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VESTIBOLOGY

Canal switch: a possible complication of physical therapeutic manoeuvers for posterior canal benign paroxysmal positional vertigo

Lo switch canalare: possibile complicanza della terapia liberatoria per la VPPB del canale posteriore

Leonardo Scotto di Santillo[1], Luigi Califano[2]

[1] ASL 3 Genovese, S.S. Vestibology and Vestibular Rehabilitation, Genoa, Italy; [2] San Pio Hospital, Department of Audiology and Phoniatrics, Benevento, Italy

SUMMARY

Objective. To study the frequency of canal switch in posterior canal benign paroxysmal positional vertigo (BPPV) treated by canalith repositioning manoeuver (CRP), quick liberatory rotation manoeuver (QLR) or Semont manoeuver (SM).

Methods. Retrospective study on 1158 patients, 637 women and 521 men suffering from geotropic posterior canal BPPV treated by CRP, QLR, or SM, retested after 15 minutes and about seven days.

Results. 1146 patients recovered from the acute phase; treatments failed in 12 patients treated with CRP. We observed 12 canal switches from posterior to lateral canal and 2 from posterior to anterior canal during or after CRP in 13/879 cases (1.5%) and after QLR in 1/158 (0.6%) with no significant difference between CRP *vs* SM and QLR. We did not consider slight positional downbeat nystagmus after the therapeutic manoeuvers as a sign of canal switch into the anterior canal, but as a sign of persistent small debris in the non-ampullar arm of the posterior canal.

Conclusions. Canal switch is rare for any manoeuver and it does not belong to the criteria to choose one manoeuver over another. Notably, due to the canal switching criteria, SM and QLR cannot be preferred over those with a more prolonged extension of the neck.

KEY WORDS: posterior canal BPPV, canalolithiasis, repositioning manoeuver, liberatory manoeuver

RIASSUNTO

Obiettivo. *Studiare la frequenza del fenomeno dello switch canalare come complicanza delle manovre terapeutiche in fase acuta della BPPV da canalolitiasi posteriore geotropa.*

Metodi. *Studio retrospettivo includente 1158 pazienti, 637 donne e 521 uomini affetti da BPPV da canalolitiasi posteriore in fase acuta trattati in sedi diverse con manovra di riposizionamento (CRP) (879 pazienti), Manovra di Rotazione Rapida Liberatoria (QLR) (158 pazienti) o manovra di Semont (SM) (121 pazienti). Il retest è stato effettuato 15 minuti e circa 7 giorni dopo l'esecuzione della manovra terapeutica.*

Risultati. *1146 pazienti sono guariti dalla fase acuta, 12 pazienti hanno presentato persistenza dei segni e sintomi dopo l'intera procedura terapeutica. Il canal switch è stato osservato in 12 casi dal canale posteriore al canale laterale, in 2 casi dal canale posteriore al canale anteriore, durante o dopo CRP in 13/879 casi (1,5%), dopo QLR in 1/1508 casi (0,6%).*

Conclusioni. *Il rischio di switch canalare appare molto basso per tutte le manovre utilizzate, tanto da non poter essere incluso tra i criteri di scelta di una manovra rispetto ad un'altra. In particolare, il basso rischio non fa preferire la SM o la QLR rispetto a quelle con maggiore e più prolungata estensione del collo.*

PAROLE CHIAVE: *VPPB, canalolitiasi posteriore, manovre di riposizionamento, manovre liberatorie*

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Correspondence
Leonardo Scotto di Santillo
ASL 3 Genovese, S.S. Vestibology and Vestibular Rehabilitation, via L.A. Vassallo 3/24, 16146 Genoa, Italy
E-mail: lescott@tin.it

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Introduction

Benign paroxysmal positional vertigo (BPPV) [1] is the most frequent balance disorder in all neuro-otological series. During the acute phase, its typical symptoms are brief episodes of recurrent vertigo occurring when the head changes position in the critical plane.

