OCCIFLEX™

BY ENRAF-NONIUS

Treatment Guidelines

Advanced and safe solution for neck and head pain:
A new treatment approach

ENRAF NONIUS
PARTNER FOR LIFE

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This booklet has been written in commission for Headway Ltd., Kiryat Ono, Israel.
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Version 20170109

CAUTION: The objective of the information provided in these "Treatment Guidelines" is to be used as a reference by a Physician and/or Healthcare Service Provider. It is not intended to replace or impose any medical practices and judgement made for patient care based on each patients' condition. Instructions for Use (IFU) provided with the device must be consulted for proper use of the Occiflex device.

The Product is Not Available in the USA

Index

Modes of treatment and rationale 20

Preparing to use the Occiflex 29

Treatment recommendations with the Occiflex 33

Advantages of the Occiflex treatment 43

Safety and side effects 46

Appendices 48

Notes 50

Introduction

Delivering an accurate, slow and effective treatment is challenging

Today more than two billion people suffer from neck pain and headache such as migraines and tension-type headaches[1]. Present treatments – medications, invasive procedures and alternative therapies – are in many cases ineffective, short-acting and associated with significant side effects[2].

Clinical studies have shown that physical or manual therapy – and, in particular, cervical mobilization – can reduce chronic neck pain and headache [3,4,5,6,7,8,9]. However, manual therapy is time consuming, physically demanding and tiring: the average human head weighs about 7% of the body (5.5 kg). These constraints can mean a therapy session is often shorter than desired and achieving a consistent treatment over time can be challenging.

Moreover, to control the precise angular and linear velocities, mobilization accelerations, and mobilization range needed by each patient can be difficult – too large movements may lead to neck injury. Further risk of injury can also occur as a result of high velocity, forceful manipulations and end-range mobilization techniques. These techniques, though effective to some extent, can also lead to over-contraction of the neck muscles, resulting in more neck pain or other more serious adverse effects.

We have developed a complementary solution that can help therapists save time, and deliver a more effective and safe patient treatment – the Occiflex™.

The Occiflex was initially intended to treat, a somewhat neglected aspect of head and neck pain syndromes – cervical muscle dysfunction – through mid-range non-segmental mobilization. Although the contribution of muscle dysfunction, to the evolution of these pain syndromes, has been recognized during the last 30 years, various treatments intended to correct it are suboptimal. We believe that our device introduces a novel therapy, which can be combined with other therapeutic modalities such as physical therapy techniques, neck exercises, trigger point injections, analgesics, biofeedback and others, to accomplish a far better pain control for patients suffering intractable head and neck pain.

The Occiflex is the first automated treatment table to relieve chronic neck pain and headache. The device enables a therapist to implement a hands-free, sustained mid-range neck mobilization more accurately, slower and for much longer than previous therapy options allowed.

1. Years lived with disability (YLDs) for 1160 sequelae of 289 diseases and injuries 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. The Lancet, 2012, 380 (9859): 2163-96.
2. Peloso P, Gross A, Haines T, et al. Cervical Overview Group. Medicinal and injection therapies for mechanical neck disorders Cochrane Database Syst Rev. 2007;18:CD000319.
3. Vicenzino B, Collins D, Benson H, Wright A. An investigation of the interrelationship between manipulative therapy induced hypoalgesia and sympathoexcitation. J Manipulative Physiol Ther 1998;21:448–53.
4. Sterling M, Pedler A, Chan C, et al. Cervical lateral glide increases nociceptive flexion reflex threshold but not pressure or thermal pain thresholds in chronic whiplash associated disorders: A pilot randomized controlled trial. Man Ther 2010;15:149–53.
5. Coppieters MW, Stappaerts KH, Wouters LL, Janssens K. The immediate effects of a cervical lateral glide treatment technique in patients with neurogenic cervicobrachial pain. J Orthop Sports Phys Ther 2003;33:369–78.
6. Bronfort G, Evans R, Anderson AV, et al. Spinal manipulation, medication, or home exercise with advice for acute and subacute neck pain. Ann Intern Med 2012;156:1–10.
7. Kay TM, Gross A, Goldsmith C, et al. Cervical overview group. Exercises for mechanical neck disorders. Cochrane Database Syst Rev 2005;(20):CD004250.
8. Hurwitz EL, Aker PD, Adams AH, Meeker WC, Shekelle PG. Manipulation and mobilization of the cervical spine. A systematic review of the literature. Spine (Phila Pa 1976) 1996;21:1746–59.
9. Gross AR, Hoving JL, Haines TA, et al. Cervical overview group. A Cochrane review of manipulation and mobilization for mechanical neck disorders. Spine (Phila Pa 1976) 2004;29:1541–8.

The treatment aims are:

1. Reduced pain.
2. Increased neck range of motion.
3. Increased neck muscle endurance.
4. Increased range of motion of facet joints (increased segmental range of movement).
5. Stretching of over contracted neck muscles.
6. Resolution of trigger points secondary to muscle stretching.
7. Restored balance between extensor and flexor neck muscles and thus a more favorable neck posture.
8. Activation of central-inhibitory-pain pathway (descending inhibition).
9. Activation of premotor-cerebral networks engaged in motor planning.
10. General relaxation.
11. As a consequence of the above, reduced disability and a better quality of life.

The Occiflex's main indication is in treating chronic neck pain. However, the device can also be used to help treat various other headache syndromes, where accompanying neck pain is a substantial part of the pain syndrome, and a significant cause of disability and reduced quality of life.

Introducing the Occiflex

The Occiflex is the first computer-controlled therapeutic treatment table for the relief of chronic neck pain and headache. It is comprised of an ergonomic, adjustable cradle (see figure 1), that automatically moves the head and neck gently along a therapist-guided three-dimensional course.

This slow, continuous and accurate mid-range mobilization of the cervical spine has been shown to reduce neck muscle contraction, alleviate pain and increase the neck's cervical range of motion (CROM) [10,11,12]. Alongside improving patient-treatment outcomes, the Occiflex can also help a therapist save time, reduce the risk of injury and improve patient compliance.

The Occiflex is designed for professional use by:

1. Physical and manual therapists, including chiropractors, and osteopaths
2. Physicians – pain specialists, physiatrists

The Occiflex can help a therapist:

- Improve patient outcomes and reduce the risk of injury
- Save time and increase productivity
- Improve patient compliance

Figure 1: The Occiflex's ergonomic, adjustable cradle

10. River Y, Aharony S, Bracha J, Levital T, Gerwin R (2014). Three-Dimensional Computerized Mobilization of the Cervical Spine for the Treatment of Chronic Neck Pain: A Pilot Study. Pain Med 15(7):1091-1099.
11. River Y, Levital T, Belgrade M (2012). Computerized mobilization of the cervical spine for the treatment of chronic neck pain. Clinical Journal of Pain 28(9):790-6.
12. River Y. Flexion relaxation ratio, neck posture, joint position error, and pressure-pain thresholds following personalized, three-dimensional, computerized mobilization of the cervical spine for the treatment of chronic neck pain. Unpublished data.

Clinical evidence

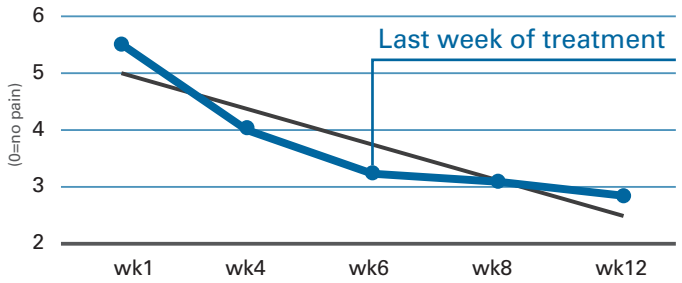
Occiflex: Alleviates chronic neck pain and associated headache. [10, 11, 12]

Three safety and efficacy clinical trials** showed:

- Pain significantly reduced by 48% (combined results from three trials; see figure 2).
- Associated headache in patients with chronic neck pain was reduced.
- CROM significantly increased throughout the treatment.
- Neck pain disability index improved.
- No safety events or serious adverse effects were reported.
- All patients were satisfied and wanted to return for further treatment.

**Two clinical trials were published in peer reviewed journals and presented at key conferences, a third clinical trial is currently being reviewed.

Pain Reduction: (0-10 NRS*; 3 trials combined)



(*) Numeric Rating (pain) Scale; [0=no pain, 10=worst pain imagineable

Figure 2: Pain reduction graph, during and post clinical trials

Neck pain specifically reduced as measured through the Neck pain Disability Index (NDI) questionnaire. Over a twelve-week period (six treatment, six follow-up), patients felt they were more able to manage in their everyday life as a result of a reduction in their neck pain. Specifically, they felt they were more able to look after themselves, read, concentrate, work, sleep, drive and enjoy more recreational activities. Pain intensity, and headache severity and frequency, also decreased during the course of the treatment.

Joint Position Error (JPE), the difference between the examiner's guided defined neck angle and the patient's attempt to reach that neck angle as measured by the CROM device, was also significantly smaller. JPE reflects the accuracy of the head and neck position sense. Position sense, coupled with vestibular information, allows an accurate activation of neck muscle and maintenance of optimal head posture[13]. Increased JPE is associated with inaccurate over-contraction of antagonistic and synergistic neck muscles, that provide less than desired proprioceptive information[14]. Thus, the reduction of JPE seen in these patients, could lead to better sensory-motor integration, improved head posture, and a different status quo of neck muscles. This improvement supports the underlying physiological reasons postulated as to the effectiveness of the Occiflex.

For further information on the pilot trials, see appendices.

13. Armstrong B, McNair P, Taylor D. Head and neck position sense. Sports Med 2008;38:101–17.
14. Treleaven J, Clamaron-Cheers C, Jull G. Does the region of pain influence the presence of sensorimotor disturbances in neck pain disorders? Man Ther 2011;16:636–40.

Patient screening

Patient evaluation

This initially starts with a three-stage evaluation:

Stage 1:
Defining the patient's pain syndrome e.g., post whiplash, disc herniation, cervicogenic headache, etc

Stage 2:
Understanding the putative mechanisms underlying the pain syndrome (i.e. bony, facet joint, myofascial, neuropathic, discogenic, etc.)

Stage 3:
Further defining the specific anatomical structure that is involved (e.g., specific muscles involved in myofascial pain or specific facet joint involved in the generation of cervicogenic headache).

Physical examination

During this three-stage evaluation, a meticulous physical examination is undertaken that includes cervical ROM, specific analysis of segmental ROM, and a full neurological examination, with an emphasis on signs compatible with radiculopathy or myelopathy. The Occiflex back-office software (Occilink™) provides an important tool to measure accurately cervical range of motion, and to follow it repetitively during the course of the treatment period. However, it is always advisable that patients with long standing head and neck pain should be examined in parallel by a physician.

Pain severity & quality of life

The next stage is to understand how the pain syndrome affects the patient's quality of life / disability, and how severe is the pain syndrome. The Occiflex back-office software (Occilink) has three embedded tools to help do this:

a. Visual analogue pain scale
   Pain can be measured numerically or using the visual analogue scale (VAS). The analogue scale is in colour.

b. Neck disability index (NDI)
   A validated questionnaire evaluating the disability of patients with chronic neck pain comprised of 10 questions covering different aspects of daily life activities. The total score is between "0" (no disability) through "50" (maximum disability).

c. Headache impact test (HIT6)
   A validated questionnaire comprising of six questions, evaluating patients' severity of headache, and its impact on emotional status, disability and level of energy. The score is between "36" (minimal impact) through to "78" (maximal impact).

   The evaluation of the severity of the patient's condition should also be based on imaging studies: X-ray, CT and/or MRI.

Red flags

The therapist must also be very sensitive to signs and symptoms constituting "red flags":

1. Head or neck pain associated with new on-set urinary retention or urinary incontinence.
2. Head or neck pain associated with lower extremity weakness.
3. Head or neck pain associated with upper extremity weakness (unilateral or bilateral), or sensory disturbance.

All of these symptoms and signs can raise the possibility of an injury to the cervical cord, or cervical roots. Therefore, the physical examination should also include a neurological examination: gross motor strength of upper extremity muscles, tendon reflexes, pyramidal signs and sensory examination.

S.I.N. Factor

The SIN factor: an acronym for "severity, irritability, nature" is a key concept in Maitland's evaluation strategy of pain irritability[15] (the degree to which an injury is exacerbated by certain activities).

Severity

The severity of the pain is determined by the patient. It will affect the way the patient is investigated and our treatment selection. A severe pain requires a meticulous examination and imaging studies, followed by a decision whether or not treatment is contra-indicated. Other symptoms, that accompany pain, such as muscle weakness, sensory disturbance, vertigo, nausea, and/or urinary retention or incontinence, should alert the therapist to a serious condition, which possibly precludes Occiflex treatment. For more information, see the contra-indications section.

