OPHTHALMOLOGY

Cervicogenic visual dysfunction: an understanding of its pathomechanism

Kingsley King Yi LEUNG, Eric Chun-Pu CHU[1], Wui Ling CHIN[1], Sharon Tze Kwan MOK[1], Esther Wui San CHIN[1]

New York Chiropractic and Physiotherapy Centre, EC Healthcare, 41/F Langham Place Office Tower, 8 Argyle Street, Hong Kong SAR, China

Abstract

Atypical symptoms of cervical spondylosis include headache, nausea, gastrointestinal discomfort, blurred vision, tinnitus, hypomnesia, and palpitations. Successful treatment of these atypical symptoms has been achieved after conservative non-invasive and surgical spinal treatments, although the role of these interventions in mitigating atypical symptoms of cervical spondylosis is unclear. Our study introduces and elaborates on the visual dysfunction caused by cervical spondylosis. Although there are reports in the literature that spinal manipulation and surgery can improve visual dysfunction, the correlation has remained unclear and controversial. The article reviews the latest research to identify the possible mechanisms of visual dysfunction caused by cervical spine diseases.

Keywords: ACDF, blurred vision, chiropractic, cervical spondylosis, spinal manipulation

Introduction

Atypical symptoms of cervical spondylosis include tinnitus, nausea, headache, gastrointestinal discomfort, hypomnesia, palpitations, and visual dysfunction [1]. Recent studies have shown mitigation of headache, dizziness, and gastrointestinal discomfort after cervical treatment with spinal manipulation, anterior cervical discectomy and fusion, cervical total disc replacement, or laminoplasty dependent on the patient's etiology and preference [2]. In addition, consistent recovery of visual dysfunction has been reported after spinal treatments in patients with cervical spondylosis and chronic ophthalmological pathologies [3].

By definition, visual dysfunction refers to a partial functional loss of vision that cannot be adjusted by eye surgery, medication, or optical lenses. It ranges from mild to severe and blurred vision to complete blindness. The incidence of visual dysfunction caused by cervical spondylosis ranges from 3% to 22.4% of other atypical symptoms [4]. A latest meta-analysis reported that the incidence of blurred vision caused by cervical spondylosis approximated at 2.6% [1]. However, the mechanics of the associated visual improvement are not fully understood, and as no consensus has been attained on the diagnostic tests for the determination of the pathoanatomic etiology of the visual dysfunctions in cervical spondylosis patients, the relationship mechanics are not well-established.

Our study provides a narrative review of visual dysfunction associated with cervical spondylosis. We have examined the evidence for the efficacy of both conservative non-invasive and surgical treatments of cervical region on visual dysfunction. In a later part of the review, we have described the possible underlying mechanisms of visual dysfunction, with anatomically and associated genetic and protein changes, caused by cervical spondylosis.

DOI: 10.15386/mpr-2507

Manuscript received: 17.03.2022
Received in revised form: 16.05.2022
Accepted: 31.05.2022

Address for correspondence:
eric@nymg.com.hk

Methods

A comprehensive literature search was performed using PubMed and MEDLINE from the inception of these databases to March 2022. The search terms included "cervical spondylosis," "blurred vision," "visual impairment," "spinal decompression," and "spinal manipulation." References for this review were also identified from the personal libraries of the authors, supplemented by the reference lists of recent reviews and book chapters. Publications relevant to visual impairment and cervical spondylosis were identified and selected based on author expertise to summarize our current understanding of the impact of neck pain on visual impairment. The reviewed studies were mostly in the form of questionnaires.

Results

We categorized the studies based on applied intervention and described the current data on their efficacy to treat visual dysfunction as given below.

Efficacy of spinal manipulation on visual dysfunction

Although no detailed evidence on vision improvement following spinal manipulation could be identified, a considerable number of studies performed in 1990s reported visual improvement after such a procedure. Successful ophthalmological recovery has been reported after spinal manipulation in presumptive optic nerve ischemia, microvascular spasm of the optic nerve, bilateral simultaneous optic nerve dysfunction after periorbital trauma, constricted fields of vision, monocular visual loss after closed head trauma, and severe glaucomatous visual field deficit [3,5-7]. Stephens et al. reported substantial repair of normal visual sensitivity of both eyes after spinal manipulation [7]. In a recent study, Chu et al. demonstrated a spontaneous resolution of myopic retinoschisis after a similar spinal manipulation [8]. Moreover, a single cohort prospective trial of the immediate effects of spinal manipulation concluded significant improvements in visual acuity after chiropractic treatments [9]. On the other hand, clinical studies with different spinal manipulation techniques also suggested varying correlations. Chiropractic treatment, i.e., instrument-assisted manipulation, to treat nonspecific dizziness and neck pain in community-dwelling older people in a feasibility randomized sham-controlled trial was rendered successful [10]. However, another study described an opposite effect wherein upper spinal manipulation resulted in ophthalmological adverse effects of unknown frequency [11].

