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Does cervical range of motion affect the outcomes of canalith repositioning procedures for posterior canal benign positional paroxysmal vertigo?

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ABSTRACT

Purpose: Canalith repositioning procedure (CRP) for posterior canal benign positional paroxysmal vertigo (BPPV), also known as Epley maneuver, is a common procedure for the treatment of BPPV. This maneuver entails flexion, extension and rotation of the patient's neck. This study aims to investigate the impact of cervical range of motion (C-ROM) on CRP efficacy.

Materials and methods: The study included 47 patients with posterior canal BPPV treated by CRP. The procedure was considered successful if vertigo and nystagmus disappeared at the post-treatment evaluation. If CRP resulted ineffective, it was repeated up to three times per session. C-ROM was measured at BPPV diagnosis before treatment. Patients were followed up for 30 days.

Results: The first CRP was successful in 29 patients (61.7%), while it was ineffective in 18 patients (38.3%) requiring multiple repositioning maneuvers. Patients who needed two or more CRP showed lower C-ROM in extension (p = .003) and flexion (p = .042), and earlier recurrences (p = .006). Univariate regression analysis showed that lower cervical extension was significantly associated with the failure of the first CRP (OR: 0.899, 95% CI 0.831–0.973, p = .008).

Conclusions: Our data suggest that a reduced C-ROM can require multiple CRPs to successfully treat BPPV and increase the risk of early recurrences.

1. Introduction

Benign paroxysmal positional vertigo (BPPV) is the most frequent vestibular disorder. BPPV is characterized by repeated episodes of vertigo triggered by changes in head position; the most accredited pathophysiology is the displacement of otoconial matter from the utricle to semicircular canals. The presence of otoconial debris modifies the endolymph flow and the responses of cupolas during head movements, determining vertigo and nystagmus. The posterior semicircular canal is interested in most cases [1–3].

Therapeutic maneuvers are highly effective for the treatment of BPPV [4,5]. The maneuver proposed by Epley, also called canalith repositioning procedure (CRP), is commonly used as first-line treatment for BPPV of the posterior canal (PC-BPPV) [1,4,5]. The proper execution of this maneuver involves flexion, extension and rotation of the patient's neck [1,6].

The normal range of motion of the cervical spine, also known as cervical range of motion (C-ROM), can be simply assessed by dividing it in six movements: flexion, extension, lateral flexion on both sides and rotation to both sides.

In the light of the above, it is conceivable that a reduced C-ROM could hinder the proper execution of the repositioning procedures or even cause their failure [7].

Despite the extensive ~~body of~~ literature on the various aspects of BPPV, this disease does not cease to be the focus of attention of physicians. However, there is little knowledge about the causative factors of treatment failure and recurrences as well as about the physiopathology of residual symptoms that sometimes arise after the disappearance of typical vertigo and nystagmus, defining a syndrome also known as residual dizziness (RD) [8,9].

This prospective study aims at investigating the role of C-ROM on CRP effectiveness, evaluating its possible role in early recurrences and

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Table 1
Demographic data.

Data		Total
Mean age (± SD)		62.06 ± 13.09
Gender	M	20 (42.6%)
	F	27 (57.4%)
Side	Left	15 (31.9%)
	Right	32 (68.1%)
Duration of symptoms	1–7 days	14 (29.78%)
	> 8 days	33 (70.21%)
		47 (100%)

in the RD appearance.

2. Methods

Forty-seven consecutive patients (20 males and 27 females, mean age: 62.06 ± 13.09 years, range 32–81 years) affected by PC-BPPV were enrolled in this prospective trial from January 2018 to April 2018. Demographic data are summarized in Table 1.

The study was conducted according to the principles of the Declaration of Helsinki.

Patients with the involvement of multiple semicircular canals or with clinical history of previous vestibular disorders other than BPPV were excluded from the study, as well as patients unable to understand Italian language and those who did not undergo the follow-up visits as planned.

Study design is summarized in Fig. 1. All patients underwent a bedside neurotologic evaluation, including ocular alignment, gaze-evoked nystagmus, saccades and smooth pursuit. Spontaneous nystagmus with and without fixation was checked using infrared Video-Frenzel goggles. Then, patients underwent diagnostic positioning tests for BPPV assessment, also using Video-Frenzel. C-ROM was evaluated before performing diagnostic positional tests in all patients in which PC-BPPV was suspected.

