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ORIGINAL ARTICLE

EFFECTIVENESS OF CERVICAL DISC ARTHROPLASTY IN CERVICAL VERTIGO

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ABSTRACT

Objective: Cervical vertigo (CV) is commonly observed in cervical degenerative disc disease (CDDD) but is often overlooked. The current study aimed to investigate the efficacy of cervical disc arthroplasty (CDA) in CV for single-level CDDD.

Materials and Methods: Between 2014 and 2021, we retrospectively analyzed patients with chronic neck and arm pain due to single-level CDDD on CV. All patients with CV underwent a detailed diagnostic work-up to investigate the cause of vertigo, and patients with vertigo due to etiologies other than CDDD were excluded. CV was analyzed preoperatively and postoperatively using the CV evaluation scale (CVES); higher CVES scores reflected fewer vertigo complaints. The intensity of dizziness and neck pain was assessed using the visual analog scale (VAS).

Results: A total of 50 patients who had CDDD with CV and underwent CDA were included in the study. The mean age of the patients was 48±8 years, and 58% were female. The vertigo and neck pain VAS scores significantly decreased 3 months postoperatively (6-4.6) and at the last follow-up period (3.8-3.0) compared with preoperatively (6.8-5.6) ($p<0.001$). CVES scores showed a significant increase 3 months postoperatively (22.8) and at the last follow-up period (23.4) compared with preoperatively (16.2) ($p<0.001$). The clinical scores showed more improvement in the upper cervical region than in the lower cervical region ($p<0.001$).

Conclusion: CDDD single-level CDA is more effective in relieving cervicogenic dizziness symptoms at higher levels than at lower levels.

Keywords: Cervical vertigo, cervical disc degeneration, neck pain, cervical disc arthroplasty, cervical disc herniation

INTRODUCTION

Cervical vertigo (CV) is not classified as a standalone disease; rather, it is a symptom that may arise from various conditions with diverse underlying causes. Vertigo is defined as a hallucination of movement or disorientation in space that is thought to be caused by faulty sensory inputs (visual, vestibular, and proprioceptive) or disturbances in the central integration and modulation of this sensory information[1]. CV is defined as dizziness and imbalance associated with neck and arm pain in patients with cervical pathology.Vertigo is defined as "a non-specific sensation caused by abnormal afferent activity in the neck, altered orientation in space and impaired balance"[2]. Vertigo in adults is a common complaint in clinical practice, affecting approximately 20-30% of the general population, with 80% of these cases requiring medical intervention[3-5]. The diagnosis and treatment of vertigo can be challenging for vestibular rehabilitation specialists and spinal surgeons. CV may be a rare cause of vertigo, or it may be one of the main causes[6]. Cervical degenerative disease, also known as spondylosis, is currently acknowledged as the leading cause of CV[7]. Patients with chronic neck pain may often present with vertigo symptoms[8]. Anterior cervical surgery may reduce vertigo, neck pain, and neurological symptoms[9]. Mechanoreceptors, such as Ruffini bodies in degenerative discs, play a significant role in the pathogenesis of dizziness. Disc degeneration leads to inflammation and causes abnormal proprioceptive inputs and dizziness. The diagnosis of this condition is difficult, and conservative treatment is usually effective. With the exception of studies on percutaneous procedures, there are limited studies in the literature on surgical interventions targeting the degenerative disc for the management of CV[4,10-12]. There is no definitive diagnostic test for CV, making its definition a subject of ongoing debate. This study the relationship between cervical disc arthroplasty (CDA), which reestablishes motion at the segment after cervical microdiscectomy, and vertigo at both upper and lower cervical levels. This study did not aim to treat vertigo directly but to investigate the effectiveness of CDA on vertigo in cervical degenerative disc disease (CDDD).

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MATERIALS AND METHODS

Ethics Statements

This study protocol was approved by the Ethics Review Board (approval number: KAEK/2021/10/267, date: 14/10/2021) of the University of Health Sciences Turkey, Kanuni Sultan Süleyman Training and Research Hospital. All patients participating in the study provided informed consent. All procedures were performed following the principles outlined in the Declaration of Helsinki.