Efficacy of surgical intervention on visual dysfunction

Our literature search demonstrated an inconsistency in the studies of surgical treatment in cervical spondylosis patients. Few reports suggested that double-door laminoplasty could significantly relieve the atypical symptoms including blurred vision [12], while others described improvement of atypical symptoms including blurred vision after artificial disc replacement [13]. Although anterior cervical discectomy and fusion (ACDF) significantly reduced the atypical symptoms, such as dizziness, headache, nausea, and palpitations, associated with cervical spondylotic myelopathy [14], relief from symptoms such as blurred vision, tinnitus, and memory are largely controversial. A study by Sharma et al. [4] found that the severity and frequency of tinnitus, palpitations, and blurred vision did not show significant improvement after ACDF. A meta-analysis published recently in September 2021, consisting of 27 studies on the effect of cervical spine surgery on atypical symptoms, demonstrated that five studies correlated cervical spondylosis with blurred vision. The meta-analysis found that cervical decompression is effective in mitigating headache, dizziness, and tinnitus, whereas no significant improvement of nausea, blurred vision, memory loss, gastrointestinal discomfort, palpitations, and hypertension occurred [1].

Functional magnetic resonance imaging (fMRI) is widely applied in spine surgery. A cross-sectional study comparing healthy adults with cervical spondylotic myelopathy patients has shown that significant recovery of the functional connectivity in the visual cortex and posterior cingulate lobe (cerebellum compensation) of patients occurs after spinal surgery [15,16]. Another study, employing multimodal functional magnetic resonance, demonstrated that the visual cortex of patients with acute incomplete cervical spinal cord injury undergoes structural and functional changes [16]. These findings indicate that there may be functional and/or structural damage to the visual cortex of the brain in cervical spondylosis patients. The visual deficits may be compensated by other parts of the brain.

Putative mechanism of visual dysfunction and cervical spondylosis (Table 1)

Currently, there are three proposed mechanisms explaining the pathophysiology of visual dysfunction (blurred vision) in cervical spondylosis. The first proposed mechanism hypothesizes the role of neurons in the mechanism of blurred vision. It is believed that the visual dysfunction is caused by cervical spondylosis through sympathetic nerve stimulation [17,18]. Briefly, cervical osteophytic stress stimulates sympathetic nerves in the neck leading to sympathetic hyperfunction such as eye pain, dry eyes, blurred vision, fatigue, enlarged eye clefts, and pupil dilation. The vertebral artery supplies blood flow to the brainstem and occipital lobe visual cortex, and sympathetic nerve hyperfunction aggravates vertebral artery spasm, resulting in aggravated cerebral ischemia symptoms, reduction in blood flow to the visual cortex, and exasperated visual impairment. Parasympathetic symptoms such as lacrimation, ptosis, and miosis may also follow.

Table I. Pathophysiology of visual dysfunction and cervical spondylosis.

Type of Approach	Pathophysiological mechanisms	Effects
Neurons	Through sympathetic/parasympathetic nerve stimulation	Cervical osteophytic stress stimulates sympathetic nerves leading to sympathetic hyperfunction such as eye pain, dry eyes, blurred vision, fatigue, enlarged eye clefts, and pupil dilation. The sympathetic nerve hyperfunction aggravates vertebral artery spasm, resulting in aggravated cerebral ischemia symptoms, reduction in blood flow to the visual cortex, and exasperated visual impairment. Parasympathetic symptoms such as lacrimation, ptosis, and miosis may also follow.
Neuro-ophthalmological	Prior history of ophthalmological ischemia in patients is shown to induce retinal cells survival at an ischemic level and hibernate in a less functioning mode	Small number of retinal cells hibernate to survive at an ischemic level subthreshold and thus remain alive. Minimal retinal circulation can activate a considerable recovery of vision. Spinal manipulation may stimulate a shift in the sympathetic reaction and improve the blood circulation and oxygenation to the hibernated tissue, resulting in reactivation of visual dysfunction.
Immunohistochemical	Neuropeptide Y, vasoactive intestinal peptide, and tyrosine hydroxylase-positive nerve fibers on the dura may be involved in sympathetic activation of the cardiovascular and gastrointestinal system, triggering the atypical symptoms	Gene and protein expression changes, such as changes in C-fos, may also cause the atypical symptoms to occur