If diagnosis of PC-BPPV was confirmed by positional tests, patients were immediately treated with CRP. About 5 min after the treatment, diagnostic positioning tests were repeated. In case of absence of positional vertigo and undetectable positional nystagmus, the CRP was defined as "successful". Conversely, the first CRP was defined as "ineffective" and repeated up to 3 times, checking the result of the treatment after every maneuver. In the absence of therapeutic success, patients were re-evaluated after 3 days with the same protocol. A maximum of two sessions per patient were carried out. If more than two sessions were required or if canal switch occurred, patients were excluded from the study.

Patients were divided into two groups based on the number of CRPs performed: subjects successfully treated with a single CRP (group A) and patients treated with multiple CRPs (group B).

Once achieved a successful CRP, patients of both groups were asked to return for a follow-up visit 7 and 30 days after the initial diagnosis. At both time points, the Dix-Hallpike test was performed; if it was positive for a PC-BPPV in the same side, the case was defined as "early recurrence", while if BPPV affected other semicircular canals it was defined as "canal switch". If vertigo occurred anytime between the 7 and 30-day follow-up, patients were instructed to immediately return to our hospital.

During the 7-day follow-up visit, the presence of RD was investigated and the Italian version of the Neck Disability Index (NDI) questionnaire was administered to all patients. RD was defined as feeling of unsteadiness and/or light-headedness and/or dizziness in the absence of true vertigo and nystagmus, was also investigated.

2.1. Diagnosis and treatment of PC-BPPV

According to the Classification of Vestibular Disorders of the Bárány Society, PC-BPPV was diagnosed if Dix-Hallpike test evoked the typical paroxysmal nystagmus (upbeating and torsional with the upper pole of the eyes beating toward the ear in a lower position, lasting < 1 min) [10].

In all cases, PC-BPPV was treated with CRP according to Epley [6]. The patient was placed in the upright position with the head turned about 45° toward the ear that was positive at the Dix-Hallpike test. Then, the patient was rapidly laid back to the supine head-hanging position, with head held approximately in a 30° neck extension. If this extension was not feasible, the neck was brought to reach the greatest extension obtainable without eliciting pain. This position was maintained for about 30 s. Next, the head was turned about 90° toward the unaffected side and held for about 30 s. Following this rotation, the patient's head was again turned reaching the facedown position while the patient's body moved from the supine position to the lateral decubitus position. After 30 s, the patient was brought into the upright sitting position, completing the maneuver.

2.2. C-ROM measurements

C-ROM was assessed using a plastic universal goniometer according to a previously described method [7].

Patients were sited, with thoracic and lumbar spine well supported by the back of the chair.

For flexion and extension measurements, the axis of the goniometer was centered over the external acoustic meatus and the fixed arm was held vertical, while the movable arm was aligned with the base of the nares.

Lateral rotation was measured with the examiner standing behind and looking down at the top of the subject head. The goniometer's axis was centered on the vertex of the participant's head, the fixed arm aligned parallel to an imaginary line between the participant's acromion processes, and the movable arm aligned with tip of the patient's nose.

Lateral flexion was measured with the examiner in front of the subject, the axis of the goniometer positioned over the center of the participant's sternal notch, the fixed arm aligned parallel to an imaginary line between the participant's acromion process, and the movable arm aligned with the tip of the subject's nose.

2.3. NDI questionnaire

The NDI is a self-administered, condition-specific functional status questionnaire with 10 items including pain, personal care, lifting, reading, headaches, concentration, work, driving, sleeping and recreation. Each section is scored on a 0 to 5 rating scale, in which zero means "no pain" and five means "worst imaginable pain". The points are summed to a total score with a maximum of 50 [11]. An Italian-validated version of NDI was used in this study [12].

2.4. Statistical analysis

Continuously distributed variables were described by median, mean and SD; categorical variables were described by frequencies and percentages. Quantitative variables were checked for normal distribution and compared via Student's *t*-test or Mann-Whitney *U* test, while Pearson x2 test was used for qualitative variables.

To highlight predictors of the need to perform multiple CRPs, Spearman's ρ coefficients were first calculated, which were subsequently quantified via univariate logistic regression analysis. The α level was set at 0.05.

