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REVIEW ARTICLE

The role of non-rigid cervical collar in pain relief and functional restoration after whiplash injury: a systematic review and a pooled analysis of randomized controlled trials

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Abstract

Purpose Whiplash injury (WI) represents a common diagnosis at every emergency department. Several investigations have been conducted to compare the different medical managements for non-surgical cases. However, the role of the immobilization with a non-rigid cervical collar (nRCC) for pain management and range of motion (RoM) preservation has not been completely clarified.

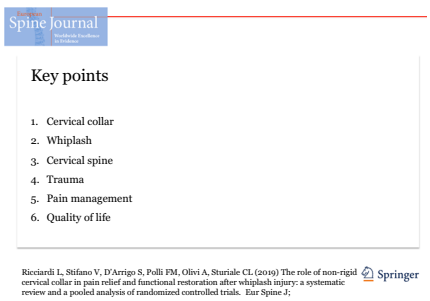
Methods We performed a systematic review of the randomized control trials (RCTs) and a pooled analysis in order to investigate the role of the nRCC for pain management, scored through the visual analogue scale (VAS) and the RoM, by comparing the use of a nRCC (for 1–2 weeks) with a non-immobilization protocols, regardless of the association with physical therapy (PhT). Only patients with whiplash-associated disorders grade I–II were included. Due to a certain heterogeneity across the RCTs, follow-up period time range resetting was necessary in order to pool the data.

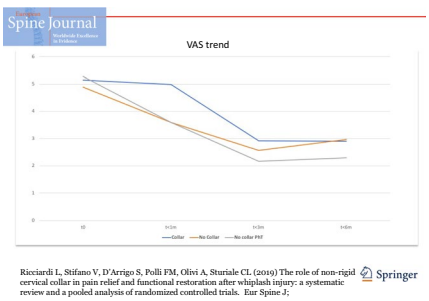
Results A total of 141 papers were reviewed; 6 of them matched the inclusion criteria and were admitted to the final study. Pooled analysis showed that nRCC does not improve the outcome in terms of VAS score and RoM trends along the follow-up. Moreover, VAS and RoM trends seem to further improve at long-term follow-up in non-immobilization associated with PhT group.

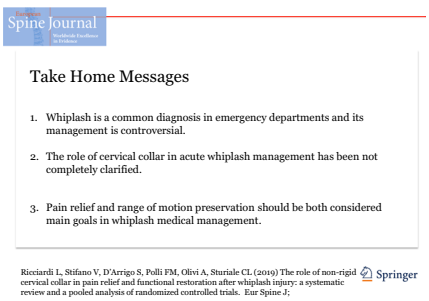
Conclusions This pooled analysis of the available RCTs shows the absence of an advantage of the immobilization protocol with a nRCC after a WI. On the contrary, non-immobilization protocols show an overall better trend of pain relief and neck mobility recovery, regardless of the association of PhT.

Graphic abstract

These slides can be retrieved under Electronic Supplementary Material.







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Extended author information available on the last page of the article

Keywords Cervical collar · Whiplash · Cervical spine · Trauma · Pain management

Introduction

Whiplash injury (WI) is an inertial trauma that results by a combination of an acceleration–deceleration energy transfer to the neck, usually occurring in motor vehicles collision [1]. Incidence varies much from different regions and among single reports [2–4], being about 677 on 100,000 inhabitants [5].

Pain and functional limitations are the most frequent whiplash-associated disorders (WADs) [6] that may cause prolonged disability [1, 6]. However, about 50% of them are reported to spontaneously recover within 3 months, whereas the remaining 50% experience pain persistence, and nearly 25% of them report a long-term complex pain-related disability [7–9].

Medical care, sick leave, and chronic disability that origin from WI are very expensive, having an estimated annual cost in the USA of $3.9 billions [10–12].

A recent comprehensive literature review on the management of acute WI [13] concluded that the immobilization with a non-rigid cervical collar (nRCC) is not more effective than an early mobilization for a rapid recovery. On the other hand, some studies that investigated the role of the physical therapy (PhT) did not show a significant role in improving the medium–long-term outcome [14] compared with the act-as-usual management [13].

Accordingly, there is not a general agreement that may support a single decision on which therapeutic protocol should be prescribed [14, 15] and no guidelines are available to help the emergency departments in the management of WI patients.