BPPV is thought to be due to either canalithiasis (free-floating otoconia in the semicircular canals) or cupulolithiasis (otoconia adherent to the ampullar cupula). Posterior canal BPPV is most common (about 75-85%) and lateral canal BPPV is less frequent (about 20%); anterior canal BPPV is much less frequent (1-2%) because of the highest anatomic position of the canal. The disease can recover spontaneously within a few days/weeks, otherwise the patient must be treated by a physical manoeuver. Drugs, except for antiemetics when needed, are not considered relevant in clinical management. During any therapeutic procedure, head movements and the affected canal must be coplanar to each other for an optimal effect. The Canalith Repositioning Procedure (CRP) [2] is a safe and effective treatment for patients with posterior canal BPPV. With some minor changes over the years [3], it is a four-step process. The patient is quickly pushed back from the sitting position to the Dix-Hallpike (DH) position on the affected side; the patient's head is turned to the contralateral DH position slowly and continuously, and then rotated with the nose 45° downward. About two minutes afterward, the patient returns seated, with the head slightly bent forward. During the manoeuver, otoconia are "guided" back to the utricle, leaving the affected canal. Mastoid vibration, performed in the original Epley's manoeuver, is currently used only in some therapy-resistant cases. Infrared video goggles allow observing nystagmus during the entire manoeuver and not just in its final positions (nose-down and sitting). Nystagmus maintaining the same direction during all the steps of the manoeuver is considered a good prognostic indicator ("liberating" or "loading" nystagmus); on the contrary, reversed nystagmus indicates an ampullopetal movement of the otoconia, which means failure of the procedure. For its favourable properties, CRP is widely applied in daily clinical practice [5]. The quick liberatory rotation manoeuver (QLR), described by Califano in 2003 [6], is a variant of CRP. It differs from CRP because the patient is translated from the side of the positive DH to the contralateral 45° nose-down position in about one second.

In the Semont manoeuver (SM) [7] the patient rapidly moves in the frontal plane, starting from the diagnostic position (45° nose-up on the affected side) and reaching the contralateral side with the nose 45°down in about one second. After 2-3 minutes, the patient sits back-up.

In all manoeuvers, "liberating nystagmus", either in the nose-down position or seated, is regarded as a favourable prognostic index [2,6,8].

A canal switch occurs when otoliths, during or after the therapeutic manoeuver, instead of moving into the utricle, migrate into another semicircular canal, or if they re-enter from the utricle into a canal other than the one affected previously.

Posterior canal-anterior canal, posterior canal-lateral canal, and lateral canal-posterior canal switches have been described [9-11], as well as the switch from the geotropic form of the posterior canal BPPV to the apogeotropic form of the same canal [12].

Two experienced operators carried out this retrospective study using similar operative procedures in two different hospitals, intending to assess the incidence of canal switch in a large series of geotropic posterior canal BPPV treated with CRP, QLR, or SM.

Patients and methods

1158 patients, 637 women (55.1%) and 521 men (44.9%), suffering from geotropic posterior canal BPPV were enrolled in the study from January 2019 to December 2020, either at the S.S. Vestibology and Vestibular Rehabilitation ASL 3 Genovese or the SSD of Audiology and Phoniatrics of the A.O.R.N. San Pio, Benevento, both in Italy. Using infrared video goggles, in the sitting position we searched for spontaneous nystagmus, gaze-evoked nystagmus and Bowing-leaning nystagmus; in the supine position, we searched for positioning nystagmus from lateral canal BPPV through the Pagnini-McClure supine head roll test, and positioning nystagmus from posterior canal BPPV through the Dix-Hallpike test (DH-T). Diagnosis of posterior canal BPPV rested on recognition of its typical paroxysmal upbeat and torsional geotropic nystagmus, with a latency of up to 30 seconds – usually less than 10 seconds – and lasting less than one minute, according to the Diagnostic Criteria of the Barany Society [1].

Immediately after diagnosis, we carried out a therapeutic manoeuver. In the case of neck problems, such as osteoporosis, hernia, stiffness, or recent trauma, we preferred SM that least engages the neck in its execution; otherwise, we performed either CRP without premedication and mastoid vibration or QLR. During treatment, we searched for the appearance of the "liberating" nystagmus as a sign of the ampullofugal shift of otoconia, congruous with the excitation of the affected posterior semicircular canal. It has a favourable prognostic relevance. We re-tested all patients after 15 minutes and about seven days after the manoeuver. Negative DH-T and Supine head roll test were consid-

ered the recovery indicators of the acute phase. After three unsuccessful manoeuvers, we used a different procedure: SM if we previously used either CRP or QLR; CRP or QLR if we had used SM. If two more manoeuvers did not solve the acute phase, the patient performed the Brandt-Daroff home protocol, a brain MRI was scheduled, and treatment was classified as "failure".

