, especially in patients with a relatively osteoporotic spine.<sup>20,21</sup> However, equivalent neurological recovery and patient-reported outcomes were obtained in patients undergoing either an AR or a PO procedure and therefore, more studies are required to further explore this issue and the related clinical significance.

**Table 3**

Every index of patients in 2 groups at preoperation, postoperation, and follow-up.

Study, year	Operation	Kyphotic Cobb Angle (°)			Anterior Vertebral Height (mm)			Wedge Angle (°)			Loss of correction (°)
		Preoperation	Postoperation	Follow-up	Preoperation	Postoperation	Follow-up	Preoperation	Postoperation	Follow-up	
Wang et al 2015	AR	25.1 ± 9.6	7.6 ± 5.5	9.8 ± 6.4	13.2 ± 3.8	–	–	20.5 ± 8.6	–	–	NR
	PO	24.9 ± 9.2	6.4 ± 4.3	8.4 ± 5.7	12.7 ± 5.4	21.8 ± 4.1	19.0 ± 4.0	21.4 ± 5.9	5.4 ± 4.2	7.1 ± 4.7	NR
Kashii et al 2013	AR	36.6 ± 9.7	15.3 ± 8.1	26.8 ± 10.0	NR	NR	NR	NR	NR	NR	54%
	PO	39.3 ± 12.4	9.0 ± 6.9	22.1 ± 6.5	NR	NR	NR	NR	NR	NR	43%
Uchida et al 2010	AR	25.5 ± 10.5	13.9 ± 6.8	18.5 ± 9.9	NR	NR	NR	NR	NR	NR	4.5 ± 5.9
	PO	24.7 ± 11.7	8.9 ± 6.0	17.7 ± 7.3	NR	NR	NR	NR	NR	NR	8.6 ± 6.2
Zhang et al 2015	PO	43.33 ± 7.44 (30–58)	1.92 ± 2.74 (-3-7)	NR	NR	NR	NR	NR	NR	NR	NR
Patil et al 2013	PO	41.5 (35–50)	12 (10–15)	NR	NR	NR	NR	NR	NR	NR	NR
Kanayama et al 2010	AR	30.8	12.5.0	21.0	NR	NR	NR	NR	NR	NR	8.0
Long et al 2009	PO	NR	0.9 ± 1.7	NR	NR	NR	NR	NR	NR	NR	NR
Saita et al 2008	PO	14.4 ± 9.0 (3–34)	-0.2 ± 5.5 (-6-10)	NR	21.5 ± 5.0 (12–31)	11.7 ± 4.8 (5–19)	NR	NR	NR	NR	NR
Li et al 2007	PO	28.6 ± 9.9	5.0 ± 3.0	10.1 ± 7.9	12.3 ± 4.8	28.9 ± 4.0	26.5 ± 4.3	22.6 ± 6.8	3.1 ± 4.1	4.0 ± 5.5	Cobb: 5.1 ± 5.5 Wedge angle: 0.8 ± 2.0
Kim et al 2003	PO	22.6 (7–29)	4.4 (1–6)	6.8 (2–15)	NR	NR	NR	NR	NR	NR	NR

**Table 4**

Detail of complications.

Study, year	Operation	Infection	Vertebral fracture	Implant-related complications	Others
Wang et al 2015	AR	2 pulmonary infection	NR	0	1 transient delirium
	PO	2 urinary tract infection	NR	0	3 transient delirium
Kashii et al 2013	AR	1 pulmonary infection 2 deep surgical site infection	26% Fused level 16% Adjacent level 11% Nonadjacent level	NR	2 infection irrigation
	PO	4 deep surgical site infection	44% Fused level 32% Adjacent level 29% Nonadjacent level	NR	4 infection irrigation 2 transient neurological deterioration
Uchida et al 2010	AR	0	2 vertebrae 1–3 levels above or below	4 Loose screw 3 dislodgment of plate 3 subsidence of cage	0
	PO	0	0	4 screw pullout 2 screw fracture 1 screw disconnection	2 Pseudarthrosis
Zhang et al 2015	PO	1 wound infection	NR	0	1 dural tear 2 unilateral front thigh numbness
Patil et al 2013	PO	NR	NR	NR	NR
Kanayama et al 2010	AR	0	7 Adjacent level	6 progression of kyphosis deformity and crew migration, need posterior reinforcement	0
Long et al 2009	PO	0	0	0	1 dural tear 1 transient nerve injury
Saita et al 2008	PO	0	3 end vertebral 1 a vertebral adjacent to the fixation region	2 Dislocation 6 Loosening	1 spinal cord comprised intensified, requiring additional surgery
Li et al 2007	PO	1 pulmonary infection 2 surgical site infection	3 Adjacent level	0	0
Kim et al 2003	PO	1 superficial infection	0	0	2 dural tear 1 died due to acute adrenal insufficiency

In terms of intraoperative and postoperative complications, the safety of AR and PO was comparable. Kashii et al<sup>12</sup> reported that PO results in higher incidence of subsequent vertebral fractures (VFs) within the fused level as well as at the adjacent and nonadjacent levels, compared with AR (AR group, 26%; PO group, 71%). However, subsequent VFs occurred only in 2 of 83 patients with AR at final follow-up in a study conducted by Uchida et al<sup>13</sup> and other case series. The reasons for this discrepancy might be explained by the following: first, the definition of subsequent VFs is unclear in these studies, resulting in considerable heterogeneity. Secondly, the patients and PO procedures were heterogeneous among the included studies, with variable protocols. Finally, in Kashii et al, the restored sagittal spinal alignment was better within the fused level obtained by posterior spine shortening osteotomy, with longer posterior spinal fusion; correcting the regional re-alignment can cause disease in adjacent vertebrae.<sup>14</sup> All the aforementioned reasons account for the inconsistency between AR and PO in subsequent VFs.