Statistical analyses were performed using the statistical package for social sciences statistical software (version 22.0, IBM SPSS Statistics for

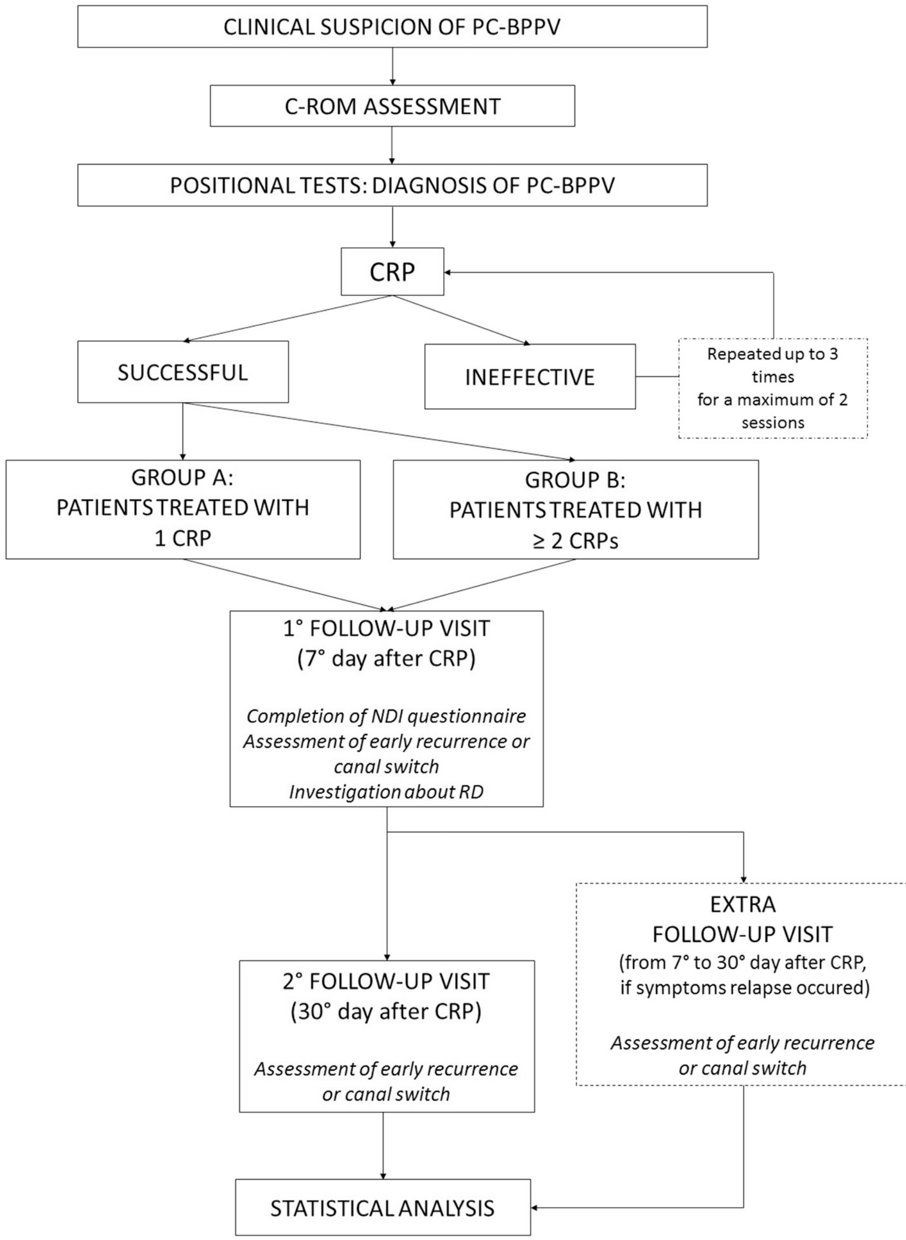

Fig. 1. Study design. PC-BPPV, posterior canal BPPV; C-ROM, cervical range of motion; CRP, canalith repositioning procedure; NDI, Neck Disability Index; RD, residual dizziness.

Windows, Armonk, NY: IBM Corp).

3. Results

All patients who initially met the inclusion criteria were enrolled in the study. In all patients, therapeutic success was achieved by performing from a minimum of one to a maximum of four CRPs. Group A included 29 patients (61.7%) for whom the first CRP was successful; group B included 18 patients (38.3%) for whom the first maneuver failed. In group B, multiple CRPs were performed: five (10.63%) subjects required 2 CRPs, 12 (25.53%) required 3 CRPs and one patient (2.12%) required 4 CRPs. In this case, CRPs were administered in two different sessions.