Because head hyperextension is maintained for a longer time in CRP, whereas it is limited to the diagnostic phase both in SM and QLR, we compared the frequency of the canal switch in two groups: CRP *vs* QLR and SM.

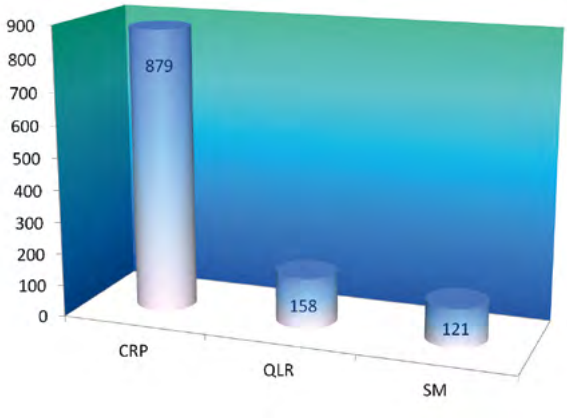
Statistical analysis was performed with Graph Pad Software using Fisher's exact test to evaluate differences in determining canal switch between CRP vs. QLR and SM.

Results

Mean age of the study cohort was 59.3 years ± 12.76 (range 19-96 years), without a significant difference between genders. The right side was involved in 624 cases (53.9%), and the left in 522 (45.1%); bilateral posterior canal BPPV was observed in 12 cases (1%). We treated 879 patients primarily with CRP, 158 with QLR, and 121 with SM (Fig. 1), performing 1.7 ± 0.86 therapeutic manoeuvers per canal (range 1-5). 1146 patients recovered from the acute phase; treatments failed in 12 patients primarily treated with CRP. Posterior canal-lateral canal switches, characterised by paroxysmal nystagmus from lateral canal BPPV, were observed in 12 patients (1.03%), 11 treated with CRP and one with QLR. In 3 patients the switch occurred during the CRP while passing from the central position to the contralateral DH position; in 5 cases we detected nystagmus from ipsilateral lateral canal BPPV at DH retest; in 4 patients we observed the switch at the follow-up visit after about seven days (Fig. 2). Three patients underwent 3 manoeuvers; nine patients had been treated with either a single CRP (8 cases) or a single QLR (one case). Paroxysmal horizontal nystagmus evoked during DH-T prompted us to verify by the Pagnini-McClure supine head roll test the involvement of the ipsilateral lateral canal. In 10 patients we found geotropic horizontal nystagmus of greater intensity on the side previously affected by posterior canal BPPV; we treated these patients with Gufoni manoeuver. In 2 patients we observed the shift posterior canal-apogeotropic lateral canal, with horizontal apogeotropic nystagmus of similar intensity on both sides. Head-shaking in the supine position converted them in the geotropic form, which was successfully treated with the Gufoni manoeuver. At the immediate retest, we observed two posterior canal-anterior canal switches in patients treated with CRP, and mild downbeat and torsional nystagmus compatible with the apogeotropic variant of the affected posterior canal BPPV in 53/1158 patients (4.6%). In this circumstance, we avoided the immediate treatment, performing it at the 7-day follow-up visit if nystagmus persisted (8/53 cases, 15.1%).

Overall, we observed 14 canal switches (1.2%): 13 during or after CRP (1.5%), one after QLR (0.6%), and none after SM. (Fig. 3).

The statistical analysis was influenced both by the few observed canal switches and the asymmetry of the groups; it did not show significant differences between the group treated with CRP vs. the group treated with either QLR or SM (p = 0.21).



CRP: Canalith Repositioning Procedure; QLR: Quick Liberatory Rotation Manoeuver; SM: Semont Manoeuver.

Figure 1. Therapeutic manoeuvers primarily performed in our series.