It is often stated that AR is superior for the surgical treatment of Kümmell's disease with neurologic deficits because the main pathological condition (fractured bone) is located in the anterior part of the spine.<sup>22</sup> However, AR has several disadvantages, such as the detachment of the diaphragm being required in numerous instances where a fracture occurs at the thoracolumbar junction, compromise of lung function in case of thoracotomy, various complications in multilevel corpectomies, and vertebral body or graft collapse that causes kyphosis. Surgical treatment of Kümmell's disease with neurological deficits poses significant clinical challenges: patients are often accompanied by advanced age, serious comorbidities and severe osteoporosis. Thus, AR is not easy and is highly invasive, and therefore AR is inappropriate for these extreme elderly individuals.<sup>13,23,24</sup> In our analysis results, we found that the incidence of implant-related complications including loose screw, screw fracture, screw disconnection and plate dislodgment were lower in PO when compared with AR (PO group, 14.3%; AR group, 21.6%). Another major complication for AR is that it more often requires a second surgery, such as posterior reinforcement using screw and/or hook instrumentation. A possible reason is that the vertebral body consists mostly of cancellous bone and cortical bone in the vertebral body is very thin. Therefore, anterior fixation is not very secure in the osteoporotic spine. In contrast, posterior fixation using the pedicle screw systems provides relatively stable fixation even in the osteoporotic spine because the pedicle remains a strong part of the vertebra. Furthermore, posterior long-segment fixation have been used to restore sagittal balance and stabilize the spinal column to prevent implant-related complications.<sup>21,25,26</sup> In addition, PO was reported to result in good therapeutic outcome.<sup>16,27</sup> It is feared that an additional procedure such as an osteotomy only increases the stress level for the surgeon and likewise increases the risk of developing complications. However, Uchida et al<sup>13</sup> reported that PO with long fusion or multiple fixation sites is sometimes required to achieve lesser degrees of deformity correction. In addition, PO avoids ending the instrumentation within kyphotic segments or is used in severe osteoporosis, with a satisfactory outcome. Other benefits are attributable to PO only, including fewer complications, early mobilization, and the familiarity of most surgeons with the approach.

In addition, dural tear is a specific complication of PO with a very low incidence. A careful dissection between the dura matter and posterior wall is therefore essential. Other complications, such as deep surgical site infection, transient nerve injury, pseudarthrosis, pulmonary infection, urinary tract infection, and transient delirium have been reported in older, fragile patients after AR and PO. Thus, it is important for clinicians to pay more attention and vigilance while treating patients with Kümmell's disease and neurological deficits.

This systematic review had some limitations. First, due to the limited available evidence and data on AR and PO proposed for patients with Kümmell's disease with neurological deficits, we relied considerably on case series in this study. This reflects the lack of a standardized surgical procedure for the management of this disease. The robustness of this review was enhanced by a comprehensive search strategy and independent data extraction by three reviewers. Another limitation was that most studies had methodological defects, including but not limited to inadequate baseline comparisons, inadequate measurement of clinical outcomes, and reported complications. Considerable heterogeneity was present in the data. This could result from incomplete data recording in individual studies, variable patient characteristics, and the diverse technical specification of each study. Given the low to very low quality of the existing literature, considerable heterogeneity was present in the data, relatively small sample sizes and short-term follow-up of AR and PO, further more well-designed and prospective studies with larger sample sizes and longer follow-up time period would help further evaluate the effectiveness and safety of AR and PO in patients with Kümmell's disease with neurological deficits.

## Conclusion

This systematic review showed that both AR and PO could achieve the improvement of pain, neurological dysfunction and imaging outcomes in treating Kümmell's disease with neurological deficits. However, patients with serious comorbidities, multilevel corpectomies and/or severe osteoporosis would be more appropriate for PO. Discrepancies were noted in the designs of available studies, and adequately powered randomized trials with appropriate subjective and objective outcome measures are required to define the best surgical procedure for Kümmell's disease with neurological deficits.

## Conflicts of interest

Feijun Liu, Zhenzhong Chen, Chao Lou, Weiyang Yu, Lin Zheng, Dengwei He and Kejun Zhu declare that they have no conflict of interest.

## Statement

The manuscript has been read and approved by all the authors and the manuscript represents honest work. No submissions and previous reports that regarded as redundant publication of the same or very similar work.

## Acknowledgments

This study was supported by the Natural Science Foundation of Zhejiang Province of China (Y17C100002), the Zhejiang Province Scientific Project of Health and Medicine of China (2016KYA200) and the High-level Personnel Training Foundation of Lishui of China (2016RC21), Zhejiang Science and Technology Program Foundation of China (2016C33245).

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