Irritability

This factor helps determine how easily symptoms are reproduced and how easy it is to give rise to an exacerbation of pain, which takes a long time to subside. If positive, care needs to be taken to limit the examination before the pain is provoked. Many of the highly irritable complaints often have a neurological origin, or can be linked to longstanding instability of the cervical spine.

Nature

The nature of the complaints can give us some clues about the origin. The experienced therapist will notice some patterns and complaints. These will give an indication that the complaint is not only caused by an arthrogenic spinal dysfunction, or muscle dysfunction, but may for instance indicate primary neurological dysfunctions.

The nature of the pain can be the first clue for evaluating the origin of pain. Dull, poorly localized pain, which is consistently experienced during a certain neck movement, is usually a nociceptive pain with an underlying pathology in muscle, fascia or joint. Whereas, sharp, burning, lancinating, or radiating pain, is most probably a neuropathic pain, due to cervical root compression or peripheral nerve entrapment.

Estimating the SIN-factor gives us a basis to choose further workup; and later, it allows us to limit the therapy in terms of the range of motion and the movement velocity.

Posture and movement

During the initial examination, it is crucial to evaluate the patient's posture both while walking, standing and sitting. Likewise, observing the avoidance of certain movements, provides a clue to complete the diagnosis. Specifically observing any asymmetry in the coronal or horizontal plane, and the degree of forward neck tilting. This may suggest an increased workload of certain muscle groups and imbalance in the pressure, in different joints. For instance, an increased forward neck tilting, is usually associated with increased workload of the extensor neck muscles, and is often associated with weakness of the deep neck flexor muscles.

15. Maitland GD, Vertebral Manipulation. 1986 5th Edition, Butterworths, London.

Indications

The Occiflex can be used with all existing therapeutic interventions to treat chronic neck pain and headache, including multimodal physical therapies, surgery, anesthetic blocks, preventative medicines and neurolysis.

The Occiflex device is indicated for use in:

- Chronic, sub-acute and acute neck pain due to whiplash injury, myofascial pain, discogenic pain, facet joint disorder and other causes of neck pain.
- Headache associated with neck pain, cervicogenic headache, tension-type headache with muscle dysfunction, migraine with significant ongoing neck pain.
- Cervicogenic dizziness.

Some of the abovementioned disorders are directly related to neck pathology, while others can be triggered or exacerbated by neck movements, but are not directly caused by neck pathology.

Relative contraindications

1. Patients suffering from cervical radiculopathy based on auxiliary tests (such as EMG or imaging data).
2. Patients with a pyramidal syndrome due to a known spinal cord or neck injury.
3. Patients with weakness or sensory loss in their upper extremities.
4. Patients suffering from grade I-II cervical spondylolisthesis verified by x-rays.
5. Patients with a herniated or ruptured cervical disc.
6. Patients suffering from skin disorder in the head and neck region.
7. Patients with a formal diagnosis of moderate to severe osteoporosis with or without medicinal treatment of this issue; or patients that have a CT scan or an X-ray of the cervical vertebra that suggest an osteoporosis condition.
8. Patients with recurrent vertigo, or dizziness.
9. Patients older than 70. We should be more cautious when providing treatment for the elderly, given the higher prevalence of degenerative cervical spine changes, and cerebral vascular diseases.
10. Patients with short stature, including young children, could have short neck length, which would not be compatible with the cradle dimensions.

Absolute contraindications

1. Patients suffering from current malignant disease, which involves the head and neck area.
2. Patients suffering from grade III-V cervical spondylolisthesis verified by x-rays.
3. Patients with a herniated or ruptured cervical disc, with progressive myelopathy.
4. Patients with cerebrovascular disease involving the vertebral arteries.
5. Patients with secondary headaches, due to intracranial vascular malformation, hydrocephalus, brain hemorrhage or defect in the blood vessels (i.e. cerebral vessel aneurysm).
6. Patients with neck pain secondary to diseases such as rheumatoid arthritis and Ankylosing Spondylitis, involving the cervical spine.

Classification of the syndromes that can be treated with the Occiflex

Neck pain	Nociceptive and referred pain
	Myofascial pain syndromes (MPS) and trigger-point-related pain
	Neuropathic pain
	Mechano-sensitivity of nerves
	Degenerative conditions of the spine (Arthrogenic)
	Whiplash-associated disorders
Headaches	Cervicogenic
	Tension-type
	Migraine
	Cervicogenic dizziness

This overview represents only those pain syndromes of the head and neck, and neck related syndromes that can be addressed with the Occiflex.

During examination, the therapist should always be alert to "Red Flags" that warn us of situations that are contraindicated to treatment. See the Patient Screening chapter. It should also be noted that the neck is the anatomical seat of various anatomical structures such as the trachea, carotid arteries, jugular veins, thyroid glands, and larynx, which can also generate neck pain. These cannot, and should not be treated with the Occiflex.

Neck pain

Nociceptive and referred pain

Nociceptive pain is pain that is due to trauma, inflammation, and other mechanisms, that disrupts the integrity of the tissue, and is generated by the activation of specialized nerve endings. We can distinguish pain with somatic origin from skin, joints and bones. A somatic pain originating from subdermal tissues (e.g., deeper para-spinal muscles, facet joints, etc.) or the spine, can give rise to "referred pain" (see figure 3). That is, pain that is referred to an area of the body, that originated elsewhere.

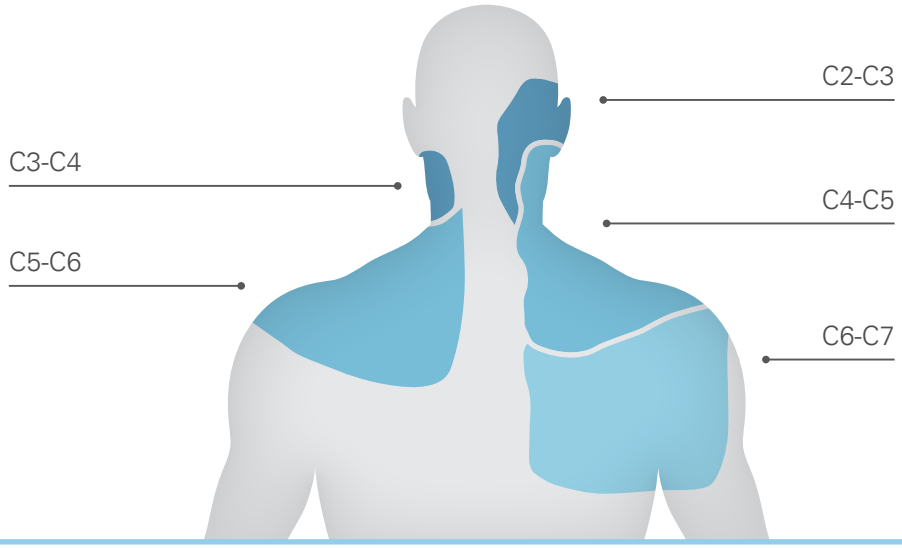


Figure 3: Facet joint referred pain

Cervical facet pain syndrome is a shoulder, neck and occipital pain that originates in the cervical facet joints. It is responsible for a substantial number of patients with chronic neck pain. It is usually a chronic condition, whose pain is referred to the shoulder, neck and occipital areas. The mode of referral is dependent on the specific joint that is abnormal. It is a unilateral pain that is often caused by arthritis of the synovial facet joints. It does not refer pain to the upper extremities.

It is proven that an experienced physio/manual therapist is capable of distinguishing the correct segmental level of the painful facet joint[16]. A further way to improve the diagnosis is achieved by injecting the joint with a local anaesthetic, the resolution of the pain further supports the facet joint, as a source of pain.

16. Schneider GM, Jull G, Thomas K et al. Intrarater and interrater reliability of select clinical tests in patients referred for diagnostic facet joint blocks in the cervical spine. Arch Phys Med Rehabil. 2013 Aug;94(8):1628-34

Myofascial pain syndromes and trigger-point-related pain

Muscles are a very important source of pain in the neck region. Myofascial pain syndromes (MPS) have been clearly defined by Travell & Simons[17]. It is assumed that improper muscle balance (for instance – between the Sternocleidomastoid and the Levator Scapula) would lead to continuous muscle contraction, localized mismatch between blood perfusion and energy requirement of the muscle tissue, which would also be associated with localised pro-inflammatory state. This condition would manifest itself with the appearance of trigger points. Trigger points are discrete sensitive points, that when palpated, reproduce the patient's pain, and refer pain to a distant body area. The trigger point can be palpated as a taut bend in the muscle. When injected, often a local twitch sign is appreciated with instantaneous resolution of pain. Thus, the trigger point is the hallmark of MPS. MPS in the neck can appear in a pure form, or they can accompany other pain syndromes, such as: facet joint disorder, tension-type headache or post whiplash injury.

One of the most common factors in the evolution of MPS, is a behavioural factor which is caused by an overuse of certain muscle groups in the work environment, where abnormal postures are adapted. A very common example is the MPS of the descending part of the Trapezius muscle. This muscle is often overused in desk-office related work. The Trapezius is over-contracted along with the extensors in the Upper Cervical Spine. The imbalance that is created by over contraction of these muscles, is also associated with forward tilting of the neck, which further demands continuous contraction of the Upper Cervical extensors. This forward posture creates an additional imbalance – weakness of the Longus Colli and Longus Capitis (deep flexor muscle), against over-contraction of the Upper Cervical muscles and the Sternocleidomastoid.

As already mentioned, the muscles in the neck can also form trigger points as part of MPS. Or as a secondary phenomenon when patients suffer from other pain syndrome (e.g., facet joint pain, discogenic pain or neuropathic pain). In these patients, the trigger points could be regarded as a manifestation of central sensitization.

17. Simons D, Travell J. Travell & Simons' Myofascial Pain and Dysfunction: The Trigger Point Manual: Volume 1: Upper Half of Body Lippincott Williams & Wilkins 1998

Neuropathic pain

Cervical radiculopathy is a neuropathic pain described as radiating pain in the shoulder and arm, caused by a process affecting the cervical nerve or nerve root, with or without unilateral neck pain. The clinical signs are radiating pain in one or sometimes two dermatomes, sensory changes in dermatomal distribution, weakness, atrophy or fasciculations in myotomal distribution, and unilateral, diminished deep tendon reflexes.

The most common cause of cervical radiculopathy is a malfunction or pathology in the mechanical interface at segmental level of the intervertebral foramina. It can be brought on by a traumatic extension rotation and ipsilateral side flexion, or a stretch of the Brachial plexus. It can also be the result of root compression by a herniated disc or a bony fragment. Any lesion that involves the intervertebral foraman can give rise to a heightened pressure on the nerve root. This results in a reduced venous return and an increase in tissue fluid pressure that leads to hypoxia and mechano-sensitivity in the nerve root.

Posture and stress in daily work-related activities can be provocative. Bulging of the intervertebral disc can also be a primary or secondary cause of mechano-sensitivity of the nerve root[18].

Mechano-sensitivity of nerves

This term is often used in physical therapy literature to denote the reproduction of neuropathic pain, following neck palpation or mobilization, in the absence of clear-cut nerve or root injury, based on nerve-conduction-velocity, EMG or MRI studies. To diagnose mechano-sensitivity of nerves can often be complex due to the wide array of possible dysfunctions.

Mechano-sensitivity or radicular pain

Referred pain from the facet together with inflammation of the nerve with peripheral sensitisation, can give rise to symptoms that seem to indicate radicular pain. However, are in nature non-specific neck-arm pain (NSNAP) syndromes arising from heightened mechano-sensitivity of the cervical nerve roots, or the brachial plexus. This referred pain is often not neuropathic pain, but rather a bony pain that radiates to a specific sclerotome, or muscle pain, which refers pain to other muscles in the same myotome.

Non-specific neck pain is not associated with sensory loss, or weakness, or indeed with other signs / symptoms considered to be related to neurological deficit.

There is no golden standard to differentiate radicular pain from heightened mechano-sensitivity. However, the following symptoms suggest true radicular pain: sensory loss in a dermatomal distribution; weakness of a muscle related to a specific myotome; reduced, asymmetric tendon reflexes; allodynia and/or hyperalgesia in a specific distribution of a nerve root; and the presence of a pain syndrome with typical neuropathic features. Additional abnormality in nerve conduction EMG studies can be supportive of this diagnosis.