Between January 1, 2014, and October 1, 2021, patients who underwent single-level CDA for radiculopathy and CV were included in the study.

Inclusion Criteria

1) Age between 18-80 years, 2) patients with CDDD with chronic neck or arm pain and CV with a duration of ≥3 months, 3) CV that usually develops after neck movement, 4) the presence of sensory loss, 5) cervical MRI results indicate the presence of a herniated disc, and 6) failure to respond to non-surgical treatments for a minimum duration of six weeks.

Exclusion Criteria

1) Vertigo due to neurological, ophthalmological, and otolaryngological diseases; 2) cervical instability (>2 mm displacement or >10° rotation change compared to adjacent spinal segment); 3) multilevel disc protrusion or disc herniation (≥2 levels); and 4) disc height of <50%; 5) psychiatric disorders; 6) the use of anticholinergics, anti-depressants, sedatives, hypnotics, and antipsychotics; and 7) cardiac arrhythmias and arterial atherosclerosis disorders.

Preoperative Evaluation

Radiological assessments included cervical X-rays, computed tomography (CT) scans, and magnetic resonance imaging (MRI). Following consultation, patients with vertigo who had neurological, ophthalmological, or ENT (ear, nose, and throat) conditions were excluded from the study. Vestibular and auditory tests and imaging were performed when necessary, in accordance with the consultation recommendations.

Surgical Procedure

The patient was fixed in a supine position, with the head slightly extended in a supin position. The surgical field was sterilized and draped. Following the identification of the correct level using the scope, a transverse incision was made in the anterior region of the neck. The anatomical layers were passed with blunt dissection, and microdiscectomy was performed at the relevant cervical level. After microdiscectomy, a polyetheretherketone (PEEK) cervical disc prosthesis of appropriate size was placed between the vertebrae. The mobility and stability of the prosthesis were evaluated under fluoroscopy and confirmed to be in the appropriate position. The surgical field and bleeding was carefully controlled. The muscle and skin tissues were closed anatomically. Postoperatively, patients wore a neck collar during activities for a maximum of two weeks.

Clinical Results

Clinical outcomes were assessed at three time points: preoperatively (at the initial presentation), three months postoperatively, and one year postoperatively using the CV evaluation scale (CVES). The CVES, originally developed by Wang and Zhou in China in 1998, has demonstrated strong criterion validity and test-retest reliability for evaluating CV and its associated symptoms[13]. Dizziness and neck pain severity were measured using the VAS.

Statistical Analysis

Statistical analyses were conducted using SPSS 22.0 software (IBM Corp., Armonk, NY, USA). Continuous data are expressed as mean ± standard deviation, while categorical variables are shown as n (%). The Wilcoxon signed-rank test was applied to compare pre- and postoperative CVES and VAS scores. A p-value of less than 0.05 was deemed statistically significant.

RESULTS

The study included 50 patients, consisting of 27 females and 23 males, all of whom experienced neck and arm pain accompanied by vertigo. Patient ages ranged from 35 to 72 years, with a mean age of 43±8 years. The average duration of symptoms was 8±4 months, varying between 2 and 36 months. Neck pain was present in 94% of the patients, radiculopathy in 100%, sensory symptoms in the upper extremities in 92%, abnormal gait in 23%, and vertigo of varying degrees in 100%. Neurological examination revealed grade 2 weakness in the upper extremities in 76% and grade 1 weakness in 14% of the patients. Cervical disc herniation levels were C5-6 (23 patients), C6-7 (16 patients), C4-5 (8 patients), and C3-4 (three patients). All patients underwent anterior cervical microdiscectomy and a cervical PEEK prosthesis (Figure 1).

In terms of vertigo scores, the mean vertigo score of the upper cervical segments (UCS) group was 8.1±1.3, while that of the lower cervical segments (LCS) group was 6.5±0.8 in the preoperative period. This difference was statistically significant (p=0.012). At the three-month follow-up, the score of the UCS group decreased to 5.9±0.2, and the score of the LCS group decreased to 6.1±0.4. However, no significant difference was found between the groups (p=0.106). At 12 months, the score of the UCS group decreased to 3.3±0.2, and the score of the LCS group decreased to 3.9±0.2, and this difference was found to be significant (p<0.001).

