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Guyon's Canal Syndrome and its' impact on everyday life and sport - literature review

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Summary

Guyon's canal syndrome (GCS) is a relatively rare neuropathy caused by injury to the ulnar nerve in the area known as Guyon's canal or the ulnar tunnel. The syndrome occurs less frequently than other clinical conditions of nerve entrapment, such as Carpal tunnel syndrome or Cubital tunnel syndrome. The injury is caused by chronic or multiple-occurring insults to the ulnar nerve. The damage may be caused by the presence of abnormal structures within the canal, or by mechanical forces acting on the area. This can result in a gradual, progressive neuropathy, which may present as sensory loss, motor weakness, numbness and tingling, burning sensation, or loss of sensation. Diagnosis can be confirmed by an oral and physical examination, as well as additional tests, including imaginary examinations. Management of the GCS includes conservative and surgical treatment. The choice of therapy depends on the patient's condition and preferences.

The syndrome concerns office and manual workers, as well as sportsmen like bikers.

Keyworlds: Guyon’s canal syndrome, Guyon’s canal, ulnar canal, ulnar nerve, wrist, neuropathy, compresion of the ulnar nerve, Hypothenar Hammer Syndrome

Introduction

Guyon’s Canal Syndrome is a rare clinical condition resulting from ulnar nerve injury in the distal portion of the nerve, situated in a narrow anatomical corridor at the wrist. [1] It is an example of neuropathy caused by pressure applied on a nerve. The pressure can be caused by various factors, which will be discussed in the following section of the review. The ulnar nerve is a mixed nerve, meaning that it provides motor and sensory innervation to the digits. This property of the nerve results in a variety of symptoms (motor and sensory) that occur during the injury. [2]

The nerve originates from the central rami of the C8 and T1 nerve roots, which form the lower trunk of the brachial plexus. The lower trunk next divides into an anterior and posterior division, with the fibres of the ulnar nerve in the anterior division becoming the medial cord. The nerve leaves the brachial plexus as a terminal branch of the medial cord and lies from the axilla into the medial part of the anterior compartment of the upper arm, where it is located posteriomedial relative to the brachial artery. It then inserts onto the medial epicondyle of the distal humerus and enters the cubital tunnel. The ulnar nerve leaves the tunnel and runs down the arm, on the surface of the flexor digitorum profundus. It then runs along the medial side of the forearm, lying superficially and being covered mostly by fascia and skin. It subsequently enters Guyon’s canal, a fibro-osseous tunnel formed between two bones: the pisiform and the hamate bone (the hook hamate exactly). The ulnar nerve in Guyon’s canal is laterally bordered by the ulnar artery. Finally, within the canal, the ulnar nerve divides into superficial and deep branches. [3]

Guyon's canal syndrome is a condition that results from the injury of the ulnar nerve at a specific point. The syndromes associated with this injury are characterised by the loss of function of a portion of the nerve, which can be used to differentiate between injuries that are proximal or distal to the nerve. However, these syndromes can be similar to those associated with the groove for the ulnar nerve, with the exception of the disturbances in the cutaneous innervation of the dorsum of the hand.[4]

Anatomy of Guyon's Canal

In order to fully comprehend the phenomenon of the Guyon's Canal syndrome, it is essential to have an understanding of its anatomy. This anatomic space was first described by French surgeon Jean Casimir Félix Guyon in 1861 [5] as an intra-aponeurotic compartment. The surgeon was inspired by the appearance of 'petits lobules' on the palmar side of his own wrist when he applied pressure to the hypothenar eminence. His curiosity piqued, he proceeded to study the anatomical dissection of the wrist. Guyon is renowned as the first to provide an anatomical description of the ulnar tunnel and its connections with other structures. The structure was subsequently given its eponym, Guyon canal, in 1953. Since then, numerous studies have been conducted on the anatomy of the ulnar tunnel. One of the most significant findings was the identification of an additional tunnel containing the deep branch of the ulnar nerve, situated distally to the ulnar tunnel, the pisohamate hiatus.[6]

Guyon's canal is a structure about 4 cm in length. It is formed by four borders: the roof, the floor, radial border and medial border. Respectively:

- The roof – volar carpal ligament
- The floor – Transverse carpal ligament (which, on lateral side, transists into roof of the carpal tunnel) [1]
- Radial (lateral) boundary – The hook of hamate
- Ulnar (medial) boundary – Pisiform, Pisohamate ligament and abductor digiti minimi [7,8]

Despite the fact that the borders of Guyon's canal have been established and respected in the literature, some researches disagree with the earlier topography of the structure and propose new ones. Based on twenty-five specimens that were dissected, Tyson K. et al. suggested that instead of Guyon (i.e., "loge de Guyon"), the canal should be referred to as the carpal ulnar neurovascular space. The boundaries of the newly delineated anatomical space, designated as the carpal ulnar neurovascular space, were as follows:

- The roof – dorosal extension of the antebrachial fascia and the palmaris brevis muscle
- The floor – muscles of the hypothenar eminence, their fibres of origin and the fleor retinaculum
- Radial boundary – junction of the roof (palmar carpal ligament), including the Palmaris brevis muscle, to the flexor retinaculum, as are the tendons of origin of the thenar muscles

— Ulnar boundary – junction of the fascial roof, with the fascia covering the hypothenar eminence distally and the pisiform bone proximally.[9]

In some anatomy textbooks, the borders of the Guyon's canal include structures from both the examples suggested above. [10] However, the most frequently used one is the first one.

The Guyon's canal contains two significant structures: the ulnar nerve, which divides into superficial (sensory compartment) and deep branches (motor compartment) [11], and the ulnar artery, which also divides into superficial and deep branches. The layout and crossing of branches may vary depending on anatomical variations. [12] The nerve lies laterally in the canal, while the artery lies medial. Additionally, veins may accompany other structures. [13]

In some cases, additional structures may be present within Guyon's canal, representing anatomical variations. The most frequently described of these are accessory muscles. Research conducted on 58 cadaveric specimens demonstrated that aberrant muscles are relatively common. They were observed in 22.4% of specimens. In 46.2% of cases, they were present bilaterally. The majority of accessory muscles (61.5%) originate from the antebrachial fascia. All 13 muscles identified in the aforementioned research were classified as accessory abductor digiti minimi muscles. Additionally, an anatomic variation involving the accessory palmaris longus muscle was observed. This variation has an incidence of 8.6%. [12,14]

An understanding of Guyon's canal anatomy enables an appreciation of the circumstances under which Guyon's canal syndrome may occur. The identification of all potential structures or structural weaknesses that may contribute to ulnar nerve neuropathy, localised in the canal, facilitates more accurate diagnosis, the selection of an appropriate treatment and the planning of a surgical procedure that is both effective and minimises the extent of any mutilation for the patient.

Etiology of Guyon's Canal Syndrome

As previously stated, Guyon's canal syndrome is induced by a number of causes of the disease, resulting in injury to the ulnar nerve within the ulnar canal or in its vicinity. The area in question is susceptible to insult, which can lead to neuropathy of the section of the ulnar nerve that runs through the canal. The damage to the nerve is typically caused by pressure applied by an external object (for instance, handlebars of a bicycle), remodelled tissues (for example, thickened ligaments as a result of multiple injuries or occupational activities), accessory muscles, ganglions or neoplasms. [11] Guyon's canal syndrome is an entrapment syndrome. The majority of cases of entrapment syndromes concern injuries to a segment of nerve, which typically measures no more than several centimetres. [15]

A study conducted by Shea et al. identified two primary causes of Guyon's canal syndrome: the mass effect of ganglion cysts and occupational neuritis. [4] Recently, the incidence of neuropathy induced by the second factor has declined. Other less common causes of ulnar canal syndrome include benign lesions (e.g., lipoma), fractures of the hook of hamate, pathological conditions or aberrancies, deviant hypothenar muscles, aberrant muscles (e.g., abductor digiti minimi mentioned earlier) or excess fat tissue within the canal, and crystal deposition disease.[1,16]

An intriguing etiology of Guyon's canal syndrome is chronic, repetitive trauma or compression over the hypothenar eminence in the long-distance cycling population. Despite the fact that the mechanism is analogous to that observed in occupational chronic trauma, scholars differentiate them as distinct inducements.[11,16]