18. Shacklock M. Clinical Neurodynamics. A new system of musculoskeletal treatment. Elsevier 2005

Degenerative conditions of the spine: (Arthrogenic)

Degeneration is a progressive condition that often proceeds from modifications of the material, biochemical, and structural properties of many tissues. The degenerative process also alters the material and mechanical properties of the joint, which eventually leads to further damage of the material integrity of the affected tissues. Since the mechanical behaviour of the facet joints and intervertebral disc are inter-dependent, degeneration of the facet joint will also affect the mechanical behaviour of the whole vertebral motion segment. Similarly, disc degeneration can impact the overall spinal degenerative cascades. Tissue degradation occurs at the structural and cellular levels during degeneration. This process can result from and/or be associated with aging, injury, and also infection or inflammation (septic arthritis, synovitis, and rheumatoid arthritis).

Degeneration of the spine and its facet joint, impact all of the tissues of that joint (bony pillars, capsular ligament, synovium, cartilage), but its primary effects are on the cartilage which can undergo osteoarthritis. The most prominent signs of degeneration are signs of pathology, including cartilaginous loss, wear, tears, and necrosis, ulceration, sclerosis, exposure of subchondral bone, osteophytes, subchondral cysts, and capsular calcification[19].

Inflammatory pain

Inflammation caused by tissue damage gives rise to so called "inflammatory pain". The pain threshold is lowered by interleukins and prostaglandins, causing a "peripheral sensitisation". Inflammatory pain is characterised by hypersensitivity, spontaneous pain hyperalgesia for heat. The pain is often dull or nagging but at times, it can be sharp. Inflammatory pain, is not associated with radicular neuropathic pain, unless the nerve root is involved.

Referred pain with a visceral origin

Visceral pain referred to the neck area should not be treated with the Occiflex device. For example, cardiac ischemic pain referred to the interior neck area, or pain that arises from the pancreas, referred to the shoulder or base of the posterior neck.

19. Jaumard NV, Welch WC, Winkelstein BA Spinal facet joint biomechanics and mechano transduction in normal, injury and degenerative conditions. J Biomech Eng. 2011 Jul;133(7) :071010

Whiplash-associated disorders

People suffering from residual complaints after a Motor Vehicle Crash form a heterogeneous group with pain complaints of musculoskeletal origin in the upper half of the body, including the head. At times, pain may extend to the lumbar spine. In addition to neck pain, dizziness, headaches, loss of balance, visual disturbances, cognitive disturbances and memory loss are experienced. About 18% of post-whiplash patients will not recover within a year. They will continue to suffer from severe neck pain, emotional, cognitive and balance dysfunction.

One third of the patients will have persisting substantial pain levels after three months[20]. Although there are no consistent structural abnormalities of the head and neck in the majority of patients, it is generally accepted that micro-structural damage occurs in the Zygapophyseal joints, intervertebral disks, vertebral bodies, synovial folds, nerve roots, spinal cord and brainstem.

"Whiplash-associated disorders are in many ways not yet clear in terms of understanding the biomechanics of the tissue injury and physiological consequences, because there is often no radiological or other imaging evidence that reveals any obvious indicators of tissue trauma"[16].

Although there is often no radiologic evidence, placebo-controlled research shows positive effects in pain on zygapophyseal joint blocks,[18] There is also evidence that we can find peripheral nerve mechano-sensitivity based on upper Limb Provocation Tests. Often positive for segmental level of C6, C7.

20. Jull G, Sterling M, Falla D. et al., Whiplash, Headache, and Neck Pain Elsevier 2008

Headaches

Cervicogenic headache

Cervicogenic headache (CH) starts in the neck and is not accompanied by dominant autonomic symptoms. CH originates mainly in the Cervical facet joints, but also extensor neck muscles, deep cervical fascia or ligaments. It is probably a referred pain that is based on a converging mechanism of afferent cervical nociceptive activity and the Trigeminal nerve complex in the Medula Oblongata. Transmission via the greater and lesser Occipital nerves and the C1-C3 nerve roots contribute to this type of headache. For a correct diagnosis, the IASP classification requires an absolute response to a local anaesthetic injection to the specific anatomical structure that generates the pain.

CH resembles migraine in its unilateral presentation, however, unlike migraine, the pain is not pulsatile and it is not associated with photophobia, nausea, and not aggravated by physical activity. Likewise, it does not respond to anti-migraine specific drugs such as triptans[21].

Research has shown various biomechanical abnormalities of the neck in this group of patients (e.g., reduced neck range of motion, reduced endurance of neck flexor muscles, changes in neck posture etc.). In addition, Sub-Occipital tenderness is often found together with tenderness over the greater and lesser Occipital nerves. There is strong evidence that a combination of positive signs of the Cranio-Cervical Flexion Test (CCFT), reduced range of motion (extension), and painful joint disorder in C0-3, are reliable indicators to differentiate CH from others pain syndromes of the neck area[18].

Another test, which could be positive in patients who suffer from CH, is the Cervical Flexion-Rotation test. This is performed in supine position with full flexion of the cervical spine. When given, if rotation is restricted to under 32 degrees to one side (normal range of motion in this position is approximately 45 degrees) it shows a positive result for restriction in the rotation range of the C1/C2 segment, which can be linked to unilateral CH. However, the test is also useful in the absence of headache, in that it can indicate a restriction in the C1 segment as a source of upper neck pain[22].

Tension-type headache

Tension-type headache (TTH) is a very common pain syndrome that affects most of the population at one time or the other. However, its chronic form affects about 3% of the population. TTH is a characterized bilateral pressure-like pain, of mild to moderate intensity. In some patients, it is accompanied with neck pain. Nausea, photophobia and incapacitating pain do not characterize TTH.

There is no agreement among physicians and researchers as to the cause of TTH. Nevertheless, muscle dysfunction is recognized as a salient feature of TTH. In fact, several models of the pathophysiology of TTH assume that it is related to muscle hyperalgesia, which is manifested by trigger points[24]. Trigger points are found in various muscles such as the Frontalis, Temporalis, Sub-Occipital, Sternocleidomastoid, and Trapezius. The tenderness of these trigger points is increased in times of heightened emotional and physical stress. In addition, significant forward neck tilting is observed, and some patients with TTH have additional bruxism and TMJ disorder.

21. Sjaastad O, Fredriksen TA, Pfaffenrath V. Cervicogenic headache: diagnostic criteria. The Cervicogenic Headache International Study Group. Headache. 1998:38(6):442-5.
22. Hall TM, Robinson KW, Fujinawa O et al. Intertester reliability and diagnostic validity of the cervical flexion-rotation test. J Manipulative Physiol Ther. 2008;31(4):293-300.

Migraine

Migraine is a genetic disorder that is caused by episodic inflammation of the meninges and the wall of the large cerebral arteries. It is due to a dysfunction of the trigeminal-vascular system as proposed by Michel Moskowitz[23]. It has unique features that distinguish it from other headache syndromes, such as nausea and photophobia. More than 90% of patients with migraine episodes will report significant neck pain before, during and after the attack.

Migraine is also a progressive syndrome. As time passes, central sensitization brings about gradual changes that are typified by increased frequency of attacks, increased duration and severity of the attack. This process is often aggravated by medication over-use.

An additional relevant aspect of the chronification of migraine is the biomechanical abnormality that is related to neck pain. This biomechanical abnormality of chronic migraine patients is manifested with abundant trigger points[24] in: Trapezius, Splenius Capitis and Sub-Occipital muscles, limited range of motion, and abnormal forward neck tilting. The central sensitization, which is the underline cause of this abnormality, is due to convergence of nociceptive data from neck muscles to the Nucleus Caudalis. The same nucleus that receives nociceptive data from the meninges and the cerebral vessels during a migraine episode. It is for this specific group of patients that physical therapy could be helpful.

Cervicogenic dizziness

Cervicogenic dizziness is an entity, which is in dispute. Certain patients with vascular disorder of the vertebral arteries, develop true vertigo as a result of vestibular artery stenosis or torsion following certain neck movements. This minority of patients should be identified and excluded from treatment with the Occiflex. They are usually elderly patients with vascular risk factors, and variable combinations of neurological deficits.

In contradiction, there is a group of patients that develop dizziness associated with limited neck range of movement. Some of these patients have accompanying chronic neck pain that develop spontaneously as a result of neck trauma. It is believed that these patients have a significant reduction of proprioceptive inflow data to the CNS. This subgroup often have increased joint position error of the neck, and limited active range of movement. It is for this group of patients that passive and passive-assisted mobilization in three-dimensional space by the Occiflex could be very helpful.

A word of caution should be voiced – some patients with dizziness have vestibular disorders, such as patients with Meniere's disease, or benign positional vertigo. These patients should be excluded from treatment with the Occiflex, as they might get worse.

23. Moskowitz MA. The neurobiology of vascular head pain. Ann Neurol. 1984;16:157-168
24. Fernández-de-las-Peñas C, Simons DG, Gerwin R et al. Muscle trigger points in tension type headache. Tension type and Cervicogenic headache: patho-physiology, diagnosis and treatment. Baltimore: Jones & Bartlett Publishers; 2009;61–76

Modes of treatment and rationale

Slow midrange passive mobilization

The Occiflex aims to achieve a full-range of painless movement in a patient. It uses the basic principle that joint mobilization is most effective, when directed to restoring structures within a joint to their normal positions, through pain-free mobilization.

The mobilization of the Occiflex can be categorized as working through grades one to three (mid-range mobilization), according to the 5-Grade Classification System described by Geoffrey Maitland, a leading researcher in joint mobilization techniques (see figure 4). As a result, the Occiflex automated treatment table enables the therapist to implement mid-range mobilization techniques more accurately, slower and for much longer than previous therapy options allowed.

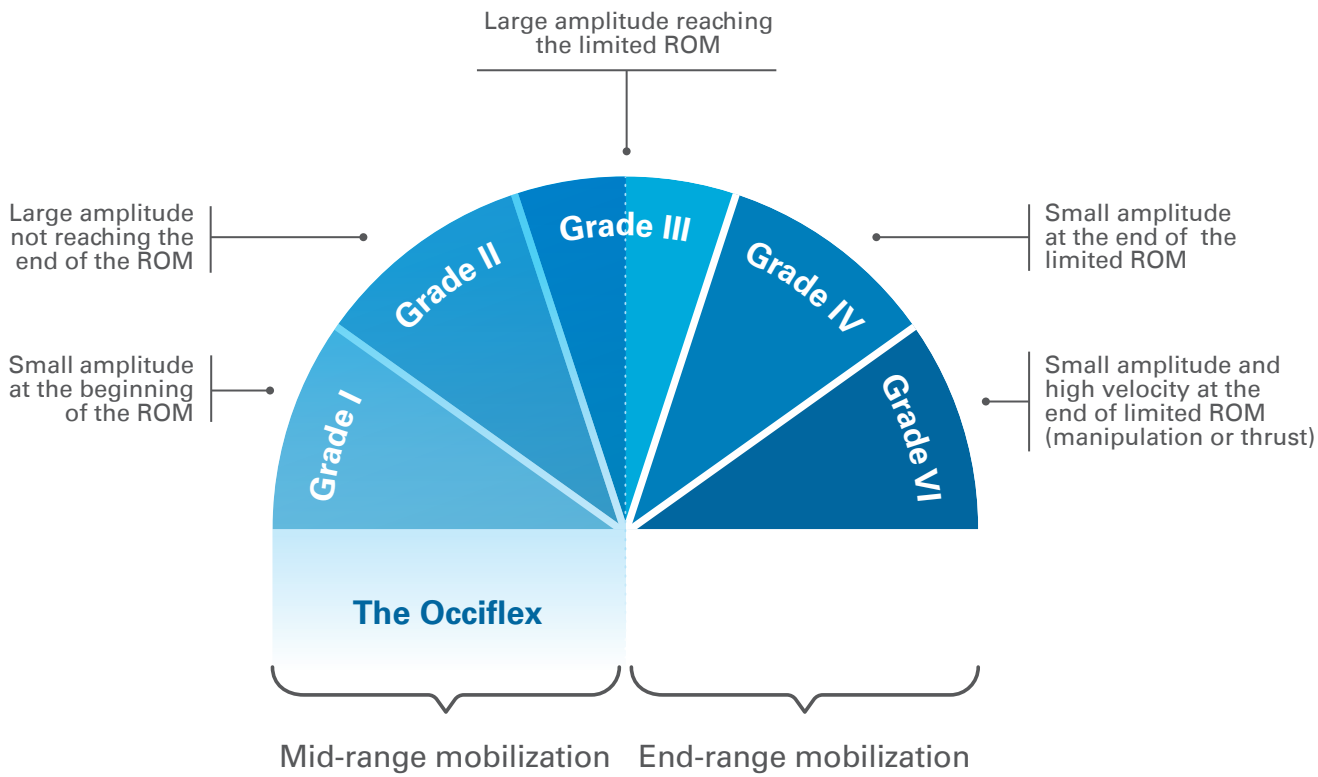


Figure 4: Maitland's 5-grade classification system

Enhancing mid-range mobilization effectiveness: How it works

The underlying mechanisms behind the effectiveness of the Occiflex, to deliver improved outputs through mid-range mobilization, are still not fully understood.