When the neck pain VAS scores were analyzed, the mean score of the UCS group was 5.4±0.8, and that of the LCS group was 5.6±0.9 in the preoperative period. No significant difference was found between the groups (p=0.24). At three months, the UCS group's score decreased to 4.2±0.4, while the LCS group's score was 4.6±0.8. This difference was statistically significant (p<0.001). At a 12-month follow-up, the UCS group's score

decreased to 1.9±0.8, and the LCS group's score decreased to 2.9±0.5. This difference was statistically significant (p=0.012).
Regarding CVES scores, the mean score of the UCS group was 12.5±2.8, and that of the LCS group was 17.7±1.8 in the preoperative period. This difference was significant (p<0.001). At three months, the mean score of the UCS group was 24.3±2.1, and that of the LCS group was 22.3±3.5, a difference that was found to be significant (p<0.001). At 12 months, the CVES score of the UCS group increased to 26.1±1.6, and the score of the LCS group increased to 22.9±2.9. This difference was statistically significant (p<0.001).
The comparison of the UCS and LCS groups revealed that the UCS group showed a more significant improvement in vertigo and neck pain scores. The scores of the UCS group were significantly different from those of the down group, especially at the 12-month follow-up, thus indicating that the UCS group achieved better clinical improvement (Figure 2, Table 1).

DISCUSSION

CV is a type of vertigo originating from the cervical region; however, there is controversy over its cause[6]. There are many theories explaining the cause of vertigo in CDDD, but none of them is conclusive. Conditions include proprioceptive CV, Barré-Lièou syndrome, vertebral artery vertigo due to rotation, and CV associated with migraines. Each of these hypotheses has a different pathophysiological mechanism, diagnostic features, and optimal treatment methods. The diagnosis is based on the association of the symptoms of imbalance and vertigo with neck pain, the patient's history, physical examination findings, and vestibular function tests to exclude other vestibular disorders. Anterior fusion was performed in cases of cervical spondylosis, and a decrease in vertigo symptoms was observed in almost 80% of these patients[10]. It has been shown that anterior cervical discectomy reduces vertigo symptoms, especially in single-level upper segments[4]. In patients with CDDD who do not respond to non-surgical treatments for at least six weeks, cervical discectomy and fusion or CDA can be performed[11-14]. CV is currently described as a non-specific feeling of spatial disorientation and balance disturbance, caused by abnormal afferent signals originating from the neck[2]. Clinical research has demonstrated that individuals with cervical disc degenerative disease exhibit significant impairments in postural control[15-17]. Research has also shown that vertigo in patients with degenerative cervical radiculopathy or myelopathy can be effectively managed through anterior cervical discectomy and fusion[10, 18-20].