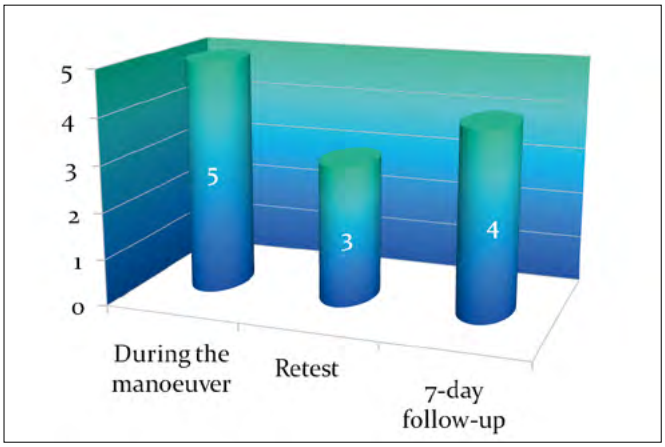


Figure 2. Timing of posterior-lateral canal switches.

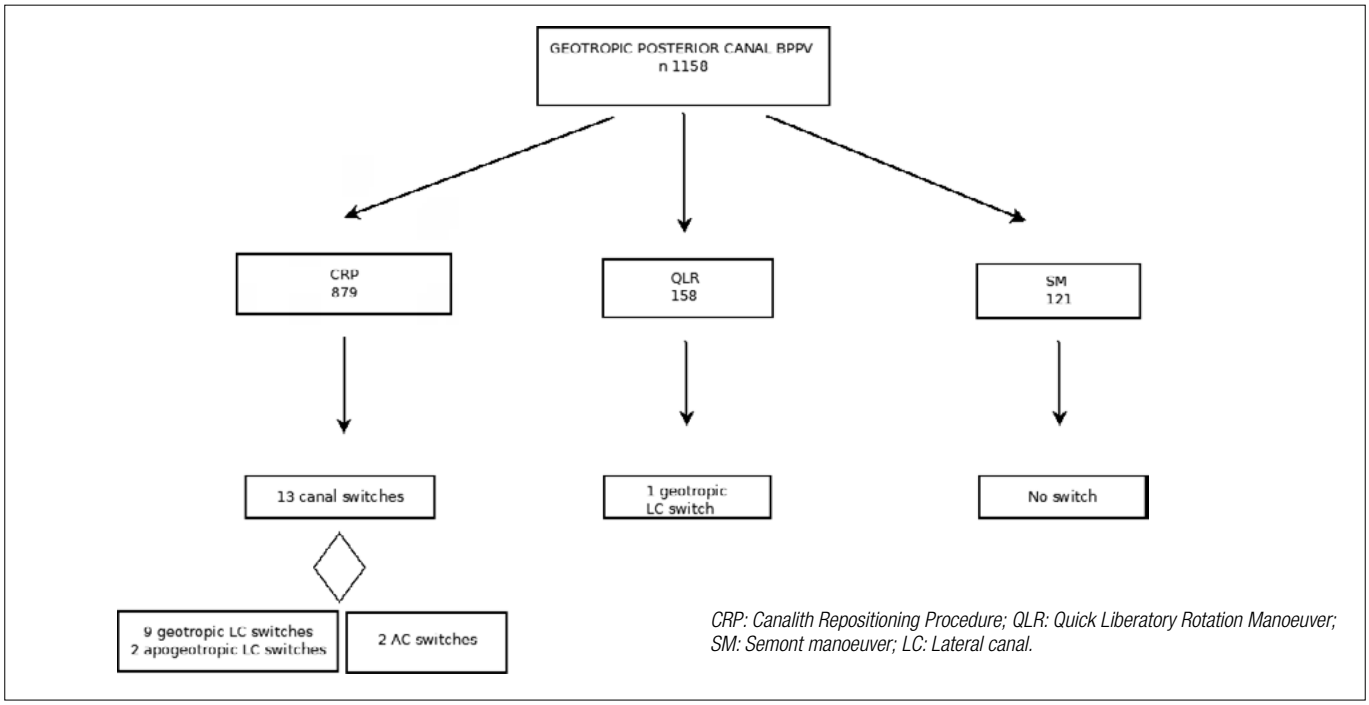


Figure 3. Posterior-lateral canal switch occurrence related to therapeutic manoeuvers.

Discussion

Canal switch is a rare complication of therapeutic manoeuvers for posterior canal BPPV, already described by many authors. Otoconia can move from the posterior canal into either the lateral or the anterior canal during, immediately after a liberating manoeuver, or a few days later.