However, it can be hypothesized that the Occiflex works through three main mechanisms:

Three ways the Occiflex works:

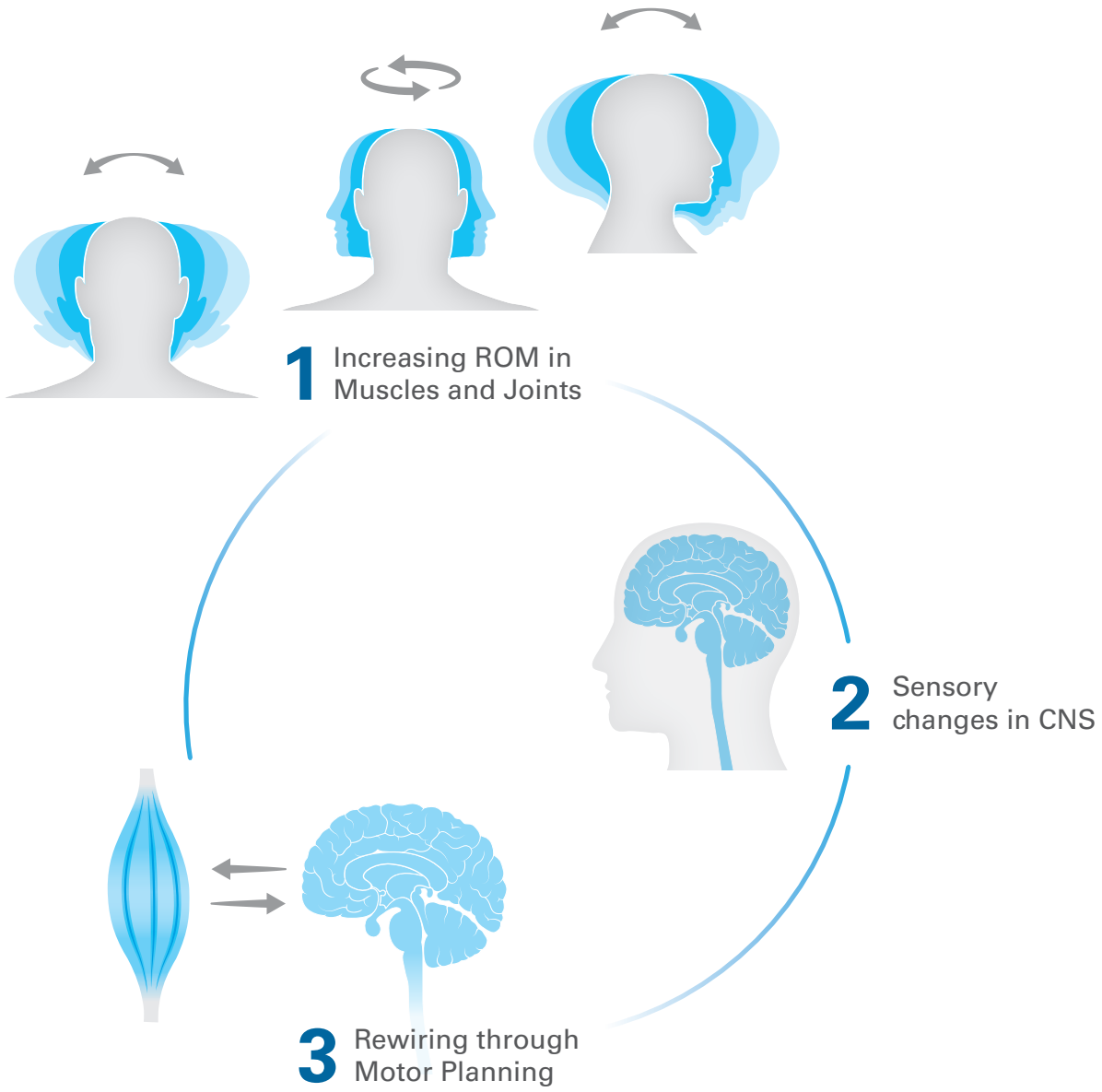


Figure 5: Three ways the Occiflex works

Increasing ROM in joints and muscles

The Occiflex's smooth, sustained pain-free mobilization enables a patient to relax more deeply than was originally possible. This more relaxed state, combined with precision mobilization by the Occiflex, enables more accurate stretching of the neck muscles back to their original physiological length. This controlled muscle stretching also reduces the innate contracting force of over-contracted muscles, leading to an overall increase in the range of motion in the muscles and joints. Consequently, normal neck posture is restored, which further helps to reduce the load on other muscles (particularly extensor muscles), leading to a decrease in chronic neck pain.

Movement of joints

The movement of joints (facet, and uncovertebral joints) not only allows movement in various segments, but is also a source of proprioceptive information. This information allows both sub-conscious and conscious position sense of the relative orientation of the head and neck in space, and in relation to the shoulder girdle. Different receptors transmit the position and movement of joints to the CNS. These receptors each adapt differently to movement with respect to: range, velocity and beginning or end of movement.

It appears that during slow mobilization techniques, there is less activation of nociceptive receptors. Consequently, there is less pain and more tolerance to neck movements.

By experiencing less pain (due to reduced nociceptive stimuli) on moving the neck, movements are tolerated more easily, and movement experience is built up, that is not directly perceived as threatening.

Improved muscle functions

Muscles govern the movement and posture of the head and neck. Neck posture can negatively affect the relationship between the muscle moment arm, and its force production. Abnormal neck posture caused by muscle shortening can gradually lead to neck immobilization, muscle atrophy and changes in the proportion of type II fibers to other muscle fibers. Conversely, muscle stretching, returning the muscle to its normal length, can lead to muscle hypertrophy. More muscle sarcomeres are added, establishing a more normal length-tension relationship, and a transition from type II to type I fibers[25].

Muscles contain specialized sensory elements, muscle spindles, that continuously generate information about the length of the muscle. When muscles are in a short abnormal state, or when they are relatively immobilized, less information is conveyed to the CNS, and there is a reduced ability of the brain to perceive the actual position of the head and neck. Mobilizations can help change the position of joints and the length of muscles. Furthermore, they can also increase the amount of information that reaches the CNS, helping improve motor planning, movement and posture.

25. Oatis C. Kinesiology : the mechanics and pathomechanics of human movement. 2004 Lippincott Williams & Wilkins, c2004

Sensory changes in CNS

Central sensitization is known to be associated with the development and maintenance of chronic neck pain. Manual mobilization therapy, alongside its peripheral effects, is known to also produce central analgesic effects. However, the short-term nature of the central analgesic effects of manual therapy may limit its clinical utility as a treatment strategy for desensitizing the CNS. Further research is needed to examine whether manual therapy has the capacity to result in long-term activation of descending anti-nociceptive pathways[26].

The Occiflex, on the other hand, provides mid-range neck mobilization for far longer than was previously possible. This long-term treatment may mean that more sensory information (proprioceptive information detected by the peripheral joints, muscle spindles and tendons) is received by the CNS. This allows a more precise sensory motor integration within the CNS, and consequently, leads to a reduction in central sensitization of pain mechanisms. As such, new movements are less painful – a reduction in kinesiophobia – and a positive pain-free cycle is achieved, that causes more in-depth mobilization and improved effectiveness of further treatments.

Rewiring of motor planning

Predictable, repetitive and sustained neck mobilizations by the Occiflex may help to return a patient's basic CNS motor planning, back to its natural pain-free physiological representation. Consequently, voluntary neck movements can be implemented more accurately and normal neck posture can be better maintained during the course of daily life.

The above theories on the possible effectiveness of the Occiflex method are backed up by a growing body of supportive clinical evidence. In their meta-analysis, Schmid et al[27]. make an emphasis on the compelling evidence for a CNS component in the response to passive cervical mobilization. They make an argument in favor of a paradigm-shift in manual therapy, based on an alternative neuro-physiological model, in which passive manual mobilization has a more profound effect on the CNS, rather than isolated effects on muscles and joints.

Passive-assisted mobilization

During our initial trials with the Occiflex, we realized that the majority of patients move their head and neck in the direction of the cradle, despite the instructions to fully relax. Thus, in essence, every passive mobilization is indeed a passive-assisted mobilization at the initiation of treatment. However, there is great advantage in giving the patient a different instruction: that is to move in the direction of the cradle, either with eyes opened, or closed.
By doing so, large motor networks in the brain are activated, coupled with sensory brain networks. Since the condition of patients with neck pain and headache is typified by limited execution of neck movements, there is a gradual reduction of the neck's motor representation in the cerebral cortex. Passive-assisted mobilization can reestablish a more normal motor representation. In addition, physical therapy literature suggest that active neck movement is superior to passive mobilization, in the restoration of function and the reduction of pain. It is also possible to combine in the same treatment both passive and passive-assisted mode, by simply changing the instructions given to the patient.

26. Nijs J, Meeus M, Van Oosterwijck J, Roussel N, De Kooning M, Ickmans K, Matic M. Treatment of central sensitization in patients with 'unexplained' chronic pain: what options do we have? Expert Opin Pharmacother. 2011 May;12(7):1087-98.
27. Schmid A, Brunner F, Wright A. et al. Systematic review Paradigm shift in manual therapy? Evidence for a central nervous system component in the response to passive cervical joint mobilization. Man Ther 2008(13)387–396

Muscle energy techniques

A manual procedure involving the voluntary contraction of skeletal muscle against the resistance of the practitioner. Initially developed by Dr. Fred Mitchel in the 1950s, the technique involves short periods of isometric contractions that lasts several seconds, repeated several times[28]. It allows the training of muscle with disuse atrophy, and allows the relaxation of antagonistic muscles for improved passive mobilization that follows muscle contraction. The Occiflex can help perform these muscle energy techniques. During the Occiflex treatment, the patient is instructed to fully relax, until the movement of the cradle stops. Once stopped, the patient should be instructed to make an isometric contraction of different muscle groups (according to the intentions of the therapist).

For instance, to lengthen the Trapezius muscle, the neck can be mobilized in a flexion movement, interrupted by short periods of isometric neck extension. Once the cradle starts to move again, the patient should fully relax again. With the same example in mind, we can ask the patient, to slightly lift his head up (not an actual movement, but merely carrying the head and neck weight). When the cradle moves again, the patient should be instructed to fully relax. This type of treatment could increase the muscle mass of deep flexor muscles (if the patient is instructed to perform capital flexion). In parallel, it may reduce the tension in the extensor muscles, the antagonistic muscles to capital flexion. These cycles, of isometric contraction and passive mobilization, can serve as a very powerful tool, in restoring the proper functions of muscles (both their gross motor strength and the ability to fully relax and lengthen).

The Occiflex cradle was not designed to withhold against pressure. However, mild pressure can be applied as elaborated above.

Segmental mobilization techniques

Although the Occiflex was developed as a tool for non-segmental mid-range mobilization, the manual procedure of segmental mobilization is still possible with certain adaptations. To program the correct therapeutic movement at every level of the neck, a number of arthrogenic physiological properties of the spine must be understood.

The neck can be divided into three regions: Upper Cx (UCx), Mid Cx (MCx) and Lower Cx (LCx). At the mid and lower level, the intervertebral joints reach their end position on flexion, whereas at the upper level, the arthrogenic end position is reached by extension. In these end positions, rotation and side flexion are no longer possible. When using the Occiflex, these "stressful" locked positions should be avoided.

To focus the movement of the Occiflex on a sub-region of the neck, the other levels of the spine must be brought into a position whereby there is limited movement at these levels except for the target segments. This is certainly true for rotation mobilizations, which in the neutral position of the spine can influence every segment of the Cervical Spine.

For a successful segmental mobilization, it is important that the chosen mobilization involves the segment to be mobilized. In addition, it is important that the tissue that is mobilized (stretched) is given the opportunity, according to the principle of viscoelastic properties (see section 'Viscoelasticity during mobilization', for concept definition), to go along with the mobilization. The chosen speed and repetition of the mobilization play a key role in the occurrence of the "creep phenomenon" whereby the mobilization occurs.

28. Fernandez-de-las-Penas C, Chaitow L, Schoenen J. Multidisciplinary management of migraine: Pharmacological, manual, and other therapies. Jones & Bartlett Publishers 2013. Chapter 16: muscle energy techniques (by Fryer G.)