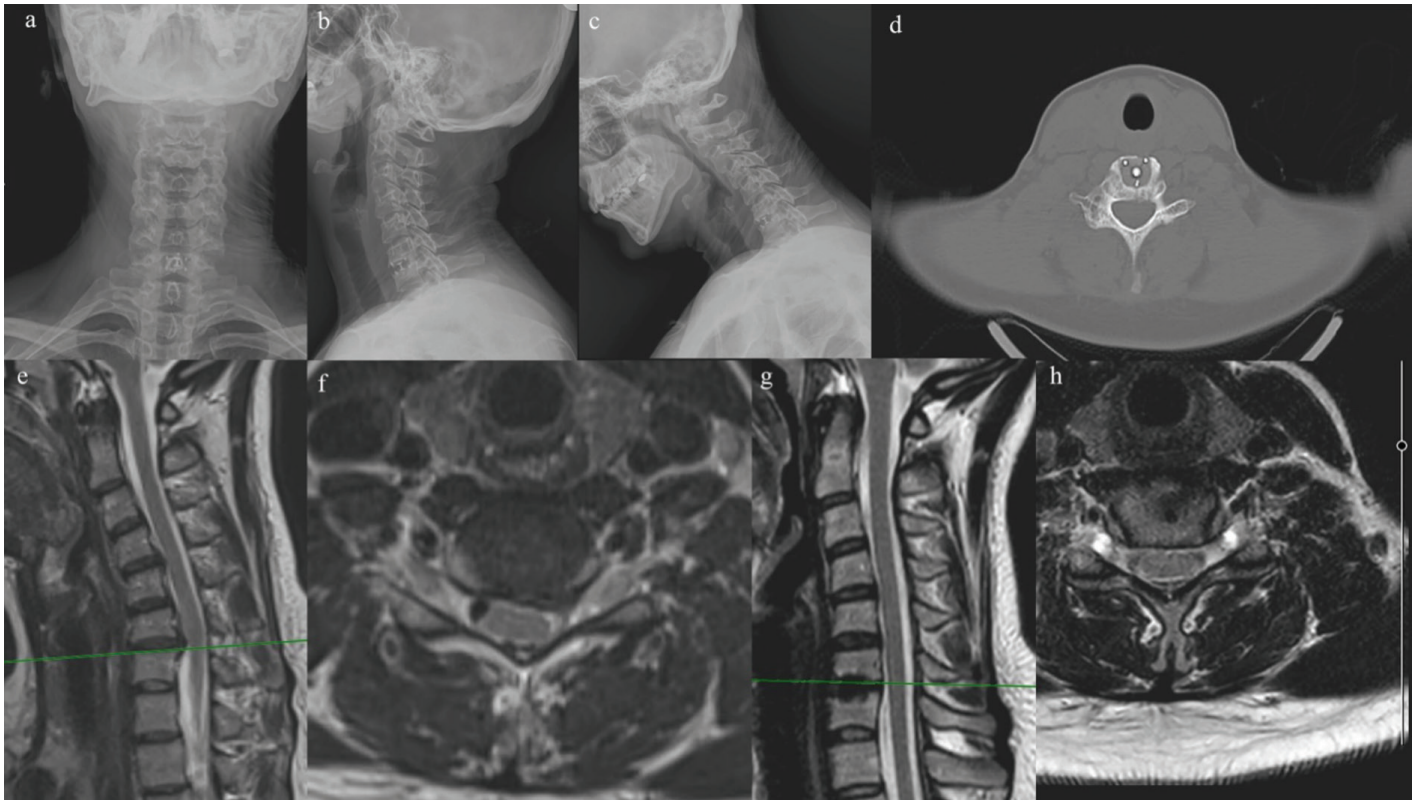

Figure 1. Radiological images of a 37-year-old female patient with left disc herniation at the C6-7 level: AP (a) flexion (b) and extension (c) positions in direct cervical radiographs. PEEK prosthesis in cervical axial plane computed tomography (d). Disc herniation at the C6-7 level causing spinal cord compression on sagittal plane MR image (e). Left paracentral disc herniation on T2 section in axial plane (f). One year later, on sagittal MR T2 sequence, hypointense changes at the C6-7 level due to PEEK prosthesis (g). Decompressed spinal cord and radix on T2 MR slice in axial plane (h).