In order to improve di understanding of this topic, we design a systematic review and a pooled analysis of the randomized controlled trials (RCTs) that specifically focused on the outcome comparison between patients who underwent neck immobilization with nRCC or not after WI.

Materials and methods

Data reported in this review are consistent with the preferred reporting items for systematic reviews and meta-analyses (PRISMA) statement [16].

Review questions

The review questions were formulated following the PICO scheme (population (P), intervention (I), comparison (C), and outcome (O)) as follows:

- Among people who experience WI (P), does nRCC (I) improve pain relief (O) trend, evaluated with a visual analogue scale (VAS) (O), compared with patients who did no wear nRCC?
- Is the cervical motility range measured by the neck range of motion—RoM—(O), influenced by wearing nRCC (I)?

Inclusion and exclusion criteria

All studies designed as randomized controlled trials published as full-text articles in indexed journals, which investigated the role of nRCC in WI management by comparing patients who received nRCC after injury and those who did not, were considered in this investigation. Language restriction to English written papers, but not publication date limits, was set. Review, case reports, and observational studies were excluded. Moreover, studies including patients who reported whiplash-associated disorders (WADs) of grade III or IV were excluded.

Search strategy and study selection

MEDLINE via PubMed and Embase were searched using the keywords “cervical spine,” “neck,” “injury,” “trauma,” “whiplash,” “collar,” “orthoses,” “orthotic,” “brace,” “RCT,” “randomized controlled trials” [MeSH] in any possible combination.

The search was iterated until June 1, 2018. The Web sites of relevant journals were searched to identify relevant studies in press. The reference lists of relevant studies were screened to identify other studies of interest.

Data extraction and analysis

Two reviewers (L.R. and V.S.) independently collected data from the included articles. Any differences were resolved by consensus with a discussion with a third author (C.L.S). For each study included in the final analysis, the following data were extracted: patients’ age and sex, admission diagnosis, nRCC administration or not, duration of brace prescription, VAS, and RoM at admission time ($t=0$) and follow-up measurements, the duration

of follow-up, and physical therapy received. RoM was defined by the authors as the degree of mean lateral flexion of the neck. In case of studies that reported updates of a previous paper, we collected global data for the meta-analysis [17, 18]. Papers reporting incomplete or not poolable data, such as means missing of standard deviations or medians missing of interquartile ranges, were excluded or included only for the follow-up periods where the data were complete.

Whenever possible, the authors of the original studies were contacted to retrieve missing data.

Data of the study populations were summarized using proportion and weighted means. The mean and standard deviations in individual studies were estimated from median and interquartile ranges, when needed, according to the method described by Wan et al [19]. Pooled mean differences (PMD) for continuous variables were computed between outcome groups with a random effects model [20]. Comprehensive meta-analysis software (version 2.2.064 Biostat Inc., Englewood, NJ, USA) was used for pooling data. *P*-value was considered significant at $\alpha < 0.05$.

Results

Study selection

The initial search on PubMed and Embase yielded 141 records, and 1 additional record was identified through forward search (Fig. 1). After duplicate removal and abstract screening, 13 articles were considered for full-text analysis. Among them, 9 were excluded because they did not fulfill inclusion criteria. These papers and the reasons for their exclusion are listed in supplementary Table (see supplementary materials). The remaining 6 studies were included in our final analysis.

Patient characteristics

Demographic characteristics of the included studies are reported in Table 1.

A total of 1202 patients (519 males and 683 females) with WI, ranging from grade 0 to grade II, were collected. Among them, 489 (40.68%) underwent neck immobilization with nRCC, whereas 713 (59.31%) received only conservative treatment. In particular, 311 out of 713 (43.61%) who did not wear a nRCC after WI also underwent PhT. Patients who wore nRCC did not receive any PhT. In 375 out of 408 patients assigned to the collar group, the nRCC was worn for 1 to 2 weeks, whereas in 33 it was not specified.

