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Diagnosis and Management of Elongated Styloid Process among Patients Presenting with Odynophagia to the ENT Department

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ABSTRACT

Background: Eagle's Syndrome, also known as elongated styloid process (ESP), is a rare, debilitating disorder; it is characterised by craniofacial pain and odynophagia caused by compression of the neurovascular system. The purpose of this study is to evaluate the diagnostic validity of new imaging modality techniques as well as post-operative surgical outcome in symptomatic individuals.
Methods: A clinical cohort study was conducted on thirty patients (18 females and 12 males) between the ages of 20 and 60 years old with odynophagia who presented to a tertiary ENT level centre. Evaluation included Orthopantomogram (OPG) and three-dimensional computed tomography (3DCT) that measured the length of the styloid and the medial angulation of the styloid. All patients underwent surgical resection (transoral tonsillectomy) while under general anesthesia.
Results: The sample was predominantly female (60%), with the highest rate of occurrence in those aged 40 to 60. The most common symptom at presentation was localised pain (43.3%), followed by painful swallowing (30%). In general, SP length was symmetrical, but there was a significant difference between male (26.1mm) and female (24.3mm) SP left-sided lengths (p=0.002). 3DCT provided the most accurate measurements for medial angulation, with females having a higher mean (41.7°-42.8°) than males; however, the difference was not statistically significant (p>.05). The amount of pain on day 0 was 40%, then at week 12 after surgery, it was at only 3.3%.
Conclusion: Preoperative planning and minimising the risk of neurovascular complications require 3DCT. Definitive treatment of the transoral styloid procedure provides statistically significant improvement in symptoms.

Key-words: Eagle's Syndrome, Styloid Process, Odynophagia, 3D Computed Tomography, Transoral Styloidectomy

INTRODUCTION

The styloid process is a thin projection of bone from the temporal bone of the skull that is usually between 2.0 and 3.0 cm long and attaches to the stylohyoid and is important for moving the muscles of the head, neck and throat [1,2].

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The styloid process is located between many important arteries and spinal nerves; therefore, an abnormally long process or a calcification of the stylohyoid ligament can change the origin of the muscles or their normal path, creating an unwelcome connection between the muscle and the bone, resulting in Eagle syndrome [2,3]. This abnormality occurs in approximately 4% of the population, with the majority falling in the range of 3.8 to 4.8 cm [2,3]; the cause of styloid elongation is multifactorial and may include a continued presence of embryological structure or a response to trauma [1,3]. For example, local irritation of the back of the throat and/or surgical trauma from a tonsillectomy can result in

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chronic inflammation of the periosteum and scar tissue development around the tip of the styloid process, leading to ossifying hyperplasia and fibrocartilaginous metaplasia in the ligaments that attach to it [1,3]. To accurately determine the length and planes of structural abnormalities requires advanced three-dimensional computed tomography [2,3].

Eagle's syndrome can be misunderstood as a neurovascular conflict. This occurs through compression of surrounding anatomy as a result of an elongated styloid process or calcified stylohyoid ligament [4,5]. As a result of the aforementioned compression phenomenon, there are two basic forms (clinical subtypes) wherein Eagle's syndrome is expressed pathophysiologically. They comprise the classic or cranial nerve type caused by irritation of the glossopharyngeal nerve (CN IX) and the vascular type resulting from compression of the carotid arteries [3].

Upon further examination, the typical presentation for both classic and vascular forms include unilateral cervical facial pain, otalgia, headaches, globus pharyngeus, and persistent sharp odynophagia exacerbated by swallowing, yawning, or turning one's head [6,7]. Symptoms from the vascular form may occur when the styloid process deviates medially or laterally, causing compression to the internal or external carotid arteries, leading to either sympathetic irritation around the arteries, pain distributions over the carotid area or ischemic stroke due to arterial dissection [3,8]. Therefore, when differentiating Eagle's syndrome from other diagnostic mimics (before implementing alternative conservative approaches or undertaking surgical procedures to shorten the styloid), there should be clinical-radiologic correlation through palpation of the tonsillar fossa for attenuation of pain and assessment (using three-dimensional computed tomography) to evaluate the degree of the angulated styloid process [4-8].

Eagle's syndrome diagnosis is based on palpation or finger pressure inside the mouth and within the tonsillar fossa. Reproducing characteristic pain (odynophagia) or providing pain relief via an anaesthetic injection confirms the diagnosis [1]. First-line conservative treatment can include non-steroidal anti-inflammatory medications (NSAIDs), neuropathic medications, or transpharyngeal corticosteroid injections [1]. If conservative treatment fails, the physician should provide surgical intervention (i.e., surgical removal of the styloid process) for patients with persistent, function-limiting symptoms [1,3]. There are two approaches to surgical removal of the styloid process that vary based on the individual surgeon's preference: approach via the mouth (transoral) or the neck (transcervical). Each approach has advantages and disadvantages (transoral-no external scarring, but limited visualisation; transcervical - superior anatomic exposure and vascular safety, but external incision) [1,3,9].