Another potential etiology is ulnar artery thrombosis or aneurysm, which is commonly referred to as Hypothenar Hammer Syndrome (HHS). This syndrome was first described in 1934 by von Rosen and later named in 1970 by Conn. It is a rare disease that primarily affects men in their working years, with occupations or activities that involve repetitive trauma affecting Guyon's canal area and the heel of the hand. The HHS is predominantly observed in the dominant hand, as it is more frequently used for a greater number of activities and is therefore more susceptible to contusion. The estimated prevalence of the syndrome in the population at risk is between 7% and 14%. HHS is a strictly arterial disease, and the damage to the ulnar nerve is a secondary consequence of abnormalities in the ulnar artery or its branches. It is noteworthy that in populations with hand vascular problems, the incidence of the syndrome is only 1.1–1.7%. This statistic suggests that environmental factors may play a significant role in the HHS incidence rate. Repetitive trauma of the ulnar artery can result in gradual damage to the arterial wall. The effects of the insults include thrombosis, internal elastic membrane disruption, medial fibrosis, hypertrophy, neovascularisation of the media and adventitia. The severity of symptoms caused by HHS depends on the extent of vessel occlusion and the presence of collateral circulation between the deep and superficial palmar arches. It is important to note that, in addition to the symptoms of Guyon's canal syndrome, other symptoms may also occur, including local symptoms such as hypothenar pain and swelling, a pulsing mass, arterial insufficiency, including embolic events, pale fingers, digital pain, fingernail haemorrhages, ischaemic pain, cold intolerance, minor ulcerations, and small necrotic areas at the fingertips.[17,18,19]

In 2022, a rare cause of acute carpal tunnel syndrome and acute Guyon canal syndrome was described, resulting from pseudogout. Pseudogout is an acute inflammatory arthropathy that

presents as a hot, swollen, painful joint. It is a very rare cause of acute neuropathic symptoms of the hand.[20]

To conclude, the majority of cases of Guyon's Canal Syndrome are induced by repetitive trauma and nerve pressure is caused by external mechanical forces. Less common causes include inflammation, exposure to vibration or vascular insufficiency.[1,21]

Epidemiology

Guyon's canal syndrome is a less prevalent condition than carpal tunnel syndrome. Unfortunately, the incidence and prevalence of the syndrome in the general population have not yet been estimated. The principal reason for this is the absence of comprehensive studies on the subject. [1,22]

Syndromes

The symptoms of Guyon canal syndrome vary according to the specific area of the ulnar nerve that is affected. The ulnar nerve is divided into three distinct zones within the canal. Each zone is susceptible to different forms of injury, which can result in a diverse range of clinical manifestations. Shea and McClain (1969) [4] were the first researchers to propose a classification of ulnar nerve compression based on the site of compression.

- Type I: Compression of the common ulnar nerve bundle, resulting in sensory loss and motor weakness.
- Type II: Compression of the deep motor branch of the ulnar nerve, resulting in motor weakness of muscles innervated by this branch.
- Type III: Compression of the superficial sensory branch of the ulnar nerve, which is indicative of sensory deficits.[6]

As previously stated, the definition of Guyon's canal underwent significant evolution over time. Similarly, the classification of ulnar nerve-related symptoms underwent a transformation. The second classification was proposed by Gross and Gelberman in 1985. [23] This is currently the most widely accepted description of the ulnar tunnel symptoms classification.

- Zone I: This zone begins at the proximal edge of the palmar carpal ligament and ends distally at the bifurcation of the ulnar nerve. Injuries to the ulnar nerve in this zone result in a combination of motor and sensory symptoms. The most common causes of injury to this area are hook of hamate fractures, malunions, nonunions and ganglion cysts.