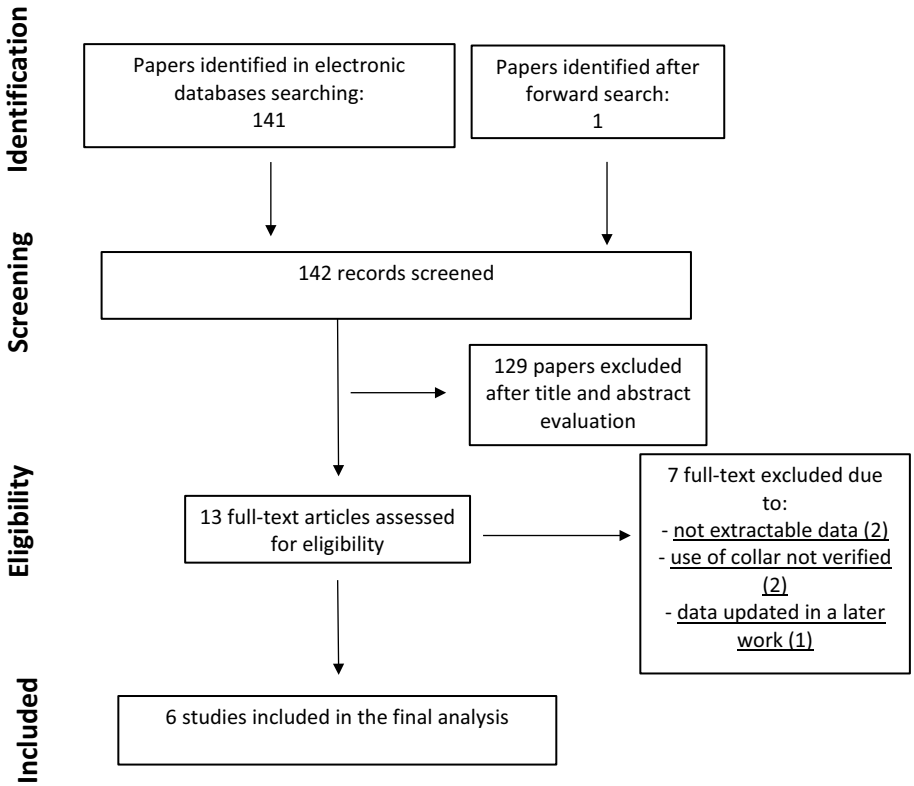

Fig. 1 Search strategy

Table 1 Demographic characteristics of the patients reported in the included studies

Author, year	No. of patients			Males, no. (%)			Age (mean year ± SD)			Mean FU, weeks
	Collar	Control		Collar	Control		Collar	Control		
Schnabel et al. [24]	97	103 (no PhT)		39 (40.2)	38 (36.9)		28.3 ± 8.94	30.1 ± 10.3		6
Mealy et al. [23]	30	31 (PhT)		16 (53.3)	21 (67.7)		28.7 ± 10.4	33.0 ± 10.6		8
Vassiliou et al. [25]	81	92 (PhT)		59 (60.8)	64 (62.1)		28.3 ± 8.9	30.1 ± 10.3		24
McKinney et al. [18]	33	71 (PhT)	66 (no PhT)	88 (52)			30.2 ± 11.3	31.6 ± 11.3 (PhT)	28.7 ± 8.9 (no PhT)	8
Borchgrevink et al. [21]	96	82 (no PhT)		37 (39)	32 (39)		36 ± 11.8	37.2 ± 13.2		–
Kongsted et al. [22]	152	145 (PhT)	151 (no PhT)	44 (29)	42 (29) (PhT)	39 (27) (No PhT)	33.7 ± 11.98	34.3 ± 14.98 (PhT)	33.7 ± 11.23 (no PhT)	–
Total	489	741		–	–		Mean ± SE 30.92 ± 1.43	Mean ± SE 32.17 ± 1.01		~ 11.5

Physical therapy (PhT), interquartile range (IQR)

The mean age ± standard error of the collar group was 30.92 ± 1.43, while the mean age ± standard error of the non-collar group (total) was 32.17 ± 1.01 ($p < 0.001$).

Mean follow-up was reported in 4 out of 6 studies (66.6%), and it was about 11.5 months.

Pooled outcomes

The comparison of the VAS trends between patients who used nRCC and patients who did not in the different RCTs is reported in Table 2 along with the pooled analysis.

The follow-up records were grouped into 4 times according to the different design of the included RCTs: at the diagnosis ($t0$); within the first month after WI ($t < 1$ m); within a quarter after WI ($t < 3$ m); and within a semester after the WI ($t \leq 6$ m). Overall, 5/6 (83.3%) of the RCTs reported the VAS at $t0$, 2/6 (33.3%) reported the VASS at $t < 1$ m, 5/6 (83.3%) reported the VAS at $t < 3$ m, and 3/6 (50%) reported the VAS at $t \leq 6$ m.