MATERIALS AND METHODS

Study Design and Ethical Considerations- The current research is a prospective clinical cohort study that was conducted at Narayana Medical College and Hospital, Nellore, India. The study aimed to assess the accuracy of various imaging techniques used to diagnose Eagle's syndrome (i.e. to identify which methods can diagnose this condition accurately) and also evaluate how effective surgical treatment was on patients with this condition (i.e. determine if surgery would help improve symptoms associated with this syndrome). Before beginning the study, the Institutional Review Board and the Ethics Committee reviewed and approved the research proposal. Participants provided written informed consent to participate in the study after being fully informed about the surgical procedure, the data collection process, and their right to discontinue participation at any time without affecting their medical care.

Participant Selection and Sample Size- The demographic of patients to be enrolled in this study will be between 20 and 60 years of age and present to the Department of Otorhinolaryngology (ENT) with primary complaints of odynophagia and persistent craniofacial pain. The sample size was calculated using the following formula: n = (z x σ / Δ) 2. A standard deviation (σ) of the styloid process length (SP) has previously been reported to be 2.34 mm with a precision (Δ) of 1 mm at a 95% confidence interval (z = 1.96). This yielded an initial sample size of 26 subjects; however, due to the possibility of attrition or variability of data, a total of 30 patients will be evaluated for this study.

In order to assure the integrity of this study, there will be strict inclusion and exclusion criteria. Inclusion criteria will consist of patients who have been clinically and radiographically diagnosed with an elongated styloid process between the ages of 20 and 60 years. Exclusion

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criteria will include patients with a history of prior neck surgery that may alter the local anatomy and/or patients who have systemic comorbidities that would make them medically unfit for general anesthesia or surgical management.

Clinical and Radiographic Assessment- The patients were diagnosed from 2 separate clinical evaluations and more advanced imaging studies. When enrolled in the study, patients' full medical history (from the date of enrollment) was recorded, including demographic data and symptoms. Symptoms focused on included pain characteristics, the area of radiation of the pain (specifically within the ear), and any increase in pain during swallowing.

To objectively determine the length of the styloid process, all 30 patients had Orthopantomogram (OPG) and three-dimensional computed tomography (3DCT) imaging completed. Digital radiographs of the patients were recorded with a digital panoramic machine (exposure parameters ranging from 62 to 66 kV, 13 mA, and 15 seconds) that were adjusted according to the patient's physical size. The 3DCT studies were performed using different technology with higher definition (90 kV, 10 mA, and 12 seconds) and the patient's facial reference points were positioned to ensure anatomical accuracy of location.

The measurement of the length of the styloid process was defined as the straight-line distance from where it exits the tympanic plate of the skull to the end of the process. This method of measurement would not vary depending on whether the styloid process was continuous or discontinuous. When the styloid process could not be seen, the point where it attaches to the skull (crania) was used as the reference location for measurement.

Surgical Technique- The surgical procedure was performed in a general anesthetic state using a transoral method. The patient was positioned in a Rose position to improve the ability to visualise the oropharynx. Orotracheal intubation is done routinely, but in multiple cases, nasotracheal intubation through the opposite nasal fossa was preferred so that there would be an unobstructed operative field. The self-retaining tonsil retractor-maintained access to the surgery.

Tonsillectomies in respect to patients who have never had one before began with coblation-assisted tonsillectomy to expose the tonsillar fossa. In cases where there had been a previous history of tonsillectomy, a mucosal incision was made directly through the fossa, down to the superior pharyngeal constrictor muscles. Hurd retractors were used to displace soft tissue laterally and posteriorly, creating a "tenting" effect over the underlying bony styloid process.

The constrictor muscle was incised through a series of small longitudinal incisions and incised along its length. The tendons associated with the styloid process were released. The surrounding bone was removed using a sharp instrument such as an elevator or a ring curette until the styloid process was sufficiently isolated from the surrounding bone and soft tissue, at which time it was possible to remove the styloid process using a Kerrison rongeur at the most proximal portion of the styloid process that was isolated. Using an electro cautery device and flushing with saline, any possible bleeding was controlled, and the surgical site was then closed in multiple layers, using interrupted 3-0 chromic catgut sutures to close the muscle layer, including the base of the pharyngeal the applicator was placed under, and the overlying mucosa.