PEEK: Polyetheretherketone, MR: Magnetic resonance

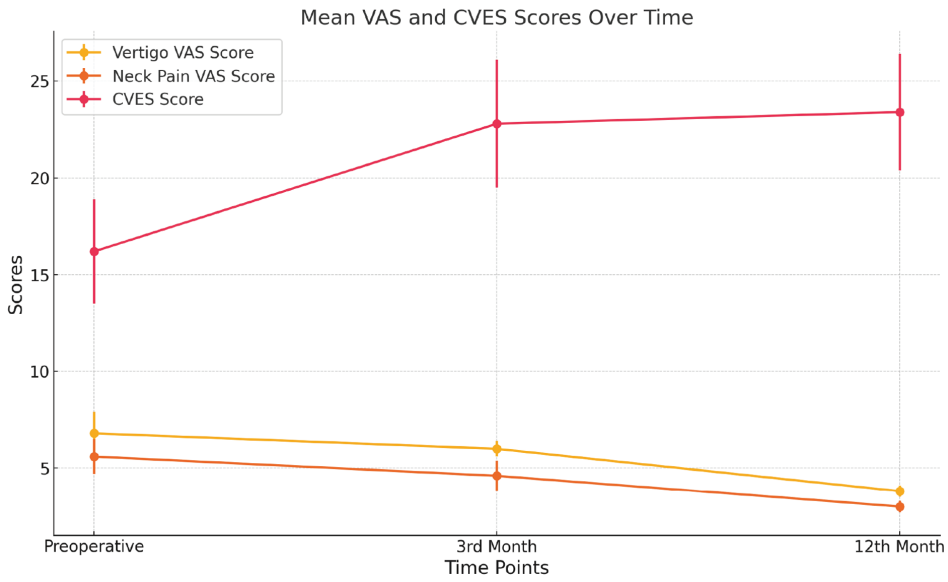

Figure 2. VAS scores for mean vertigo and neck pain and CVES at each follow-up

VAS: Visual analog scale, CVES: Cervical vertigo evaluation scale

Vertigo often signifies a discrepancy between vestibular, visual, or cervical proprioceptive inputs[17]. Abnormal proprioceptive signals from Ruffini endings in degenerated cervical discs and muscle spindles in strained neck muscles send incorrect afferent information to the brain's higher centers. This mismatch with vestibular or other sensory inputs can lead to a subjective sensation of vertigo. Immunohistochemical examinations have shown that numerous free nerve endings and Ruffini bodies grow toward degenerative cervical discs[17]. Cervical intervertebral disc herniation and cervical spine instability may lead to vertebral artery spasms by affecting the cervical sympathetic nerve, which may cause CV[21]. Managing CV is challenging due to the difficulty in pinpointing the exact source of symptoms. The neck is a complex region that can contribute to dizziness through multiple mechanisms. It contains key arteries that supply blood to the brain, ganglia that regulate autonomic nervous system functions, and structures that provide proprioceptive feedback. Consequently, cervical issues related to vascular, autonomic, and proprioceptive dysfunctions can result in dizziness, each displaying distinct signs and symptoms[7].

Table 1. Distribution of clinical scores according to cervical upper and lower cervical segments

	Upper cervical segments (C3-4-5)	Lower cervical segments (LCS) (C5-6-7)	Comparison of the groups	Mean score of the groups	Preoperative and 3rd month comparison	Preoperative and 12 months comparison	Comparison between 3rd month and 12th month
Mean VAS score of vertigo					p<0.001	p<0.001	p<0.001
Preoperative	8.1±1.3	6.5±0.8	p=0.012	6.8±1.1			
3rd month follow-up	5.9±0.2	6.1±0.4	p=0.106	6.0 ±0.4			
12th month follow-up	3.3±0.2	3.9±0.2	p<0.001	3.8±0.3			
Mean VAS score of neck pain					p=0.005	p=0.010	p=0.47
Preoperative	5.4±0.8	5.6±0.9	p=0.24	5.6±0.9			
3rd month follow-up	4.2±0.4	4.6±0.8	p<0.001	4.6±0.8			
12th month follow-up	1.9±0.8	2.9±0.5	p=0.012	3.0±0.3			
Mean CVES score					p<0.001	p<0.001	p=0.35
Preoperative	12.5±2.8	17.7±1.8	p<0.001	16.2±2.7			
3rd month follow-up	24.3±2.1	22.3±3.5	p<0.001	22.8±3.3			
12th month follow-up	26.1±1.6	22.9±2.9	p<0.001	23.4±3.0			

VAS: Visual analogue scale, CVES: Cervical vertigo evaluation scale

Previously established criteria for diagnosing CV include: 1) the presence of neck-related symptoms, 2) a history and temporal correlation between neck pain and dizziness, and 3) the exclusion of other potential causes of dizziness[22]. The sensory properties of the cervical region are vital for controlling head and eye movement and postural stability, which may lead to dizziness. This role has been confirmed in healthy asymptomatic individuals by the effects produced when artificial disturbances are applied to cervical afferents in the laboratory. CV is one of the most common clinical complaints, and misdiagnoses are uncommon. Therefore, correctly identifying vertigo and excluding other possibilities are essential.