There were no significant differences between group A and group B for age ($p = .991$), according to sex ($p = .61$), side of involved canal ($p > .99$) and duration of BPPV before diagnosis ($p = .19$).

Thirteen subjects experienced RD (27.65%). Considering the occurrence of RD, no differences were recorded between the two groups ($p = .307$).

Five cases of early recurrences were recorded: three were diagnosed during the first follow-up visit, while the others after 10 and 13 days from diagnosis, respectively. All early recurrences occurred in group B (27.7%) ($p = .006$). Canal switches were not observed in this study. Comparison between qualitative variables is summarized in Table 2.

We observed significant differences in C-ROM measurement between the two groups. Mean cervical extension was 35.03° ± 12.63° in group A and 25.16° ± 4.46° in group B. Difference was statistically significant ($p = .003$). Significant differences were also recorded for flexion: 33.93° ± 8.87° in group A and 29.55° ± 5.42° in group B ($p = .042$) (Fig. 2). No differences between the two groups were observed for lateral flexion and rotation on both sides.

The mean NDI-score was 8.36 ± 4.7 (range: 2–21); no statistically significant differences were observed between the two groups ($p = .17$). Outcomes of C-ROM and NDI are summarized in Table 3.

Univariate regression analysis showed that lower extension was significantly associated with multiple CRPs: the reduction of a degree in

Table 2
Comparison between qualitative variables.

Variables		Group A	Group B	Total	*p* value
Gender	M	11 (37.9%)	9 (50.0%)	20 (42.6%)	.610
	F	18 (62.1%)	9 (50.0%)	27 (57.4%)	
Side	Left	9 (31.0%)	6 (33.3%)	15 (31.9%)	> .99
	Right	20 (69.0%)	12 (66.7%)	32 (68.1%)	
Duration of symptoms	1–7 days	11 (23.4%)	3 (6.38%)	14 (29.78%)	.19
	> 8 days	18 (38.29%)	15 (31.91%)	33 (70.21%)	
Residual dizziness	No	23 (79.3%)	11 (61.1%)	34 (72.3%)	.307
	Yes	6 (20.7%)	7 (38.9%)	13 (27.7%)	
Early recurrence	No	29 (100.0%)	13 (72.2%)	42 (89.4%)	.006
	Yes	0 (0.0%)	5 (27.8%)	5 (10.6%)	
Total		29 100.0%	18 100.0%	47 100.0%	

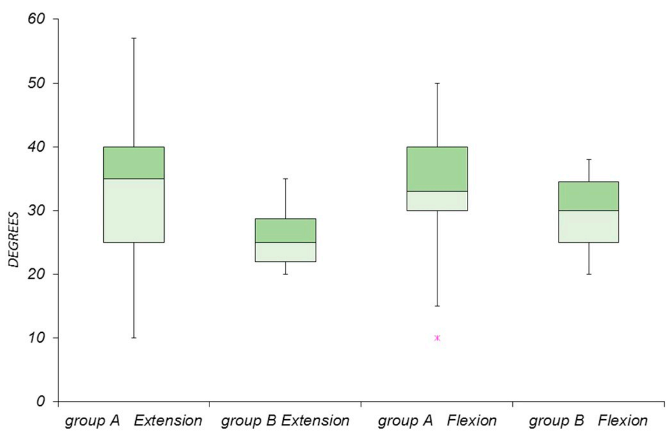

Fig. 2. C-ROM: comparison between cervical extension and flexion between the two groups.

Table 3
Comparison between quantitative variables.

Variables (mean ± SD)	Group A	Group B	*p* value
Flexion	33.93 ± 8.87	29.55 ± 5.42	.042
Extension (± SD)	35.03 ± 12.63	25.16 ± 4.46	.003
Right lateral flexion	38 ± 82.24	33.55 ± 6.23	.079
Left lateral flexion	37.44 ± 8.67	33 ± 6.62	.083
Right rotation	45.93 ± 9.57	46 ± 6.73	.611
Left rotation	47.44 ± 5.85	47.5 ± 6.36	.982
NDI-score	7.37 ± 3.67	9.94 ± 5.76	.173

cervical extension gave a 10.1% increase in odds (OR: 0.899, 95% CI 0.831–0.973, $p = .008$).