Mobilizations at LCx: C5-C7

The LCx (Lower Cervical Spine) is defined as a functional unit starting from the superior articular process of C5 to the inferior articular process of C7. In a Lower-Cervical problem requiring the therapeutic movement of rotation-side flexion, the neck is brought to Mid-Cervical level in flexion and at Upper-Cervical level in extension. As a result, no more movement is possible at the Mid- and Upper-Cervical level. The therapeutic movement is subsequently performed by directing the point of rotation of the mobilizing movement at the Lower-Cervical level.

By clasping the neck at Mid- and Upper-Cervical level with both hands, and moving this as one fixed part, the mobilization is focused on the target area of the LCx (see figure 6). On playing the "Teach", the movement will now arrive at the desired region (provided that the patient's head is securely immobilized in the cradle). By the so-called principle of coupled motion[29] in the Lower-Cervical region, the idea that one motion cannot be produced without the other, namely side flexion and ipsilateral rotation, the therapist can change the desired mobilization by varying the ratio between said movements (see figure 7). Of note, there will be 1 degree of coupled rotation for 7.5 degrees of side flexion. The range of coupling decreases as we go down from C2 to C7[30]. Also at the lower part of the Cervical Spine, ventral and dorsal translations will occur with respective flexion and extension movements.

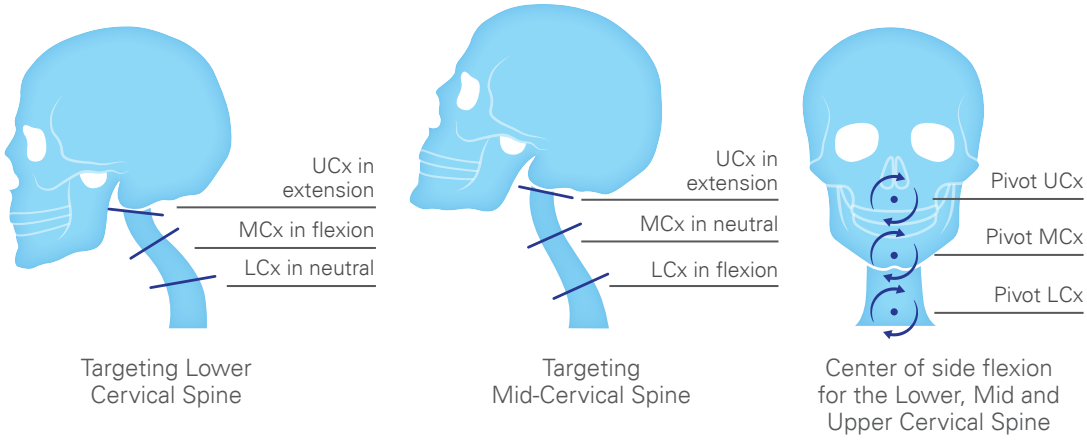


Figure 6: Positioning the Cervical Spine ready to 'Teach' the Occiflex a side flexion and ipsilateral rotation.

Mobilizations at MCx: C2-C5

The MCx (Mid-Cervical Spine) is defined as starting from the inferior articular processes of C2 to the upper articular processes of C5. If the problem is diagnosed in the Mid-Cervical Spine, this area can be isolated for mobilization techniques, by bringing the higher-cervical region in an extension position, and the Lower-Cervical part in a flexion position. By choosing the point of rotation in the mid-cervical region, a movement to side-flexion will mainly take place in the intersegmental levels of C2/3 till C4/5. Due to the physiological coupling of movements, a side-flexion will be accompanied by a ipsilateral rotation movement and vice-versa. Just as in the Lower-Cervical region. For each degree of rotation we find a coupled motion of 0,75 degree of ipsilateral side flexion[31].

29. Blauvelt, C. T., & Nelson, F. R. (1994). A manual of orthopaedic terminology (5th ed., pp. 344-352). St. Louis: Mosby.
30. Lysell E Motion in the cervical spine. An experimental study on autopsy specimens. Acta Orthop Scand. 1969:Suppl 123:1+
31. White A, Panjabi M Clinical Biomechanics of the Spine Lippincott Williams & Wilkins 1990.

Mobilizations at UCx: C0-C2

The UCx (Upper-Cervical Spine) is defined as starting from the articular condyles of the Occiput to C2. In the Upper Cervical Spine, the coupling of movements between rotation and side flexion is opposite in direction. Initiating a movement of side flexion is accompanied by an ipsilateral rotation of the vertebrae of the Upper Cervical Spine, and vice versa. This phenomenon will occur independent of the position in the sagittal plane (i.e. flexion, neutral or extended position of the cervical spine). At the end-range of extension, the Upper Cervical Spine will come to a locked position where there is no room for side flexion and rotation.

A rotation mobilization for the right part of C0/1/2 takes place by introducing a side flexion to the left with a rotation to the right (note that we stay within 45 degrees rotation so that we do not place too much strain on any structure in the upper part of the neck). By performing extension and flexion in this three-dimensional movement, the therapist can vary the degree of mobilization.

By applying the abovementioned mobilization principles, and by performing small partial movements, the load on the vascular structures in the neck can be reduced. Consequently, the safety of the Occiflex therapy is increased.

In order to achieve Upper Cervical Spine mobilization, it is recommended to start from a flexion position in the mid and Lower Cervical Spine.

Functional aspects of segmental mobilization

In addition to the mechanical phenomena that occur during elongation, there is also the matter of neuromuscular adaptation.

An important factor is occurring pain, that is delivered via nociceptors in the joint capsules, ligaments and muscles around the joint. By carrying out a slow mobilization, whereby the tissue is given as much opportunity as possible to lengthen itself according to the viscoelasticity principle mentioned below, pain is kept within limits. This assumes, of course, that there is no serious pathology, which stands in the way of the mobilization.

In our daily functional movements of the head and neck, we are not aware of the above described coupling of motions. We also do not realize that a lot of our movement behaviour is in fact based on this phenomenon. If we for instance look up at the sky, we seldom only make an extension of the cervical spine, but also a small side-flexion of the upper cervical spine with a contra-lateral rotation with extension. If we continue our view upwards and behind us, the side flexion and rotation will give place to even more extension. On looking downwards we follow more the principles of the lower- and mid-cervical region by combining flexion with a ipsilateral coupling of side flexion and rotation. Surprisingly the latter mentioned movements will give less stress to the vertebral artery. This is stressed more with a combined movement of extension, side flexion and ipsilateral rotation and flexion, combined with side flexion and contralateral rotation[32]. In our therapy section we will use this knowledge to ensure a safe way of handling our patients.

32. Hagenaars LHA, Bos JB De halswervelkolom nekklachten en fysiotherapie 2008

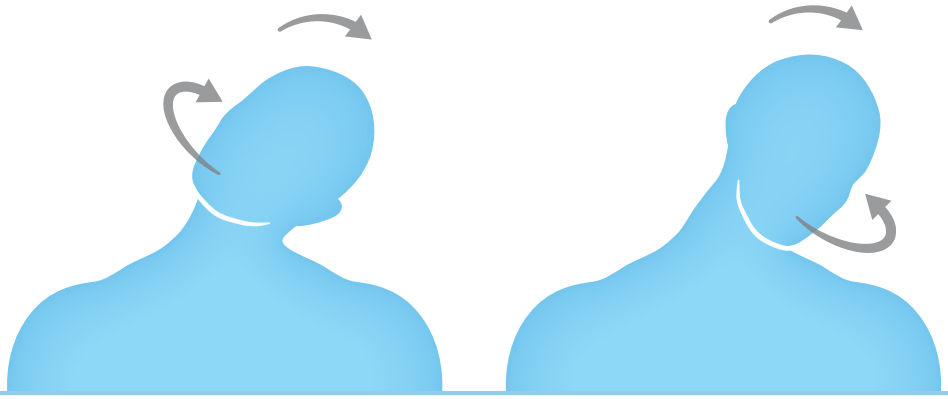


Figure 7: Functional coupled motions

With a maximum of side flexion of the total cervical spine in all regions, the side flexion will be coupled with an ipsilateral rotation in the middle and lower regions, and with a contralateral rotation in the upper region. The coupling of motion in the upper, middle and lower part will result in a side flexion with the subject facing forward during the whole range.

In the therapy section we will learn that this combination of directed movement can be used as a strong mobilization tool for restricted joints in the Cervical Spine. By combining different midrange directed movements, the capsules and ligaments of the joints will be effectively stretched.

Viscoelasticity during mobilization

It is clear that mobilization is enabled by a basic property of soft tissue that is viscoelasticity.

Viscoelasticity is the property of materials that exhibit both viscous and elastic characteristics when undergoing deformation. Viscous materials, like honey, resist shear flow and strain linearly with time when a stress is applied. Elastic materials strain when stretched and quickly return to their original state once the stress is removed. Viscoelastic materials have elements of both of these properties and, as such, exhibit time-dependent strain.

To understand what actually happens outside of the intra articular structures during joint mobilization, the characteristics of ligamentary and musculotendinous structures must be understood.

Ligaments and musculotendinous tissues have viscoelastic properties, thus, display time-dependent and load-history-dependent mechanical behaviour[33]. Eyal Lederman[34], in his textbook The Science and Practise of Manual Therapy, describes the principle for stretching ligamentous and musculotendinous tissue. The viscoelastic properties of biomechanical tissue is understood as a combination of an elastic characteristic and a viscous characteristic.

33. Provenzano P, Lakes R, Keenan T et al. Nonlinear ligament viscoelasticity. Ann Biomed Eng. 2001 Oct;29(10):908-14.
34. Lederman E. The Science & Practice of Manual Therapy, 2nd Edition Churchill Livingstone 2005

Stretching of biomechanical tissue can be best understood if we divide this process into three phases:

Phase 1: Toe region

Stretching requires no force, the collagen fibres are pulled up to their original length: "taking up the slack".

Phase 2: Elastic phase

Stretching where stress is applied to the tissue. Applying constant tension during the elastic range will lead to "Creep deformation": The tissue will give way and lengthen without the need to increase force.

The viscoelastic response of muscles, tendons, and ligaments means that a slow stretch will create less tension than a faster stretch to the same length. Different tissues (i.e. mucsles, tendons, joint capsule) have different viscous-elastic properties, which is dependent on the concentration and proportion of collagen and elastin fibres. Stretching is time-dependent, slow stretch enables the tissue to lengthen better than a fast stretch. Muscle tissue will "give" more easily than ligamentous tissue. After a few repetitions, the tissue sets itself and will adapt to the new situation. This newly achieved length should be exercised to maintain it. There is also a neural component in the process of adaptation, which is related to a new threshold of muscle spindles, and the Gamma motor neurons.

Another phenomenon, which occurs in this phase, is: "Force Relaxation". This is experienced if we maintain a "hold" in the elastic range or at the end of range, and manifests itself by diminishing resistance.

Phase 3: Plastic Phase

Stretching at the end of range where some collagen fibres reach their maximum and tear. Continued force will cause more and more fibres to rupture. Midrange, slow mobilization with the Occiflex device will help therapists to avoid reaching this plastic phase.

Preparing to use the Occiflex

Before treatment is provided, the therapist is required to examine the patient, acknowledge imaging and EMG data if available, in order to direct the therapy with regard to a putative mechanism.

If a segmental mechanism is responsible for the pain and disability, therapy should be essentially a segmental mobilization. If however, myofascial pain syndrome with trigger points and muscle dysfunction is the leading cause of pain, mobilization should be directed at lengthening the involved muscles and increasing muscle bulk, with Occiflex based muscle-energy techniques and supplemental, home exercises.

Often, when the patient is examined an abnormal neck posture is realized. This could be a manifestation of avoidance pain behavior, muscle imbalance or segmental joint pathology. The abnormal posture can aggravate pain and disability, by imposing an abnormal load on muscles/joints and should be corrected. For example, for a patient with significant forward neck tilting, over-contraction of the sternocleidomastoid and relative weakness of the Longus Coli muscle. Treatment could be performed with the patient instructed to assume capital flexion. Whilst at the same time, bilateral mobilization is performed with the aim to lengthen the sternocleidomastoid muscles.

If neck pain is associated with significant radicular-neuropathic pain, mobilization should not exacerbate the pain at all. It should be of relatively small range, and away from the side of pain in many patients. In addition, Occiflex treatment can be combined with selective nerve roots blocks, and necessary changes in life-style (e.g., avoidance of carrying heavy loads, too long periods in front of computer). Isometric home exercises to increase the neck muscle bulk, and exercises to increase the cervical range of movement are also warranted.

Therapy with the Occiflex should not stand alone but rather it should be accompanied by other measures such as trigger point injection, facet joint blocks, Occipital nerve blocks, analgesic drugs, home exercises, acupuncture, other physical therapy techniques and necessary changes in lifestyle (e.g., avoidance of carrying heavy loads and ergonomic work environment modifications).