— Zone II (the most commonly affected zone): This zone begins distal to the bifurcation of the ulnar nerve and ends at the fibrous arch of the hypothenar muscles. This zone contains the deep branch of the ulnar nerve, which innervates all the interosseous muscles, the fourth and fifth lumbricals, the hypothenar muscles (opponens digiti minimi, abductor digiti minimi, flexor digiti minimi brevis), and the adductor pollicis muscle. Injuries at this zone result in paresis of the aforementioned muscles. The most common etiology of insult to the area is the same as in Zone I.
— Zone III: This zone begins just distal to the bifurcation of the ulnar nerve and contains the superficial branch of the ulnar nerve. Damage to this area results in sensory symptoms only, such as pain, numbness and tingling, burning sensation and loss of sensation. The most common etiology of insult to this area is an ulnar artery aneurysm or thrombosis. [16,]

The sensory symptoms of Guyon canal syndrome are as previously described: numbness and tingling, burning sensation, loss of sensation. It is crucial to identify the areas where patients experience these symptoms. The areas of acrodysaesthesias correspond with the field of the ulnar nerve sensory nerve. On the palmar side, the ulnar nerve innervates the V finger, the medial part of the IV finger, and the medial side of the palm, corresponding with finger nerve innervation. On the dorsal side, the affected areas include the V finger, IV finger, and the medial part of the III finger, which includes the proximal and distal phalanges. It is possible for symptoms to radiate along the proximal aspect of the Guyon canal, in regard to the ulnar nerve.[24]

Diagnostics

The initial stage of any comprehensive evaluation is a medical interview. The patient presenting with Guyon’s canal syndrome typically exhibits symptoms that are highly indicative of the disease, as previously discussed. The subsequent step is to conduct a physical examination, which serves to reinforce the preliminary diagnosis. In addition to the aforementioned symptoms, it is also worth noting the presence of the Hoffmann-Tinel sign, which is a hallmark of peripheral nerve injury. The sign was first described in 1915 by Paul Hoffmann and Jules Tinel as the "pins and needles" sensation. This sensation can be elicited by tapping on a proximal part of the nerve (in this case, the ulnar nerve). Tapping results in a paresthesia experienced in the corresponding distal cutaneous distribution of an injured peripheral nerve. Inducing the Tinel sign can provide meaningful information about the nerve. [25] Following an oral and physical examination, the subsequent step in the evaluation

process is to administer additional tests to verify the diagnosis and to determine the source of the nerve injury.

The most crucial additional tests are electromyography (EMG) and nerve conduction velocity (NCV). Both electrodiagnostic tests can confirm the nerve damage. They are essential for verifying whether the nerve injury is the source of the patient's complaints. EMG records the electrical activity of a muscle by measuring the tested muscle's response to stimulation. NCV measures the amplitude, velocity, latency and time of conduction across the nerve. The results of both additional tests are dependent on the duration and degree of Istlu. It is therefore crucial that they are ordered simultaneously.[24,26] Several studies have demonstrated a strong correlation between the actual length of the damaged nerve (as visible on an MRI scan) and the degree of nerve conduction slowing. This correlation allows for an estimation of the size of the injured part of the nerve.[15]

Other tests are available to determine the mechanism of nerve damage and to plan appropriate management of the syndrome. These include a hand X-ray, computed tomography (CT), magnetic resonance imaging (MRI), Doppler ultrasound and angiography. It is in the best interest of patients to perform as many of these tests as possible. The first two can be used to evaluate for fractures, especially hamate fractures and other injuries to bones or cartilages. Furthermore, they are beneficial in the context of suspected entrapment at the wrist and carpal tunnel.[26] Magnetic resonance imaging (MRI) is capable of capturing soft tissue anomalies. The utilisation of standard MRI pulse sequences, modifications and advanced coils enables the significant improvement of nerve visualisation. The collective utilisation of T1, T2 and short tau inversion recovery (STIR) sequences enables the depiction of focal or segmental abnormalities in nerve configuration and size. It is also important to note that the combination of sequences described above can demonstrate signal intensity in entrapment syndromes, such as Guyon’s canal syndrome. The DTI sequence of MR imaging enables the visualisation of the presence or absence of axons due to their anisotropic properties. [15] Doppler ultrasound and angiography can be employed to depict changes in the ulnar artery, such as thrombosis or aneurysm. [1,26] The classic ultrasound examination also assists with evaluation, by demonstrating morphologic changes and the extent of the ulnar nerve and ligament apparatus. [27]

A well-conducted evaluation allows for the confirmation of a preliminary diagnosis. The utilisation of additional tests, such as MR, CT, x-ray, Doppler ultrasound and angiography, enables the selection of the optimal management strategy for Guyon’s canal syndrome, which

is the most suitable for the patient. The results of imaging tests facilitate the planning of surgical procedures, which is a significant advantage for the surgeon and the patient.