The second mechanism has been explained with a neuro-ophthalmological approach. Prior history of ophthalmological ischemia in patients is shown to induce retinal cells survival at an ischemic level and hibernate in a less functioning mode, confirming that an association exists between retinal morphology and spinal manipulation [8]. Briefly, small number of retinal cells hibernate to survive at an ischemic level subthreshold and thus remain alive. Further, minimal retinal circulation can activate a considerable recovery of vision. It is hypothesized that spinal manipulation may stimulate a shift in the sympathetic reaction and improve the blood circulation and oxygenation to the hibernated tissue, resulting in reactivation of visual dysfunction. Indeed, this pathophysiology mechanism is able to explain the cases of vision recovery after spinal manipulation in patients with a past history of visual disorders [3-6].

The third mechanism explains the pathophysiology with an immunohistochemical approach. Neuropeptide Y, vasoactive intestinal peptide, and tyrosine hydroxylase-positive nerve fibers on the dura may be involved in sympathetic activation of the cardiovascular and gastrointestinal system, triggering the atypical symptoms [19]. Gene and protein expression changes, such as changes in C-fos, may also cause the atypical symptoms to occur [20]. Nevertheless, this theory cannot explain recovery of non-cardiovascular and non-gastrointestinal symptoms.

Location of the sympathetic nerve

The location of the sympathetic nerve has long been discussed as an important factor in occurrence of blurred vision associated to cervical spondylosis. The sympathetic preganglionic neurons are located within the central nervous system, and it is believed that posterior longitudinal ligament (PLL) plays a role anatomically in the manifestation of blurred vision with cervical spondylosis. Briefly, the sympathetic cell bodies originate at the base of the skull and extend into the inferior spinal column. The sympathetic nerve fibers are located in the PLL. These nerve fibers have similar anatomical structure and immunohistochemical properties to the nerve fibers of the cardiovascular and gastrointestinal system [22]. This may explain the similar origin of atypical symptoms of cervical spondylosis, even in the cardiovascular and gastrointestinal system [22]. A prospective study has confirmed that these sympathetic atypical symptoms are relieved after anterior cervical surgery, possibly due to the surgical resection of the PLL at the cervical site owing to its above described role [23].

On the contrary, few reports exist that believe that the triggered sympathetic nerve fibers are located at the dura and spinal cord, instead of the PLL. Accordingly, it has been shown that the symptomatic relief rate of atypical symptoms in patients that underwent posterior cervical laminoplasty and the patients that underwent anterior cervical surgery

were similar [19]. Hence, it can be concurred that the atypical symptoms of cervical spondylosis are significantly relieved with or without PLL removal and as all the three surgical procedures concentrate on decompressing the dura and the spinal cord, these regions are the root cause of atypical symptoms. Currently, the hypothesis states that the cervical degenerative process surrounding the dura and spinal cord, including the ossification of PLL, hypertrophy of ligamentum flavum, osteophytosis of vertebral body, disc degeneration, vertebral subluxation, and inflammatory reaction stimulates the atypical symptoms. However, the reviewed studies have strong limitations due to their questionnaires design. Questionnaire design, diabetes, hypertension, surgical anesthesia, postoperative activities, and patient subjective factors do have a relevant impact on the results of our study.

Conclusion

Atypical symptoms are relatively rare in cervical spondylosis. It is suggested that ophthalmological consultations are given priority in cervical spondylosis patients that have visual dysfunction. Once ophthalmological examination is excluded, cervicogenic visual dysfunction should be considered for the differential diagnosis. In addition, our review yielded equal effectiveness of both spinal manipulation and surgery in treating visual dysfunction of a spinal origin.