Start position

In the "Teach" phase, the recording should start and end at roughly the same position. However, this position can be either a neutral position or a non-neutral position. Thus, the Occiflex offers us the choice to:

a. start the movement sequence from a neutral position; or
b. start from a pre-chosen treatment position (non-neutral position).

Option a, is most suitable for non-segmental myofascial syndromes, where lengthening of the involved muscles, and the actual movements are the most important therapeutic input.

Option b may be perceived as more intense because the number of movements are carried out in a shorter time, and therefore, do not continually return to the neutral position. It can also offer a solution for patients who find larger movements of the head an unpleasant experience. For instance, when dizziness is the result of larger movements, a restricted movement starting from a non-neutral position could be advantageous.

Teach:
Before recording the movements (this recording phase is called the "Teach"), a number of questions must be asked:

Important therapy questions

Are we going to work in one or more axes?

The therapist can choose to work in one axis if a high SIN-factor is observed, or from a medical point of view, when in our judgement, the risk of treatment is somewhat increased. Multiple axes can be used in the case of a low SIN-factor. It should be noted that the movement in the sagittal axis (flexion/extension) and a rotation from neutral position are both single axis movements. As discussed during coupled movements, side flexion from a neutral position is always coupled with rotations and therefore concerns a multi-axis movement.

Do we start the movement from a neutral zero-position, or do we begin the movement from a pre-chosen position, whereby one or two sub-regions are already brought to the end position?

This choice can differ greatly per person. A movement sequence with a neutral zero-position will take longer because the movement sequence is longer. On the one hand, it delivers more desirable proprioceptive stimuli, but on the other hand, it will have a greater impact on the vestibular organs. An advantage of a neutral zero-position starting-point is that this position is the most relaxing, and has a higher chance of relieving kinesiophobia. Patients who are very sensitive to movement will receive fewer stimuli if the zero-position is located closer to the target movement. In the development of therapies per related disorder, (e.g., post-whiplash injury), it is recommended to set the zero-position close to the target movement. The therapist can modify the treatment by adjusting the angular velocity.

At which level of the neck do we focus our movements?

If there is a clearly-defined diagnosis with a clearly-defined region in which the cause is located, it is possible, after an initiation of movement, to direct the focus to a sub-region of the neck. The introductory movement is a neutral movement on the Occiflex, allowing time to get used to the automated movement.

With less clearly defined disorders that can be provoked by neck movements, but do not have a direct cause in the neck, such as migraine and TTH, it is quite possible to perform a gentle single-axis motion without focusing on any sub-region.

Do we stay under the pain provocation level with our movements or do we accept moderate pain?

Depending on the SIN-factor of the complaint, we try in our motion study to reproduce the pain complaints of the patient. With a high SIN-factor, a provocation of pain may exacerbate the complaint. To prevent this, the therapist must adapt the movement sequence with the Occiflex so that no pain is provoked.

Our initial trials with the Occiflex device and our accumulating experience have shown us that even mid-range mobilization in the non-painful range, can bring about significant improvement.

If however the patient has a moderate SIN-factor and if after provocation the pain immediately decreases, the therapist can go a little further in their provocation of pain during the playback of the Occiflex. The pain must always remain within acceptable limits. As soon as the pain evokes a stress reaction, the mobilization is counterproductive.

Do we move in the direction of the provocation or away from it?

Here again there is a strong relationship with the SIN-factor. A high SIN-factor forces us in the first instance to move as much as possible away from the pain. Depending on the severity and nature of the complaint, the therapist can choose per treatment to focus the movement sequence in the direction of the provocation, or to repeat a number of sessions. Each time, guided by the progression, the therapist can shift the boundary a little.

With complaints in which the "mechanical interface" of the exit site from the nerve root plays an important provoking role (where the patient does suffer from neuropathic radicular pain), this can mean the movement from and to the provocation is not straightforward. The space reduction of the mechanical interface causes a provocation of pain (this is a movement in the direction of the pain). Due to side-flexion movement of the neck away from the pain, there occurs an elongation of the nerve root, and as a result, pain provocation. This makes the choice complex. In these cases it is prudent to choose a movement either away or towards the painful side, which will not provoke the pain. (See also the choice of therapy for mechano-sensitivity of nerves).

What speed do we choose for our therapy?

Per treatment session, the therapist can set the angular velocity in every movement. Here

also, the SIN-factor of the complaint guides us. It is usually recommended to work in an angular velocity below 1.5 deg/sec, and in most cases around 1 deg/sec. However, in patients with high SIN factor it is usually recommended to prescribe slow movements (around 0.5 deg/sec). In patients with low SIN factor, angular velocity can be as high as 2 deg/sec. As a rule, a higher frequency would increase the chance of adverse effects. In younger patients, with completely normal imaging studies of the cervical spine, and in certain conditions (e.g., tension-type headache), higher angular velocity, up to 2.5 deg/sec might be of benefit.

What other therapies are important?

1. Exercises aimed at increasing the endurance of deep flexor muscles
2. Exercises to reduce tension in the extensor muscles
3. Exercises meant to increase the neck range of motion in all three axes
4. Exercises to reduce tension in the masticatory muscles (since bruxism and neck pain are interrelated disorders).
5. Relation techniques, such as yoga, guided imagery, meditation etc.
6. Other therapies such as trigger point injection, facet joint blocks, Occipital nerve blocks, analgesic drugs, acupuncture, other physical therapy techniques and ergonomic work environment modification.

What advice do we give our patients (including homework exercises)?

Often daily activities and posture are partly to blame for the onset of complaints and/or for maintaining these complaints. It is up to the therapist to investigate this thoroughly with the patient. It is useful to inform the patient well on this topic, and to give him the assignment to critically examine his daily actions closely. Together, the therapist and the patient, can figure out what alternatives there are in his daily actions to prevent provocation. Incorrect position of the neck during office work in front of a PC screen are notorious causes of chronic neck pain and headache. Other daily activities can also cause neck pain, such as sleeping on the stomach. Here the neck is forced for a long time in a static position into a full rotation with extension. This is a notorious cause of neurogenic compression along the mechanical interface from Mid-Cervical to Lower Cervical.

Treatment recommendations
with the Occiflex

Neck pain	Nociceptive and referred pain
	Myofascial pain syndromes (MPS) and trigger-point-related pain
	Neuropathic pain
	Mechano-sensitivity of nerves
	Degenerative conditions of the spine (Arthrogenic)
	Whiplash-associated disorders

Headaches	Cervicogenic
	Migraine
	Tension-type

	Cervicogenic dizziness

All shown treatment recommendations are based on current experience using the Occiflex. They are guidelines to be interpreted and changed, based on a therapists own experience from working with the Occiflex.

Neck pain

Nociceptive and referred pain

When treating patients with nociceptive neck pain we should define the origin of pain: muscle, disc, joint etc. In addition, the therapist should distinguish between the source of pain and referred pain. The treatment target is the disrupted anatomical region. When nociceptive pain is confined to a joint or a specific disc, segmental mobilization is often helpful. However, even if the source of pain were localized, nociceptive pain would give rise to referred pain and to muscle dysfunction, which would benefit from non-segmental mid-range mobilization.

Symptoms		Tests	Variables		Occiflex therapy
Pain referred to face and vertex	High SIN	Positive extension-rotation test	Inflammatory pain Continuous pain Inter scapular pain (referred from intervertebral discs)	Low Impact	**UCx:** Start pos.: flexion, mid- & low-Cx, UCx side-flex w/ contral. rotation, mobilize: UCx Flex- Ext.
Local pain with referred pain. Pain is not extending to arms (acc to Bogduk)		Manual spinal examination (intervertebral PA's and AP's)			**MCx:** Start pos. from ext. UCx & Flex. LCx, Mobilize: LF ipsilat. Rot. - away from pain - towards pain
Local neck pain (no referred pain)	Low SIN	Cervical palpation on intervertebral facet joints	Local pain	High Impact	**LCx:** Start pos.: from ext. UCx and flex. LCx, Mobilize: LF, ipsilat. Rot - away from pain - towards pain

Treatment recommendations: Nociceptive and referred pain

Myofascial pain syndromes (MPS) and trigger-point-related pain

MPS is perhaps the most responsive pain syndrome to the Occiflex therapy. In most patients, significant pain relief is observed after the first treatment session. In order to provide proper treatment with the Occiflex device to patients with MPS, it is crucial to identify the involved muscles, and to document the presence of active and latent trigger points. Often, the therapist will identify trigger points belonging to the same functional group (e.g., Levator Scapula and Scalenus muscles which bring about side flexion). Before the treatment, the therapist should remind himself of the origin and insertion of the involved muscle. This will enable him to apply mobilization in the teach phase, which would truly lengthen the specific muscle. Two techniques are suggested:

First – repetitive oscillatory movements, which would lengthen one or more muscles (usually in the opposite direction of the functioning of the contracting muscle). This movement could be non-segmental when dealing with muscles that span several segments, or all the length of the cervical spine, such as the Semispinalis Capitis, Trapezius and Levator Scapula. Alternatively, segmental mobilization when dealing with muscles that span one or two segments only, such as the Sub-Occipital muscles (e.g., oblique inferior and superior).

There are several choices:

1. Start with a minimal movement and gradually increase it.
2. Start with the full range required, and keep it for the rest of the recording.
3. Use "1" or "2" abovementioned, but add a plateau phase of a few seconds between the active movements.

Second – use of muscle energy techniques. These techniques allow us to achieve three goals: 1). Strengthen the involved muscles; 2). Bring about better relaxation of the involved muscles when the antagonistic muscles are contracting; and 3). Increase the proprioceptive information sent to the CNS from the involved muscles.
This method is different form passive mobilization. Instruct the patient to move his head and neck in the direction of the cradle – even if the patient is completely passive. We have observed that they tend to actively follow the cradle movements, especially during the initial therapeutic sessions.

A different option is to instruct the patient during the Repeat phase, to actively contract the neck whenever the cradle stops moving. These breaks in the movement of the cradle should last no longer than 10-15 seconds, and should have a clear therapeutic goal, that is, to reduce tension in the muscle that antagonizes the direction of mobilization, or, to train and increase the endurance of the muscles that contain the trigger point, and that are directly related to MPS.

For example, for a patient with MPS that involves the right levator scapula muscle. The proper treatment of this patient should include mobilization of the neck with left side flexion, and additional sagittal flexion. During the mobilization, two or more breaks in the movements can be provided in which the patient is instructed to activate the muscles that move the head in the direction of the recent mobilization. This active movement will provide a relaxing input to that muscle. The same patient could benefit from a different approach. That is, to antagonize the movement of the cradle in each break of the mobilization (to activate the right levator scapula muscle). This would bring about alternating periods of activation-relation of the involved muscle, which would better restore the function of the muscles involved in MPS.

The treatment of MPS should include additional measures aside from the Occiflex treatment: strengthening of muscles, which were under-activated. For instance – strengthening of the deep flexor muscles in patients with forward neck tilting, and over activation of the sternocleidomastoid muscles. Trigger point injection of the involved muscles, and critical evaluation of the patient's behaviour at home and working environment, in order to identify abnormal movement patterns and postures.

How many treatments are required for a patient with MPS?
The answer to this question depends on the chronicity, severity, additional underline pain mechanisms (e.g., degenerative spine disease) and finally the motivation of the patient to perform home exercise and to cooperate with his therapist. Initial therapy requires sessions that last about 20min once or twice a week, for 4 to 8 weeks. Once the patient recovers, at times, additional maintenance treatment could be provided every couple of weeks for a few months.

In most patients, extreme mobilization is not required. In fact, it could be counter-productive. The range of the mobilization should be sufficient to lengthen the involved muscles. Obviously, as the patient gets better, repeated recordings could use different mobilization directions to treat other muscles, which often contain latent trigger points that now become active trigger points in the same muscle or adjacent muscle.

As an example of the complexity of treatment of local muscles, we will describe MPS of the Obliquus Capitis Inferior. The Obliquus Capitis Inferior is an important muscle in the Sub-Occipital space and is mainly involved with rotation of the neck. The muscle spans between the lateral transverse process of the Atlas and the spinous process of the Axis. Due to its transverse position and the long lever of both the spinous and transverse processes, it provides rotation in the Atlanto-Axial (AA) joint. The AA joints can span 45 degrees of rotation towards each side. Contraction of the M Obliquus Capitis Inferior induces rotation towards the side of its location.