Herdman et al. [13] described the switch from the posterior canal to the anterior canal in 2/85 cases treated with CRP (2.4%) and the switch from the posterior canal to the lateral canal in 3/85 cases observed three days after CRP had been performed (3.5%). The authors hypothesised that the entry into the lateral canal may occur in the supine position when the patient turns toward the affected side. They did not exclude that the switch may occur during the manoeuver, but the hypothesis was not supported by an immediate retest. In our CRP series, we found the posterior-lateral switch in a much lower percentage (3/879: 0.34%). For Herdman et al., the posterior-anterior canal switch would occur because of the direct passage of otoconia through the common crus. A personal interpretation that also applies to the subsequent literature: downbeat nystagmus, considered the sign of the posterior-anterior canal switch, was actually caused by either the canal re-entry or the persistence of small otoconial debris in the non-ampullar arm of the posterior canal because of the similar downbeat positional nystagmus evoked either in the anterior canal or the apogeotropic posterior canal BPPV. An alternative hypothesis is the displacement of otoconia above the utricular side of the cupula to a position that could provoke downbeat nystagmus [14]. In a randomised trial, Yimtae et al. [15] reported the immediate shift posterior canal-lateral canal BPPV in 2/29 cases (6.9%) treated through CRP. The authors used up to five repetitions, preceded by the immediate retest through the DH-T. They did not specify the time between each CRP and the retest that could be a critical factor in the canal switches. Stenerson et al. [16] observed no canal switch in 607 cases of posterior canal BPPV treated through CRP, performing up to 4 manoeuvers for each patient. The delay between CRP and the retest was not indicated. White et al. [17] reported 15 posterior-lateral canal switches, not specified if geotropic or apogeotropic, in 242 patients treated with CRP (6.2%). In 44 patients treated with CRP, Foster et al. [18] found 4 posterior-lateral canal switches (geotropic form) (9.1%); in another 4 cases (9.1%), they observed downbeat nystagmus, interpreted as due either to canal re-entry or otoconia persistence in the non-ampullar arm of the affected posterior canal. The authors stated that the immediate reassessment through the DH-T performed less than two minutes after CRP could facilitate the canal switch; a 15-minute delay seemed sufficient to avoid it. Babic et al. [19] reported 41/162 cases (25.3%) of either canal switch or canal re-entry: 39

from the posterior canal to the lateral canal, 24 in geotropic form and 15 in apogeotropic form -lateral cupulolithiasis according to the authors' terminology, and 2 posterior canal re-entries. Switches did not occur during CRP but at the control through DH-T performed less than one minute after CRP. The authors recommended a longer delay in rechecking patients. Their observation agrees with our data: our low canal switch rate is probably also determined by the 15-minute delay between the therapeutic manoeuver and the retest. In 7/8 cases, either the switch or the canal re-entry occurred after a single successful CRP. Their hypothesis was that large otoconial debris moved easily during the manoeuver, but could more easily cause canal re-entry. Lin [20] highlighted that all canals, and not only the posterior ones, should be retested after CRP to recognise possible canal switches, since persistent symptoms would be caused by the secondary involvement of another canal in about 26% of patients. The authors considered it necessary to maintain a head extension of at least 30° below the horizontal plane during CRP. They also suggested that patients should not be retested immediately after CRP, especially if no liberating nystagmus was detected. On the contrary, when we did not observe liberating nystagmus we think that it is possible to immediately retest the patient since otoconia probably did not reach the utricle and, consequently, the risk of canal switch is almost null.

Park [21] reported posterior-anterior canal switches in 13/564 cases treated with CRP (2.3%). When the shift occurred, the successful treatment of posterior canal BPPV required more manoeuvers than the cases without canal switch (3.6 *vs* 1.6 manoeuvers), suggesting that canal switch was a negative prognostic factor.