Treatment

The management of Guyon canal syndrome can be divided into two categories: conservative and surgical. The treatment of ulnar neuropathy is dependent on a number of variables. The selection of an appropriate treatment modality for Guyon canal syndrome necessitates an assessment of the underlying cause, clinical presentation, duration and severity of symptoms, as well as other patient-specific factors, including weight, comorbidities and overall condition. In the case of mild to moderate ulnar neuropathy, conservative management may be considered the optimal treatment option. In cases where the underlying cause is not amenable to surgical intervention, the proposed treatment should be non-surgical. Non-surgical treatment options include modifying patient habits, such as avoiding weight bearing, static postures, or repetitive movements that place pressure on the ulnar canal area, and limiting prolonged wrist extension. It is also important for patients to remember the correct way of holding the steering wheel of a bicycle, using pads for office work and minimising mechanical pressure on the canal localisation. Furthermore, splinting (placing the wrist in a neutral position and wearing it for 1-12 weeks at night and during the day during aggravating activities) and ultrasound (US) can be employed. The selection of treatments is contingent upon the patient's circumstances and personal preferences.[28,29] It is important to note that physical therapy involves a variety of exercises. In the case of Guyon canal syndrome, it is beneficial to perform ulnar nerve glide exercises based on the Butler concept for the ulnar nerve. The aforementioned treatments can be categorised as follows:

- wrist extension,
- forearm pronation elbow flexion,
- glenohumeral lateral rotation,
- glenohumeral depression,
- shoulder abduction.[29,30]

In the event of conservative management failure, it is advisable to consider minimally invasive techniques before resorting to surgical intervention. These attempts can relieve an entrapped ulnar nerve without the necessity for more invasive procedures. It is important to note that these techniques cannot be relied upon to fully treat patients with Guyon canal syndrome. One of the minimally invasive techniques is peripheral percutaneous electrode placement. The technique involves the use of a stimulating needle to place the electrode. The

electrode produces impulses that cause a reduction in pain symptoms, with the most favourable outcomes observed at a slow frequency and intermittent stimulation. Ultrasound-guided techniques can be invaluable in the placement of the electrode. Previous studies have yielded promising results. The probability of success of minimally invasive techniques correlates with the degree of compression. They are most effective in mild and medium severe cases. Non-operative measures were entirely unsuccessful in treating severe ulnar nerve compression. It is possible that even less invasive techniques, such as needle injection or collagen injections, may be beneficial in relieving ailments. However, further research is required to confirm this hypothesis.[15,26,31]

The surgical treatment of Guyon canal syndrome is indicated in the following cases: when the cause of the syndrome cannot be cured by other measures, when conservative management has failed, when a surgical lesion is present, when minimally invasive techniques have failed, or when complications have developed. The surgical treatment is recommended if the benefit of the procedure outweighs the risk and if the patient does not have absolute contraindications. The surgical intervention should be patient-tailored, as there are multiple sites of possible ulnar nerve compression. This is the reason why imaging tests are of such importance in the planning of the procedure.[26,29,32]

The primary objective of surgical management of Guyon's canal syndrome is the removal of compressive masses and decompression of the space, thereby relieving pressure on the ulnar nerve. The procedure should encompass an examination and decompression of all three zones of the Guyon's canal, in order to prevent the necessity for reoperation in the event that surgery was performed on a too-short fragment of the nerve. The primary focus of surgical management of Guyon's canal syndrome should be on compressive structures, including the antebrachial fascia, the volar carpal ligament, and the hypothenar fibrous arch (overlying the deep motor branch). It is essential to inspect the ulnar artery and other vascular lesions to ascertain the presence of neurovascular conflict. In the event of such conflict, vascular lesions should be resected, with or without vessel reconstruction. [32,33]