Together with the M Obliquus Superior and the M Rectus Capitis Major, the muscle forms the Sub-Occipital Triangle. These three muscles are synergists in rotation, extension and rocking the Occiput. Possibly, they are responsible for some action in the contralateral side-flexion of the Occiput during rotation, by initiating the Atlas to translate with the Occiput towards the contralateral side. In recent years, it appears that these muscles have in addition to their mechanical roles as rotators, also a role in attaching the dura in the Upper Cervical spine to the posterior wall of the spinal canal. This role is fulfilled with specialized myo-dural bridges. Two additional aspects that should be noted with regard to this muscle is that it contains abundant muscle spindles. These probably provide the CNS with information on the length between the posterior spinous process of C2, the lateral spinal process of C1 and possible information on the position of the dura. In recent years, it has been found that patients with chronic neck pain have atrophy and fatty replacement of this muscle.

Subjective and Physical signs: the muscle can provoke a local palpable pain in the region between the spinous process of the Axis and the transverse process of the Atlas. When the muscle has an active trigger point, the pain is referred to an area dorsal and ventral to the upper auricle.

Differential test: on performing the Flexion-Rotation test, the AA joint will be provoked by an ipsilateral rotation and will give, when restricted, a hard end-feel. The M Obliquus Capitis Inferior will give when shortened, a contralateral restriction with a smoother or soft end-feel.

Our therapy will be different. For the AA joint we will direct ourselves to the physiological action of this joint, with a coupled movement of side flexion, and a contralateral rotation performed in flexion and extension (anteroposition and retroposition) in the Sub-Occipital region (see also chapter Cervicogenic headache).

With an active trigger point or a strained M. Obliquus Inferior, we will perform a contralateral rotation with a starting position of flexion of the mid and Lower Cervical Spine.

Of note, the majority of MPS in the neck area do not require segmental mobilization, but rather will respond to non-segmental mobilization, which stretches the involved muscle.

Symptoms		Tests	Variables		Occiflex therapy
Dull pain	High SIN	Trigger point: when palpated, reproduced the patient's pain.		Low Impact	Limited movement in 1 or 2 axes in order to stretch the muscle that contains the trigger point. Passive-assisted (up to 1 deg/sec)
Pain exacerbated in certain neck position and movements		Trigger point disappears upon injection			3D complex movement that stretches several muscles contain trigger points (up to 2 deg/sec)
	Low SIN	Limited neck ROM in the direction that stretches the involved muscle, with soft end-feel		High Impact	Muscle energy techniques

Treatment recommendations: MPS and trigger-point-related pain

Neuropathic pain

The Occiflex device can treat neuropathic pain, however the SIN factor must be considered when choosing this treatment mode. Excessive mobilization can exacerbate neuropathic pain. However, chronic neuropathic pain is often associated with abnormal neck posture and excessive muscle contraction. The posture and the muscle contraction should be the targets of our treatment, while avoiding mobilization, which actually triggers the pain by irritating the compressed nerve roots.

Mobilization is usually away from the side of pain, avoiding extension, and combining rotation and side-flexion, contralateral to the painful side.

Symptoms		Tests	Variables		Occiflex therapy
Radiating pain to shoulders and arms – 1 or 2 dermatomes	High SIN	Nerve provocation test		Low Impact	Low frequency, small amplitude contralateral to the side of pain (0.5 deg/sec)
Sensory changes, weakness, atrophy…		Movement dysfunction in muscles innervated by the provoked nerve			Combined 3D movements contralateral to the pain (0.5-1.5 deg/sec)
Dominant arm pain over neck pain	Low SIN	Abnormal response to clinically relevant upper limb nerve trunk palpation		High Impact	
		Transient sensory disturbance and/or reduced upper extremity tendon reflexes			

Treatment recommendations: Neuropathic pain

Mechano-sensitivity of nerves

Treatment should be based on two factors.

First – avoidance of mobilization, which narrows the inter-vertebral foramen (extension coupled with rotation towards the side with pain)

Second – the actual mobilization should usually reduce trigger points in muscles that are either innervated by the irritated nerve root, or muscles that do not belong to the myotome of the irritated nerve, but contract as part of a guarding posture.

The mobilization should be slow, and should not exacerbate the patient's pain during the treatment. This principle is valid for most syndromes treated with the Occiflex device. However, in this particular case of neuropathic pain, it is of utmost importance.

Symptoms		Tests	Variables		Occiflex therapy
Neuropathic (sharp, burning, lancinating) pain, elicited by movement	High SIN	Nerve provocation test		Low Impact	Low frequency, small amplitude contralateral to the side of pain (0.5 deg/sec)
Paresthesia		Movement dysfunction in muscles innervated by the provoked nerve			Combined 3D movements ipsilateral and contralateral to the pain (0.5-1.5 deg/sec)
Reduced sensation in a dermatomal distribution	Low SIN	Abnormal response to clinically relevant upper limb nerve trunk palpation		High Impact	
		Transient sensory disturbance and/or reduced upper extremity tendon reflexes			

Treatment recommendations: Mechano-sensitivity of nerves

Degenerative conditions of the spine: (Arthrogenic)

Degenerative conditions of the spine can comprise of disc degeneration, facet joint arthritis, or associated muscle dysfunction. These degenerative changes in turn, bring about a harmful modification to the muscle function. If facet joint disorder is the main cause of pain, mobilization should be directed towards the involved facet joint. Often it should be a segmental mobilization to exclude movement in unwanted segments of the cervical spine. Usually, extension should be avoided as it would markedly increase the pain.

If disc degeneration is thought to be the main cause of pain, a combination of two types of mobilization should be employed:

1. Gentle, non-segmental, three-dimensional mobilization to reduce tension in neck muscles.
2. Segmental mobilization particularly of the Mid and Lower Cervical Spine, in order to bring about movement of the involved disc space.

It is believed that gentle movement could improve the condition of the degenerating disc, if there is no extruded disc that compresses the spinal cord of the cervical roots.

Whiplash-associated disorders

With acute whiplash injury, in the absence of neurological deficits, and in the absence of imaging data that suggests structural damage, treatment should increase the range of motion. Starting from a very small amplitude, low velocity mobilization, in one plane, and gradually moving towards larger amplitude mobilization in three-dimensional space.

The initial angular velocity in acute whiplash injury should be as little as 0.5 through 1 deg/sec and stay within the "neutral zone".

Subacute and chronic post-whiplash pain syndrome, is usually associated with muscle atrophy, fatty infiltration of deeply seated muscles, abnormal neck posture, severe muscle hyperalgesia with abundant trigger points, and at times, degenerative changes in one of more disc spaces and facet joints. In a significant number of patients, kinesiophobia is present.

The goals of treatment are to increase muscle bulk and increase the active neck range of movement. Initially, a very slow (0.5 deg/sec) small amplitude, simple movement should be employed in order to reduce kinesiophobia. This should be followed by mobilization, which targets muscle that contains abundant trigger points. Passive-assisted mobilization is also very helpful.

If, at later stages of treatment, the improvement in the neck range of motion, and the increase in muscle bulk are not satisfactory, muscle energy techniques could also be employed.

Symptoms		Tests	Variables		Occiflex therapy
Neck pain	High SIN	Positive neck-flexion test	Dizziness	Low Impact	Slow midrange single axis flexion-extension (0.5 deg/sec)
Occipital pain			Loss of focus		
Dizziness, fatigue		Negative Sharp-Purser test	Fatigue		Moderate slow multiple axis flexion-extension, rotation, side flexion (0.5–1.5 deg/sec)
Reduced neck movements	Low SIN	Reduced segmental and non-segmental neck movements		High Impact	

Treatment recommendations: Whiplash-associated disorders

Headaches

Cervicogenic headache

In most cases the trigger of the occipital headache is either a facet joint, uncovertebral joint and/or trigger point in neck extensor muscles. Accordingly treatment should target the putative source of pain (e.g., joint or muscle). In case the source of pain is one or more facet joints, than treatment should be a segmental mobilization intended to increase the range of motion of the facet joint. One should start with segmental mobilization well within the active non-painful range of movement, and gradually and slowly proceed to a wider mobilization range. If the source of pain seems to be mostly a myofascial trigger point, the specific mobilization should be a movement that particularly involve the target muscle. For example, if a trigger point is found in the Levator Scapulae muscle, mobilization should involve a combination of flexion and contralateral side flexion.

Symptoms		Tests	Variables		Occiflex therapy
Consistent one-sided headache	High SIN	Cervical Flexion-Rotation test < 32 deg (not unique to cervicogenic headache)	Combined with minor autonomic symptoms	Low Impact	UCx flexion / extension. Very low speed (0.5 -1 deg/sec)
Sub-Occipital unilateral neck pain (musculoskeletal)			High frequency		UCx rotation in neutral
No response to Ergotamine or Sumatriptan			Highly irritable		Passive-assisted, using a "plateau phase"
No dominant autonomic symptoms	Low SIN		Low frequency	High Impact	UCx 3D movements
Bilateral in a minority of patients			Not irritable		

Treatment recommendations: Cervicogenic headache

Migraine

The Occiflex device is not a treatment for episodic migraine. Migraine is caused by neurogenic inflammation of the dura and the wall of the large cerebral vessels. Most migraine patients are very sensitive to neck movements particularly during the attacks. As migraine becomes more frequent, a subset of patients develop accompanying neck pain, during the attack, as well as before and after it. Neck pain in these patients is particularly prominent in patients with chronic migraine. That is, patients with migraine who have more than 15 headache-days a month. In these patients, a significant biomechanical abnormality is recognized, and when treated, an improvement in both the headache and neck frequency and severity is observed.

Patients with chronic migraine are often found with trigger points in the Trapezius muscles, Spelenius Capitis, Splenius Cervicis, Semispinalis Capitis, and Sub-Occipital muscles. This sub-group of patients could benefit from a combination of Occiflex therapy, and needling of the trigger points, both performed on a weekly basis. Treatment should comprise of non-segmental, three-dimensional, non-painful, mid-range mobilization, using a slow angular velocity (0.5-1 deg/sec).

The patient should feedback that the treatment is indeed relaxing. Another indication that the treatment is relaxing is that the patient simply falls asleep.

If dizziness occurs (very common in migraine patients), then the velocity and/or range of motion should be decreased.

Treatment should never be provided during an attack.

Symptoms		Tests	Variables		Occiflex therapy
Patients fulfilling IHS criteria for migraine* with neck pain (sometimes with Occipital headache)	High SIN	Normal neurological examination.	Aggravated by physical exercise	Low Impact	Very slow midrange movements (0.5-1 deg/sec). Single axis: flexion / extension.
		Multiple trigger points	High frequency		
Usually patients with frequent migraine (more than 6 headache days / month)	Low SIN		Not aggravated by physical therapy	High Impact	Slow moderate midrange movements (1-1.5 deg/sec). Flexion / extension or rotation from neutral.
			Low frequency		

* Severe episodic headache with nausea, vomiting, auras and oversensitivity to light and noise; Aggravated by physical exercise; One-sided pulsatile pain.

Treatment recommendations: Migraine

Tension-type headache

Patients with Tension-type headache (TTH) usually develop muscle hyperalgesia and muscle trigger points in the following muscles: Frontalis, Temporalis, Trapezius, Splenius Capitis and Sternocleidomastoid. Many patients have forward neck tilting and this is particularly true for TTHs. Patients with TTH, especially the chronic variant, respond to any physical and emotional stress with contraction of Pericranial and neck muscles.

The principles of treatment with the Occiflex:

1. Treatment should be relaxing, pleasant, in the midrange
2. Should target the muscles that contain trigger points
3. Repetitive single axis flexion could be the initial therapy followed by more complex three-dimensionalmovements
4. If possible, mobilization should include Capital flexion – i.e. flexion at the Upper Cervical spine
5. As opposed to patients with migraine, TTH patients tolerate higher angular velocity, and may even enjoy it. Thus, higher angular velocities, up to 2deg/sec can be prescribed.

Symptoms		Tests	Variables		Occiflex therapy
Pressure-like bilateral headache lasting from 30min to 7days, usually without nausea and without photophobia or phonophobia	High SIN Low SIN	Positive invisible pillow test Pericranial muscle tenderness	Aggravated by static physical exercise or neck movements High frequency Not aggravated by physical therapy or neck movements Low frequency	Low Impact High Impact	Mobilization should stretch muscles that contain trigger points Slow midrange movements (0.5-1 deg/sec). one axis, possibly 3D Moderate midrange movements (1-2 deg/sec). 3D movements.

Treatment recommendations:TTH

Cervicogenic dizziness

Before treatment starts, the therapist should identify the movement that elicits the dizziness. Patients should be instructed to keep their eyes open in the beginning of the session. In addition, they should be instructed to actively move their head and neck together with the Occiflex's supporting cradle. After a few moments, they can be asked to close their eyes, but to keep track of the cradle movements.

At the beginning of treatment, the therapist should record movements that do not induce dizziness. Gradually, further recordings should include mobilization in the direction that induces dizziness.