4. Discussion

This prospective study demonstrated a relationship between C-ROM and both the number of CRPs necessary to treat PC-BPPV and the incidence of early recurrence.

Although there are no previous studies in the literature, performing CRPs in patients presenting neck stiffness is a common challenging experience for specialists who practices neurotology.

CRP takes advantage of the inner ear anatomy: the rotation and the extension of the patient's neck allow to variate the orientation of the head in the space, moving the floating otolithic mass from the ampullary arm of the posterior canal to the utricle [6].

C-ROM is an objective and measurable index of cervical mobility. C-ROM can provide a reliable valuation of the limitations in the execution of complex movements involving both the extension and the rotation of the head, such as those carried out during CRP [13–16]. A reduced cervical mobility limits head movements thus preventing the correct orientation of the posterior semicircular canal axis; therefore, the movement of otoconial debris toward the non-ampullary arm of the canal and then toward the utricle is hindered. In the light of above, three events are more likely to occur if the patient presents reduced cervical mobility:

1) Debris could remain trapped in the canal lumen and then return to the ampullary arm, causing the failure of the maneuver. The need to perform more than one CRP to achieve recovery could be attributed to this event [17–19].
2) Part of debris could leave the canal while the rest could disperse in the endolymph and then aggregate again after some time. In this case, a transient regression of vertiginous symptoms followed by an early relapse can occur. Early relapse could be caused by the return of previously expelled debris in the canal lumen or by the re-aggregation of residual otoconial matter, or both [20].
3) The otoconial could migrate into the superior or horizontal semicircular canals, determining a canal switch [21–23].

Therapeutic failures and early recurrences can prostrate patients, frighten them and cause negative effects on their emotionality.

Devices to perform a 360° body rotation along the plane of each semicircular canals without cervical manipulations have been proposed to minimize the complications described above [24–25]. However, these instruments are expensive and currently not widespread, so manual bedside maneuvers remain the cornerstone of BPPV treatment.

There are other variables, such as the position and the mass of the otoconial matter, which could play a role in determining the need of multiple CRPs and the occurrence of early relapses. We agree with the theory that patients successfully treated by a single CRP are likely to have some high mass or aggregated particles whereas patients requiring more CRPs could have many low-mass otoliths dispersed into the utricle during the numerous maneuvers performed, therefore being more prone to recurrences [20]. Although there is no evidence about this hypothesis, it is likely that the need to perform multiple CRPs and the incidence of early recurrences could be influenced by both the cervical mobility and the features of the otolithic mass.

No correlation between NDI-scores and the need for multiple CRPs emerged from this study.

This could be explained by the fact that the NDI-score expresses pain and functional limitation experienced in the active movements of the head, but is not related to the limitation in passive movements of the neck, like those practiced during CRP. Furthermore, NDI-score is conditioned by patient's emotional state [11]. In the light of above, NDI-score is not functional to predict the need of multiple CRPs and early of relapses in patients affected by PC-BPPV.

Although the CRPs are usually very effective in improving vertigo, some patients report non-positional, persistent imbalance without positional vertigo for a certain period the treatment.

Many theories were proposed to explain RD, such as the persistence of debris in the canal lumen [26], the presence of utricular dysfunction [27] or an incomplete central adaptation. A significant association of RD with older age and anxiety was recently demonstrated [7]. It is likely that different causal factors can play a role in the genesis of RD, acting singularly or synergistically. We hypothesized that a reduced C-ROM could be linked with disturbances in cervical proprioception, which is believed to affect the perception of spatial orientation [28,29].

In our study, no correlation between RD, the number of CRPs performed and C-ROM results. However, our series was limited, and we did not have available clinical tests to quantify the impact of cervical proprioception on balance. Therefore, the cervicogenic contribute to the pathophysiology of RD remain debatable.

5. Conclusions

A reduced C-ROM may represent an obstacle to the correct execution of CRP and is a risk factor for treatment failure and early recurrence of BPPV. Although measuring CROM in patients with PC-BPPV is a time-consuming procedure, our data suggest that physicians who find difficulties in obtaining a proper extension of the patient's neck during CRP should inform the patient about the possibility to perform multiple repositioning maneuvers and about the increased risk of recurrence.

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Declarations of interest

None.

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