The precise cause of CV remains controversial, and its underlying mechanism has not been fully clarified. Proposed hypotheses include rotational misalignment of the vertebral artery and CDDD, cervical stenosis, and spondylosis, the which may cause a decrease in vertebral artery flow velocity or the compression of the spinal cord and nerve roots, causing vertigo. It has been reported that changes in vertebral artery diameter are not associated with vertigo[23]. The diagnosis of CV is mostly based on the subjective symptoms of the patients and positive findings. Due to the lack of specific laboratory tests and clinical studies, diagnosis often relies on the limited clinical experience of healthcare professionals. In addition to relying on cranial CT, MRI, other imaging techniques, detailed inquiries about the cause of the disease, the time of onset, and the characteristics of the vertigo are necessary to exclude and correctly identify vertigo. The manifestation of vertigo varies and may be due to a combination of multiple causes. Therefore, each cause must be thoroughly investigated and correctly diagnosed, and the relevant treatment must be selected. Identifying vertigo is difficult. In addition to exclusion by MRI, CT, and other ancillary tests, simple exclusion methods can be used during consultations and physical examinations. Thus, clinicians can quickly and accurately assess the condition and exclude life-threatening causes.

The causes of CV can be grouped into four main categories: sympathetic dysfunction, proprioceptive vertigo, vertebral artery rotational CV, and migraine-associated CV. In rotational vertebral artery vertigo, a rare condition, decompressive surgery should be the treatment of choice when the exact site of arterial compression is determined by appropriate testing magnetic resonance angiography, CT angiography or digital subtraction angiography. It has been reported that Ruffini bodies are more abundant in diseased cervical discs than in other discs in vertigo patients, indicating that Ruffini bodies may play a significant role in the pathogenesis of vertigo of cervical origin[24]. Proprioceptive CV is the most prevalent type, highlighting the critical role of the cervical spine, along with visual and vestibular inputs, in maintaining sensorimotor control. Dysfunctional cervical proprioception can result in symptoms such as dizziness, imbalance, visual disturbances, and disrupted sensorimotor control.

Treatment strategies targeting cervical musculoskeletal and sensorimotor control have proven effective in alleviating symptoms in individuals with cervical musculoskeletal disorders[25]. We found that the severity of vertigo significantly decreased in patients who underwent microdiscectomy ($p<0.02$). However, when comparing cervical vertebral levels, a significantly greater reduction in vertigo severity was observed in patients who underwent surgery on the upper cervical vertebrae compared to those treated in the lower segments. Apart from studies of percutaneous procedures, few studies have approached surgical intervention of the degenerative disc for the treatment of CV. Anterior fusion surgery was conducted on patients diagnosed with cervical spondylosis, resulting in an improvement of vertigo symptoms in approximately 80% of the cases[10]. In patients with multilevel cervical disc degeneration, upper level disc surgery has been shown to treat vertigo better than LCS[4].

Clinicians should acknowledge the distinctive and critical role of the cervical spine in vertigo and assess its impact when patients present with neck pain, dizziness, and other symptoms indicative of altered sensorimotor control. The limitations of this study are that it was retrospective, had a small sample size, and was single-centered, comprehensive prospective and multicenter studies are necessary to confirm the results obtained.

CONCLUSION

CDA is an effective treatment for vertigo symptoms, especially in the upper cervical segment. However, the mechanisms and treatment approaches of CV are still controversial.

Ethics

Ethics Committee Approval: This study protocol was approved by the Ethics Review Board (approval number: KAEK/2021/10/267, date: 14/10/2021) of the University of Health Sciences Turkey, Kanuni Sultan Süleyman Training and Research Hospital.

Informed Consent: This study was retrospective.

Footnote

Authorship Contributions

Surgical and Medical Practices: B.O.G., S.D., Concept: B.O.G., S.D., Design: B.O.G., S.D., Data Collection or Processing: B.O.G., S.D., Analysis or Interpretation: B.O.G., S.D., Literature Search: B.O.G., S.D., Writing: B.O.G., S.D.

Conflict of Interest: The authors have no conflicts of interest to declare.

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