Initial angular velocity should be as small as 0.5 deg/sec. As the patient becomes more tolerant to the therapeutic process, a larger angular velocity may be used. Of note, patients with cervicogenic dizziness have limited range of motion, and an important goal of treatment is to increase ROM (particularly true for the Upper Cervical Spine, since the Sub-Occiptal muscles contain abundant spindles that are an important source of proprioceptive information).

If the treatment is associated with true vertigo, treatment should be stopped, and further treatment with the Occiflex should be avoided.

Symptoms		Tests	Variables		Occiflex therapy
Dizziness, but not vertigo, associated with neck movements	High SIN	Dizziness consistently elicited with certain movements	Aggravated by physical exercise	Low Impact	Single axis, passive-assisted, open-eyes, slow mobilization (0.5-1 deg/sec)
		Limited active neck range of motion	High frequency		
	Low SIN		Not aggravated by physical therapy	High Impact	3D, passive or passive-assisted, moderate mobilization (1-2 deg/sec)
			Low frequency		

Treatment recommendations: Cervicogenic dizziness

Advantages of the Occiflex treatment

The Occiflex has been designed to help therapists overcome several inherent disadvantages of current techniques and improve patient treatment outcomes.

'Teach and Repeat'

The Occiflex uses the advanced 'Teach and Repeat technology' (see figure 8). The treatment table mimics the techniques of a manual therapist and enables the therapist to teach the Occiflex to deliver an automated, tailored patient treatment. As the treatment is now executed without the need of a therapist, the therapist can treat other patients simultaneously. The teach and repeat principle provides a perfect match between the therapeutic intention and the actual mobilization.

Figure 8: The therapist teaches the Occiflex. Treatment executed without the need of a therapist

Minimize adverse effects with slower mobilization

The Occiflex can help a therapist prevent the risk of injury caused by undertaking manual mobilization movements too quickly. High velocity aggressive manipulation or mobilization techniques have been known to cause over-contraction of neck muscles, increased neck pain, or serious adverse effects, such as dissection of the vertebral arteries, dural tear, nerve injury, disc herniation, hematoma, and bone fracture[35].

35. Ernst E. Adverse effects of spinal manipulation: A systematic review. J R Soc Med 2007;100:330–8.

The Occiflex executes neck mobilizations with a lower angular velocity (0.1-2 deg/sec.) and slower accelerations. Clinical trials have shown a reduction in kinesiophobia (fear of movement – often patients did not even know their head had moved) and a greater range of motion was achieved pleasantly[10, 11, 12]. Furthermore, the lower velocity and smooth mobilization of the Occiflex can also help prevent vestibular activation, limiting side effects such as vertigo, nausea and dizziness[36].

Determine patients' conditions with embedded diagnostic tools

The Occiflex can help a therapist gain an in-depth and objective understanding of patients' conditions, over time.

The Occiflex can:

1. Define patients' full range of movement accurately. An objective CROM test takes a couple of minutes at the start of the treatment. The recorded baseline data can provide the therapist with objective data concerning a patient's limit of movement, that complements the therapist's subjective examination. The test can measure both active and passive ROM.
2. Define the magnitude of pain, based on a numeric and visual pain score.
3. Define patients' disability based on neck pain (NDI) and headache (HIT 6) questionnaires.

Implement more accurate changes in the prescribed treatment

The Occiflex sensors can store and track the exact three-dimensional movements (trajectory, velocity, duration) undertaken by the therapist. Therapists can then apply their expertise to fine-tune the recorded movement parameters to build a more precise, smoother and tailored ongoing session. These can then be executed and recorded by the Occiflex. With more objective and detailed information, the therapist can implement highly accurate changes in the degree and speed of treatment, helping the therapist improve patient treatment outcomes and reduce the risk of injury.

Deliver "as long as needed" tailored treatments

Currently there is no literature advising on the desired length of a mobilization treatment session. Until now, the length of a treatment session was defined by the physical constraints of the therapist and usually lasts a few minutes. This can mean a treatment session maybe shorter than desired. The Occiflex's "Teach and Repeat technology" enables the therapist to program an "as long as needed" automated treatment session.

36. Reid SA, Rivett DA, Katekar MG, Callister R. Comparison of mulligan sustained natural apophyseal glides and Maitland mobilizations for treatment of cervicogenic dizziness: a randomized controlled trial. Phys Ther 2014;94(4):466-76.

Tailor the operational modes to the needs of the patient

The Occiflex can help a therapist accurately and expertly treat specific pain types by:

1. Fine-tuning automated recorded movements.
2. Performing passive, active-assisted and mixed mobilizations (interchangeable between the two modes).

Provide consistent treatment sessions

To repeat a treatment session with precision over time is extremely challenging. Further variability between different practitioners within a treatment course can also occur. The Occiflex can help a therapist to automatically execute a pre-programmed and tailored course of consistent treatment sessions.

Enhance monitoring and home follow-up performance

Monitoring: The Occiflex can generate a progress report based on the Numeric Rating Scale (NRS), Neck Disability Index (NDI), CROM test and Headache Impact Test (HIT6). This combined data can be used to provide the therapist and patient with a progress report on patients' overall condition.

Home follow-up: The Occiflex recording tool can be used by the therapist to help teach a patient more accurate home follow-up exercises.

Improve patient compliance

The Occiflex's comfortable ergonomic design, combined with its reliable, consistent and smooth mobilization, can help patients relax more deeply. A further sense of patient control is also provided, as the patient is completely free to sit up and stop the treatment at any time. Recent studies have shown that no serious adverse effects were reported, and all patients were satisfied and wanted to return for further treatment[10,11,12]. The Occiflex also has an excellent safety record with no issues reported after more than 1000 sessions during clinical trials.

Safety and side effects

Circulation in vertebral arteries during three-dimensional movements

Movements of the neck in the sagittal plane do not, or hardly, compromise the blood flow in the vertebral arteries. So single axis movement of neck flexion and neck extension are safe to use in therapeutic interventions.

Movements in the atlanto-axial intervertebral joints influence the blood flow in the vertebral arteries (VAs). Rotation is the most compromising movement. The above described feature of the contralateral rotation during full side flexion of the head is less compromising to the blood flow than single Upper Cervical rotation.

Rotation of the head from a flexed position will have an effect on blood flow through the VAs.

Combined movements of the neck can compromise the circulation in the VA's more than single axis movements.

To manage the Occiflex therapy in a safe manner, we must be aware of our actions and what kind of symptoms we can expect when we do compromise the circulation through the VAs: Compression of the VA would cause in most cases true vertigo, nausea, vomiting, blurred vision, and at times complete blindness, diplopia and loss of consciousness. **Patients who develop any one of the above mentioned symptoms should not be treated with the Occiflex.**

These symptoms can evolve in a gradual manner and are also dependent on the angular velocity of the treatment. Since the treatment of the Occiflex allows only slow angular velocities, the risk of VA compression is very small. The Occiflex does not allow forceful manipulations and in addition, it limits extension, which is another feature that decreases the risk of VA compression.

In order to further reduce the risk of vascular compression, the following measures should be taken:

a. Patients with cerebrovascular disease should be excluded, particularly patients who have previously had a stroke.
b. For elderly patients treatment should be very conservative, that is – avoiding eccentric mobilization, and focussing the treatment on slow velocities and midrange mobilization.

Side effects

In the current trial mild treatment related adverse effects appeared in 12% of the therapeutic sessions.

Trial results indicate that there are two distinct groups of side effects:

1. Side effects related to over-pressure of the cradle on the scalp, or discomfort associated with the posture of the patient in relation to the treatment table, such as mild headache, auricular pain, and scapular pain.
2. Side effects related to the actual mobilization/movement of the head/neck, such as dizziness and neck pain.

Changing the body posture and the position of the head during mobilization, could diminish the occurrence of the first group of adverse effects. Whereas reducing the velocity and the range of mobilization, could diminish the occurrence of the second group of adverse effects.

Appendices

Pilot trial abstracts

Computerized mobilization of the cervical spine for the treatment of chronic neck pain

Background: Manual therapies for chronic neck pain are imprecise, inconsistent, and brief due to therapist fatigue.
Objective: Investigate the safety and efficacy of computerized mobilization of the cervical spine in the sagittal plane for the treatment of chronic neck pain.
Design: Pilot, open trial.
Setting: Physical therapy outpatient dept.
Participants: 10 patients with chronic neck pain.
Interventions: A computerized cradle capable of 3-dimensional neck mobilization was used. Treatment sessions lasted 20min, biweekly, for 6 weeks.
Main outcome measures: Numerical rating scale (NRS) for pain, neck disability index (NDI) questionnaire, muscle algometry, cervical range of motion (CROM), sEMG, and SF-36 questionnaire.
Results: Treatment was not associated with any significant adverse effects. Pain scores dropped by 2±0.5 NRS points. CROM showed significant improvement at the end of the study ($p<0.05$). NDI showed marked improvement by fourth week, end of study, and 2 weeks post treatment ($p<0.05$); headache-subscale showed marked reduction.
Conclusions: These preliminary results demonstrate the safety of a novel computerized mobilization of the cervical spine. In addition, the data suggests that this method is effective in increasing CROM, and alleviating neck pain and associated headache[10].

Three-dimensional computerized mobilization of the cervical spine for the treatment of chronic neck pain: a pilot study

Background: Manual therapies for chronic neck pain are imprecise, inconsistent, and brief due to therapist fatigue. A previous study showed that computerized mobilization of the cervical spine in the sagittal plane is a safe and potentially effective treatment of chronic neck pain.
Objective: To investigate the safety and efficacy of computerized mobilization of the cervical spine in a three-dimensional space for the treatment of chronic neck pain.
Design: Pilot, open trial.
Setting: Physical therapy outpatient department.
Participants: Nine patients with chronic neck pain.
Interventions: A computerized cradle capable of three-dimensional neck mobilizations was used. Treatment sessions lasted 20 minutes, biweekly, for six weeks.
Main outcome measures: Visual analog scale (VAS) for pain, cervical range of motion (CROM), neck disability index (NDI), joint position error (JPE), and muscle algometry.
Results: Comparing baseline at week one with week six (end of treatment), the visual analog

scale (VAS) scores dropped by 2.9 points ($p<0.01$). The six directions of movement studied by the cervical range of motion (CROM) showed a combined increase of 11% ($p=0.01$). Neck disability index (NDI) decreased significantly from 16 to 10 ($p=0.03$) and joint position error (JPE) decreased significantly from 3.7° to 1.9° ($p=0.047$). There was no change in the pressure pain threshold in any muscle tested. There were no significant adverse effects.
Conclusions: These preliminary results demonstrate that this novel, computerized, three-dimensional cervical mobilization device is probably safe. The data also suggests that this method is effective in alleviating neck pain and associated headache, and in increasing cervical range of motion (CROM), although the sample size was small in this open trial[11].

Flexion relaxation ratio, neck posture, joint position error, and pressure-pain thresholds following tailored three dimensional computerized mobilization of the cervical spine for the treatment of chronic neck pain

Background: Manual therapies for chronic neck pain have shown limited efficacy. Two previous studies showed that computerized mobilization of the cervical spine is safe and potentially effective treatment of chronic neck pain.
Objective: Investigate several physiological measures, efficacy, and safety following individualized, computerized mobilization of the cervical spine in a three dimensional space for the treatment of chronic neck pain.
Design: Pilot, open trial.
Setting: Physical therapy outpatient dept.
Participants: Nine patients with chronic neck pain and a control group without neck pain for the assessment of the flexion relaxation ratio.
Interventions: A computerized cradle capable of three dimensional neck mobilization was utilized. Individualized treatment sessions lasted 20 minutes, biweekly, for six weeks.
Main outcome measures: Visual analog scale (VAS) for pain, cervical range of motion (CROM), neck disability index (NDI), joint position error (JPE), pressure pain thresholds (PPT), forward neck tilt (FNT), and flexion relaxation ratio (FRR) measured by surface electromyography (EMG).
Results: Comparing baseline at week 1 with week 6 (end of treatment), the VAS scores dropped by 2.2 points ($p=0.040$). The six directions of movement studied by CROM showed a marginally significant combined increase of 11% ($p=0.061$). NDI decreased with marginal significance (week 1 versus week 8) from 15.42 to 9.42 ($p=0.086$); JPE decreased significantly from 2.88° to 1.14° ($p<0.01$); PPT increased from 1.27 Kg/cm^2 to 2.44 Kg/cm^2 ($p=0.043$); FNT decreased from 20.36 cm to 19.02 cm ($p=0.104$). Left sided FRR significantly increased ($P=0.017$).
Conclusions: This study provides preliminary physiological evidence suggesting that individualized computerized, three dimensional cervical mobilization brings about a positive change in neck posture, cervical neuromuscular control, and the processing of nociceptive and proprioceptive information[12].

Notes

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