The comparison of the collar group and the no collar group total (including patients who underwent PhT and those who did not) showed that the trend of VAS improvement is not superior when using nRCC (Fig. 2). This difference was even more evident when comparing the collar group with the subgroup of patients who underwent PhT.

The comparison of RoM trends between patients who worn nRCC and who did not is reported in Table 3 along with the pooled analysis. Only two studies reported RoM at $t0$, at $t2$w–2m, and at $t = 2$m–6m [17, 22]. The comparison between the collar group and the no collar group total (including patients who underwent PhT and those who did not) showed that the trend of RoM improvement was significantly better in patients who have not undergone immobilization with nRCC, regardless of the association of PhT (Fig. 3).

Discussion

This pooled analysis of RCTs showed that the use of nRCC does not significantly improve the trends in pain relief and RoM recovery after WI, compared with an act-as-usual management, regardless of the prescription of PhT.

Despite some minor differences in the studies' design, all the included trials randomized the patients in two subgroups: those who used a nRCC and those who did not; some of them also distinguished the patients of the second group in those who underwent PhT and those who only followed an act-as-usual management.

We pooled all the patients who received the nRCC in a single group (collar group) and those who did not in a second one (non-collar group). When possible, we also

Table 2 Comparison of VAS progression at the different follow-up periods between patients who used and who not used collar, and pooled estimation of their mean ± standard error

Author and year	Collar use	VAS *t*0 No. of pts (mean ± SD)	VAS $t < 1$ m No. of pts (mean ± SD)	VAS $t < 3$ m No. of pts (mean ± SD)	VAS $t \leq 6$ m No. of pts (mean ± SD)
Vassiliou et al. [25]	Collar	–	81 (4.76 ± 2.15)	59 (1.60 ± 2.15)	51 (0.99 ± 1.36)
	No collar with PhT	–	92 (4.36 ± 2.14)	86 (1.04 ± 1.81)	72 (0.52 ± 1.13)
	No collar no PhT	–	–	–	–
McKinney et al. [18]	Collar	33 (5.6 ± 1.4)	–	–	–
	No collar with PhT	71 (5.3 ± 2.0)	–	–	–
	No collar no PhT	66 (5.3 ± 1.9)	–	–	–
Mealy et al. [23]	Collar	30 (6.44 ± 0.41)	30 (5.08 ± 0.48)	30 (3.94 ± 0.58)	–
	No collar with PhT	31 (5.71 ± 0.44)	31 (2.85 ± 0.57)	31 (1.69 ± 0.43)	–
	No collar no PhT	–	–	–	–
Schnabel et al. [24]	Collar	97 (4.76 ± 2.15)	–	62 (1.60 ± 2.15)	–
	No collar with PhT		–	–	–
	No collar no PhT	103 (4.36 ± 2.14)	–	88 (1.04 ± 1.81)	–
Borchgrevink et al. [21]	Collar	96 (3.81 ± 0.26)	–	96 (2.97 ± 0.27	96 (3.11 ± 0.32)
	No collar with PhT	–	–	–	–
	No collar no PhT	82 (3.3 ± 0.25)	–	82 (3.29 ± 0.39)	82 (2.66 ± 0.26)
Kongsted et al. [22]	Collar	152 (5.1 ± 1.5)	–	118 (4.3 ± 1.9)	121 (4.6 ± 1.9)
	No collar with PhT	145 (4.8 ± 1.7)	–	109 (3.8 ± 1.8)	108 (4.1 ± 2.0)
	No collar no PhT	151 (5.3 ± 1.7)	–	102 (4.6 ± 2.0)	100 (4.6 ± 2.0)
Pooled analysis					
Mean ± SE	Collar	408 (5.14 ± 0.69)	111 (4.99 ± 0.14)	365 (2.92 ± 0.37)	268 (2.90 ± 0.75)
	No collar (total)	649 (4.89 ± 0.54)	123 (3.59 ± 0.75)	498 (2.57 ± 0.49)	362 (2.96 ± 0.70)
p-value		< 0.001	< 0.001	< 0.001	0.3026
Mean ± SE	Collar	408 (5.14 ± 0.69)	111 (4.99 ± 0.14)	365 (2.92 ± 0.37)	268 (2.90 ± 0.75)
	No collar with PhT	247 (5.27 ± 0.32)	123 (3.59 ± 0.75)	226 (2.17 ± 0.71)	180 (2.30 ± 1.79)
p-value		0.0055	< 0.001	< 0.001	< 0.001