The procedure commences with axillary block anaesthesia, with a tourniquet in place to facilitate optimal surgical field visualization. The next step is to ensure that the anaesthesia is in place. The incision commences proximal to the wrist, longitudinal and radial to the flexor carpi ulnaris tendon. Thereafter, the incision becomes transversal at the wrist flexion plica and then longitudinal over the Guyon's canal. The subsequent step is to incise the fascia radially to the flexor carpi ulnaris tendon, the ulnar nerve and artery that cross the canal. At this point, it is possible to identify superficial sensitive branches and the deep motor branch of the ulnar

nerve. It is necessary to reassess the area and ensure that the nerve is not compressed. Two main structures that must be dissected from surrounding tissues and protected throughout the procedure are the ulnar nerve and artery.[34] At this juncture, two primary approaches to the subsequent step are possible. One is a simple decompression (the cutting of constricting nerve fibres without the relocation of the ulnar nerve) and the other is a decompression with the transposition of the ulnar nerve. Both methods have advantages and disadvantages. The less selected option is medial epicondylectomy.

Nevertheless, there are numerous surgical techniques that can be employed to treat Guyon's canal syndrome. Endoscope-assisted and in-situ small-incision procedures for nerve decompression with and without transposition represent potential alternatives to classical surgery. The most promising aspect of these procedures is that they can be less invasive. Currently, most of them have been performed on cubital canal syndrome, although the potential for introducing them into other nerve compression syndromes appears promising.[26,35,36]

The final stage of surgical management is postoperative care. Following surgery, patients begin a gradual functional recovery. It is important to inform patients that returning to previous activities should be gradual. According to studies, this process should take approximately 20 days. Follow-up visits should be carried out at 15 days, one month, three months, six months and then every six months after surgery if necessary.[34]

Conclusions

In conclusion, Guyon's canal syndrome represents a particularly complex variant of neuropathy. The condition is characterised by damage to the ulnar nerve in a specific location, known as Guyon's canal, which is situated on the median side of the wrist. The canal is formed by the volar carpal ligament, the transverse carpal ligament, the hook of hamate, the pisohamate ligament and the abductor digiti minimi. Nevertheless, there are a number of different definitions of the canal that have been described in the literature. The canal contains the ulnar nerve, which divides into two branches: the superficial branch, which supplies sensory information, and the deep branch, which supplies motor information. The ulnar artery also divides into two branches: the superficial branch, which supplies the superficial layer of the hand, and the deep branch, which supplies the deep layer of the hand. There is considerable variation in the additional structures that can be found in the ulnar canal. The majority of these structures are additional muscles, which are anatomical variants.

The aetiology of Guyon's canal syndrome is typically attributed to pressure applied by external, remodelled tissues, accessory muscles, ganglions or neoplasms. An intriguing etiology of the syndrome is the pressure exerted on the nerve by bicycle riding.

The epidemiology of Guyon's canal syndrome remains entirely unknown. The principal reason for this is the absence of comprehensive studies on the subject. It is likely that the incidence of this condition is lower than that of carpal tunnel syndrome.

The syndromes associated with Guyon's canal syndrome include sensory loss, motor weakness, numbness and tingling, burning sensation, and loss of sensation. The extent of the damage to the canal depends on the specific area affected. The structure can be divided into three distinct zones. The division of the canal has implications for clinical practice.

The evaluation of Guyon's canal syndrome typically involves an oral and physical examination, as well as the performance of accessory tests, such as electromyography (EMG), nerve conduction velocity (NCV), computed tomography (CT), magnetic resonance imaging (MRI), ultrasonography (USG), ultrasonography Doppler imaging, and angiography.

The treatment can be divided into two categories: conservative and invasive. The first category encompasses modifications to the patient's lifestyle, physiotherapy, and exercise regimens. Surgical techniques can be divided into minimally invasive and classic techniques. The decision regarding the most appropriate treatment plan is dependent on a number of patient-specific factors.

It is notable that Guyon's canal syndrome is less frequently described in the medical literature than more common nerve pressure syndromes such as carpal tunnel syndrome or cubital canal syndrome. In order to fully understand the syndrome and provide optimal management, further characterisation of the topic is required through case reports, reviews, systematic reviews and meta-analyses. The most crucial information to be researched is the epidemiology of Guyon's canal syndrome. Currently, this information is not available.

This article collates the most comprehensive body of knowledge on Guyon's canal syndrome, encompassing its definition, historical context, aetiology, associated syndromes, evaluation and treatment. It is our hope that this information will prove useful to practitioners, physiotherapists, other medical personnel and future researchers.

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Author's contribution

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