References

1. Garg K, Aggarwal A. Effect of cervical decompression on atypical symptoms cervical spondylosis-a narrative review and meta-analysis. World Neurosurg. 2022;157:207-217.e1.
2. Chu ECP, Lin AFC. Neck-tongue syndrome. BMJ Case Rep. 2018;11:e227483.
3. Gorman RF. Monocular visual loss after closed head trauma: immediate resolution associated with spinal manipulation. J Manipulative Physiol Ther. 1995;18:308-314.
4. Sharma R, Garg K, Agrawal S, Mishra S, Gurjar HK, Tandon V, et al. Atypical Symptoms of Cervical Spondylosis: Is Anterior Cervical Discectomy and Fusion Useful? - An Institutional Experience. Neurol India, 2021,69:595-601.
5. Gorman RF. The treatment of presumptive optic nerve ischemia by spinal manipulation. J Manipulative Physiol Ther. 1995;18:172-177.
6. Wingfield BR, Gorman RF. Treatment of severe glaucomatous visual field deficit by chiropractic spinal manipulative therapy: a prospective case study and discussion. J Manipulative Physiol Ther. 2000;23:428-434.
7. Stephens D, Gorman RF. Does 'normal' vision improve with spinal manipulation? J Manipulative Physiol Ther. 1996;19:415-418.
8. Chu EC, Pong JC. Spontaneous resolution of myopic retinoschisis. AME Case Rep. 2019;3:3.
9. Athaide M, Rego C, Budgell B. A single cohort prospective trial of the immediate effects of spinal manipulation on visual acuity. J Can Chiropr Assoc. 2016;60:88-92.
10. Kendall JC, French SD, Hartvigsen J, Azari MF. Chiropractic treatment including instrument-assisted manipulation for non-specific dizziness and neck pain in community-dwelling older people: a feasibility randomised sham-controlled trial. Chiropr Man Therap. 2018;26:14.
11. Ernst E. Ophthalmological adverse effects of (chiropractic) upper spinal manipulation: evidence from recent case reports. Acta Ophthalmol Scand. 2005;83:581-585.
12. Sun Y, Muheremu A, Yan K, Yu J, Zheng S, Tian W. Effect of double-door laminoplasty on atypical symptoms associated with cervical spondylotic myelopathy/radiculopathy. BMC Surg. 2016;16:31.
13. Sun YQ, Zheng S, Yu J, Yan K, Tian W. Effect of total disc replacement on atypical symptoms associated with cervical spondylosis. Eur Spine J. 2013;22:1553-1557.
14. Muheremu A, Sun Y, Yan K, Yu J, Zheng S, Tian W. Effect of Anterior Cervical Discectomy and Fusion on Patients with Atypical Symptoms Related to Cervical Spondylosis. J Neurol Surg A Cent Eur Neurosurg. 2016;77:395-399.
15. Chen Z, Zhao R, Wang Q, Yu C, Li F, Liang M, et al. Functional Connectivity Changes of the Visual Cortex in the Cervical Spondylotic Myelopathy Patients: A Resting-State fMRI Study. Spine (Phila Pa 1976). 2020;45:E272-E279.
16. Chen Z, Wang Q, Liang M, Zhao R, Zhu J, Xiong W, et al. Visual cortex neural activity alteration in cervical spondylotic myelopathy patients: a resting-state fMRI study. Neuroradiology. 2018;60:921-932.
17. Sun Y, Muheremu A, Tian W. Atypical symptoms in patients with cervical spondylosis: Comparison of the treatment effect of different surgical approaches. Medicine (Baltimore). 2018;97:e10731.
18. Machaly SA, Senna MK, Sadek AG. Vertigo is associated with advanced degenerative changes in patients with cervical spondylosis. Clin Rheumatol, 2011,30:1527-1534.
19. Ahmed M, Bjurholm A, Kreicbergs A, Schultzberg M. Neuropeptide Y, tyrosine hydroxylase and vasoactive intestinal polypeptide-immunoreactive nerve fibers in the vertebral bodies, discs, dura mater, and spinal ligaments of the rat lumbar spine. Spine (Phila Pa 1976). 1993;18:268-273.
20. Chen Q, Zheng W, Chen X, Li X, Wang L, Qin W, et al. Whether Visual-related Structural and Functional Changes Occur in Brain of Patients with Acute Incomplete Cervical Cord Injury: A Multimodal Based MRI Study. Neuroscience, 2018;393:284-294.
21. Wang Z, Wang X, Yuan W, Jiang D. Degenerative pathological irritations to cervical PLL may play a role in presenting sympathetic symptoms. Med Hypotheses. 2011;77:921-923.
22. Gu Q, Jiang D, Wang X, Chen D, Yuan W. Chronic compression of the posterior longitudinal ligament of the cervical spine is associated with abnormal discharge of middle cervical ganglion. Int J Clin Exp Med. 2014,7:4316-4321.
23. Li J, Jiang DJ, Wang XW, Yuan W, Liang L, Wang ZC. Mid-term Outcomes of Anterior Cervical Fusion for Cervical Spondylosis With Sympathetic Symptoms. Clin Spine Surg. 2016;29:255-260.