Visual analogue scale (VAS); standard deviation (SD); patients (pts); time (*t*); physical therapy (PhT)

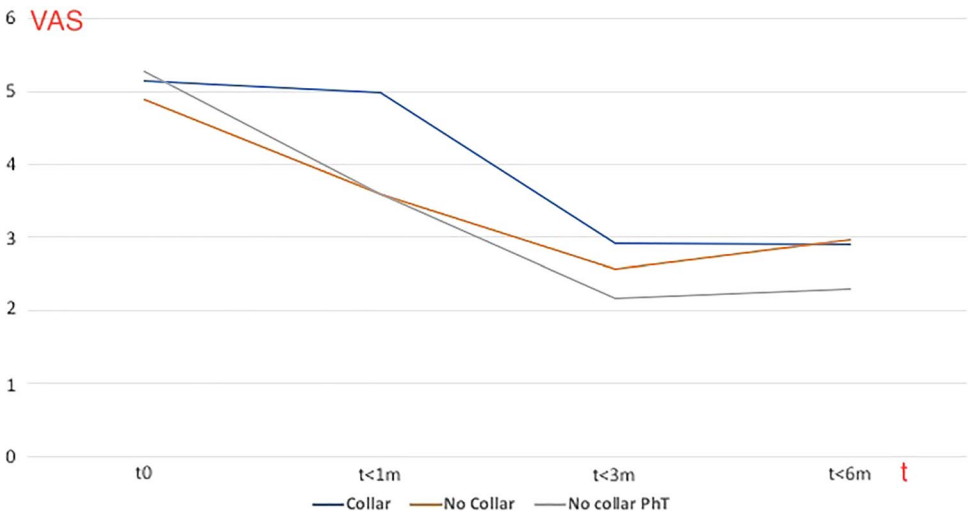

Fig. 2 Trend curve of the mean VAS values in patients subgroups stratified by treatment

Table 3 Comparison of range of motion improvement at the different follow-up periods between patients who used and who not used collar, and pooled estimation of their mean ± standard error

Author and year	Collar use	RoM *t*0 No. of pts (mean ± SD)	RoM *t* = 2w–2m No. of pts (mean ± SD)	RoM *t* = 2m–6m No. of pts (mean ± SD)
McKinney et al. [17, 18]	Collar	33 (44.4 ± 14.7)	33 (41.8 ± 18.9)	33 (55.1 ± 14.8)
	No collar with PhT	71 (45.6 ± 18.5)	71 (53.3 ± 20.3)	71 (64.0 ± 12.9)
	No collar no PhT	66 (47.3 ± 20.7)	66 (54.1 ± 19.7)	66 (64.1 ± 12.7)
Mealy et al. [23]	Collar	30 (25.0 ± 2.17)	30 (27.56 ± 2.09)	30 (29.57 ± 1.61)
	No collar with PhT	31 (19.92 ± 1.74)	31 (29.03 ± 2.12)	31 (34.11 ± 1.5)
	No collar no PhT	–	–	–
Pooled analysis				
Mean ± SE (random effect)	Collar	63 (34.53 ± 9.69)	63 (34.3 ± 7.11)	63 (42.2 ± 12.76)
	No collar (total)	168 (37.51 ± 10.75)	168 (45.37 ± 10.02)	168 (54.03 ± 12.13)
p-value		0.0554	< 0.001	< 0.001
Mean ± SE (random effect)	Collar	63 (34.53 ± 9.69)	63 (34.3 ± 7.11)	63 (42.2 ± 12.76)
	No collar with PhT	102 (32.66 ± 12.84)	102 (41.04 ± 12.13)	102 (49.01 ± 14.94)
p-value		0.3218	< 0.001	0.0015

Range of motion (RoM); patients (pts); standard deviation (SD); time (*t*); physical therapy (PhT)