Anagnostou [22] observed posterior-lateral canal switch in 4/51 cases treated with CRP (7.8%) and in none of 51 cases treated with SM. The prolonged position of the head in the extended position below the horizontal plane to a much greater extent in CRP than SM would facilitate the entry of otoconial debris in the lateral canal across its utricular opening, located next to the common crus exit. Switches occurred during CRP rather than at the retest, performed between 2 and 5 hours later. If so, similar rates would be found even after SM. In our series, also, no patient treated with SM presented a canal switch. Shan [23] reported 2/135 cases (1.5%) of posterior-lateral canal switch during a Computer-Controlled Repositioning Procedure. On the other hand, Dispenza et al. [12] observed weak positional downbeat nystagmus at Dix-Hallpike retest due to ipsi-canalar reentry in 12/97 cases of posterior canal BPPV (12.4%) treated either with SM or the so-called "hybrid" manoeuver, corresponding to the QLR previously described by Califano et al. [6]. The re-entry was immediate in 7 cases and delayed, i.e. observed at the follow-up visit, in 5 cases. The re-entry frequency was inversely proportional to the time of the immediate retest: no case was observed when the retest was performed at least 5 minutes after the manoeuver. Similar to what reported by White [17], whose statements were accepted by Dispenza, patients who needed only one manoeuver for resolution of the disease more frequently showed an immediate canal re-entry, whereas delayed re-entry was observed in patients who needed more than two manoeuvers and who were sign-free at the first immediate control. The authors proposed a minimum time of 15 minutes between the therapeutic manoeuver and retest. In this view, we did not consider downbeat positional nystagmus evoked at the DH-retest as an expression of canal re-entry, but rather as a sign of small otoconial debris still present in the non-ampullar arm at the end of the manoeuver. Lacking in the oldest case-series a differential diagnosis between anterior canal and apogeotropic posterior canal BPPV, we believe that in the past some of these forms could be interpreted wrongly as posterior-anterior canal switches.

Lee [24] reported 29/204 cases (2.4%) of posterior-lateral canal switch after CRP, 21 in geotropic form, 8 in apogeotropic form. The authors performed a maximum of two CRPs per session without reporting the time from CRP to the first control. Otoconia enter the common crus during the manoeuver; if the neck is extended < 45° or the head rotates > 45° in the final "nose-down" position [7] when the patient returns to the sitting position, canaliths would move from the common crus to the anterior canal.

We observed 14 canal switches in 1158 patients (1.2%): 12 from the posterior to the lateral canal, 2 from the posterior to the anterior canal; no switch after SM (121 cases), during or after CRP in 13/879 cases (1.5%), after QLR in 1/158 cases (0.6%) (Fig. 3), without significant differences between CRP group vs. SM and QLR group.

To avoid any undesirable effect, CRP should be performed with accuracy, after adequate instructions to the patient. She/he must not lift her/his head during the manoeuver; the return to the sitting position should be slow, keeping the head bent forward by 20/30° and avoiding extension movements that could compromise the success, causing either the re-entry of otoconia into the affected canal or the switch in the anterior or the lateral canal.

Another relevant key point is the delay between each manoeuver and retest through DH-T. We agree that a 15-minute delay is sufficient to minimise the immediate canal switch rate: in fact, we observed only 5 canal switches at the 15-minute retest, all during or after CRP. The delayed canal switches, posterior-lateral canal or posterior-anterior canal, could be caused by "casual" positions assumed by patients during the lying-down position in the

days after the treatment, and not directly attributable to the dynamics of any manoeuver.

Conclusions

The risk of canal switch is extremely low for any procedure, and as such is not among the criteria for choosing a specific manoeuver over another. In particular, the low-rate risk of canal switch for all manoeuvers does not make SM preferable to procedures with a more prolonged head extension, but SM could be the preferential manoeuver for patients with neck problems because the neck remains blocked during its execution. Some methodological rules – the extension of the neck of minimum 30° during the movement, avoiding head rotation > 45° in the final "nose-down" position, and the retest with DH-T at least after 15 minutes – can minimise the problem. At follow-up visit, it is mandatory to test each semicircular canal to exclude a canal switch, eventually treating the secondarily affected canal.

Conflict of interest statement

The authors declare no conflict of interest.

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Author contributions

Both authors contributed equally to all the phases of the article (ideation, execution, design, analysis, drafting, revision).

Ethical consideration

As a retrospective observational study, it did not require approval of Ethics Committee. This was done internally as part of our routine evaluation, so as to improve our quality of care. The research was conducted ethically, with all study procedures being performed in accordance with the requirementsof the World Medical Association's Declaration of Helsinki.

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