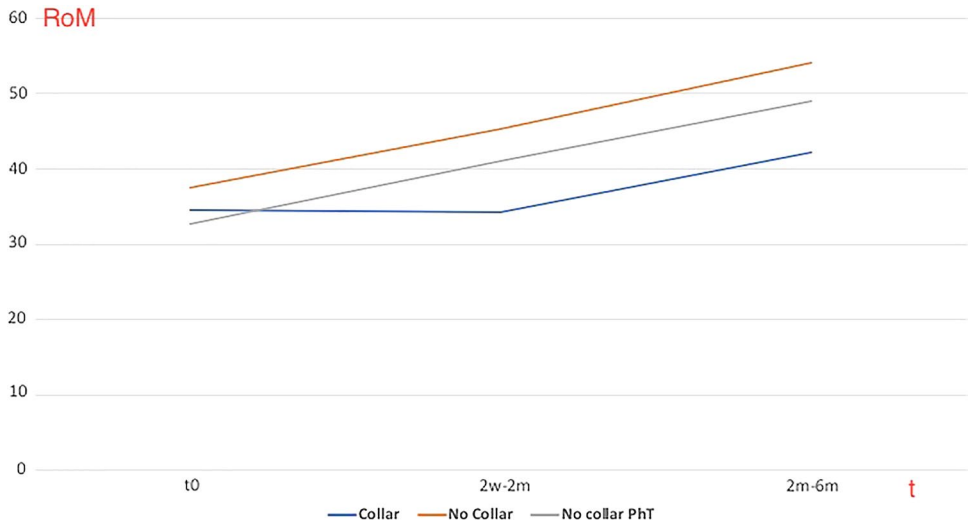

Fig. 3 Trend curve of the mean RoM values in patients subgroups stratified by treatment

distinguished the outcome of the patients who underwent PhT from that of the patients who did not.

In the pooled analysis, we observed a difference in the mean VAS between the collar and non-collar groups already at the time of diagnosis ($t = 0$), but it should be considered as an incidental finding in consideration of the randomized design of the included trials.

We also observed a persistent significant difference in the VAS mean values between collar and non-collar groups at $t < 1$ m and $t < 3$ m follow-ups, showing that the VAS score was not positively influenced by the immobilization with nRCC over time. However, this difference appeared no more significant at longer follow-up ($t \leq 6$ m).

On the other hand, when comparing, in a subgroup analysis, the patients assigned to the collar group with those who underwent PhT, the difference in VAS score still appeared significant at $t \leq 6$ m showing a further clinical improvement for medium–long-term follow-up, according to the results by Wiangkham et al [25].

Hence, the visual analysis of the VAS trend over time showed that the recovery was faster for patients who were not immobilized, regardless of the association of PhT, whose benefit appeared evident only in the long-term follow-up [25].

Similarly, the RoM trend appeared more rapidly ameliorative in the group of patients who did not underwent

immobilization at every follow-up, regardless of the association of PhT.

Thus, our data do not support a favorable role of the nRCC in improving the clinical outcome after a WI, if compared with an act-as-usual management and in particular when associated with PhT.

Some previous studies investigated the best medical treatment for whiplash-associated disorders [25–27]. In a recent comprehensive review on this topic, Teasell et al. had already observed that active mobilization was considered by most of the authors as the preferable treatment [13].

Besides to confirm the superiority of PhT in acute WI management, our results suggest that wherever active mobilization protocols (PhT) are not pursuable for either patients or society-related conditions, best treatment remains the act-as-usual management, discouraging the use of a nRCC.

Limitations

The first limitation of this study is the small number of RCTs that specifically focused on the comparison between the nRCC use and the non-immobilization management after WI. Secondly, the durations of the follow-ups were slightly different among the RCTs and a pooling was possible by collecting data within interval ranges. According to this difference in the studies' design, not every RCT contributed to the pooled outcome at the different follow-ups. Also, nRCC group had significantly higher VAS at *t*0. Lastly, data extraction on drugs administration and their differences among treatments groups during follow-up was not possible, and this represents an additional selection bias.

Conclusions

This systematic review and pooled analysis confirm that there is no evidence supporting the role of the nRCC in improving outcomes of patients suffering from WI. Compared with the patients who underwent no immobilization, nRCC could represent a pejorative factor for VAS and RoM trends within 6-month follow-up.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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