Statistical Analysis- The initial data were analysed using IBM SPSS Statistics 22.0. Descriptive statistics were used to describe the demographics and clinical distributions of the data. The mean lengths of styloid processes were compared by an independent t-test between OPG and 3DCT to determine the relative accuracy of the imaging techniques. A p-value less than 0.05 was used as the level of significance for all tests.

RESULTS

Table 1 and Fig. 1 showed that the female gender was significantly more prevalent (60% vs 40%) in our study population. The majority of females studied were aged between 50 and 60 years old, while males were predominantly aged between 40 and 50 years old. The most commonly occurring complaint was localised pain (43.3%), followed by odynophagia (30%) and otalgia, like radiating pain (26.7%), which correlates to nociceptive symptoms as described in Eagle's triad (odynophagia, local pain, otalgia). Morphometric analysis of the styloid

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process (SP) revealed that males have a longer SP than females; however, the most important finding in this study was the lateralisation of the measurements between genders. For right-sided measurements, no significant differences between groups were found (p=0.678). However, when measured on the left, males displayed an average SP (26.1mm) significantly longer than females (24.3mm), (p=0.002). Based on the above analysis, the condition is typically bilateral; therefore, it is likely that elongation would have different gender-related growth characteristics on the left side, and that these growth differences will impact the severity of the symptoms and the technique required for proximal resection.

Table 1: Demographic distribution, clinical presentation, and comparative morphometric analysis of the styloid process

Category	Sub-Category	Frequency (n=30)	Percentage (%) / Mean (SD)
Gender Distribution	Male	12	40%
	Female	18	60%
Age Group (Males)	20-30 Years	3	-
	30-40 Years	2	-
	40-50 Years	4	-
	50-60 Years	3	-
Age Group (Females)	20-30 Years	4	-
	30-40 Years	3	-
	40-50 Years	5	-
	50-60 Years	6	-
Primary Symptoms	Pain	13	43.30%
	Pain radiating to the ear	8	26.70%
	Pain during swallowing	9	30.00%
Styloid Process Length	Side	Males	Females
	Left Side	26.1 (0.115)	24.3 (0.877)
	Right Side	25.4 (0.827)	25.1 (1.04)
Statistical Significance	p-value	0.002*	0.678 (NS)

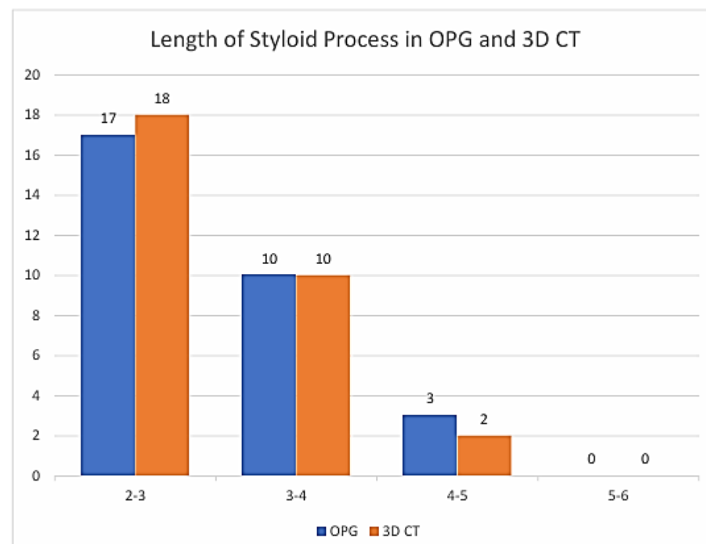

Fig. 1: Length of styloid process in OPG and 3D CT

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The styloid process (SP) dimensions of the study group were analysed and measured in the radiograph image, and the results are shown in Table 2. The average length of both sides (right and left) was roughly the same (25.2 & 25.3 mm), suggesting that for the majority of participants in their cohort, SP elongation followed a mathematical pattern of symmetry. However, the SP variable of medial angulation had a broader range of variance, with left-sided SPs having greater medial tilt (38.4°) compared to right-sided SPs (36.5°). These angulation measurements are relevant in surgical planning as an increase in the medial angle would place the SP closer to both the internal carotid artery and the lateral wall of the pharynx, which directly impacts the degree of symptomatic impingement.

Table 2: Comparative radiographic analysis of bilateral styloid process length and medial angulation

Measurement Parameter	Mean Value	Standard Deviation (SD)
Length of Right Styloid Process (mm)	25.2	1.11
Length of Left Styloid Process (mm)	25.3	0.897
Medial Angulation of Right Styloid Process (°)	36.5	9.95
Medial Angulation of Left Styloid Process (°)	38.4	9.59

Table 3 demonstrates that the medial tilt of the styloid process was assessed using 3D CT. The data shows that while girls have greater mean medial angulation than boys on both sides (Right: 41.7°; Left: 42.8°), the p-value for both sides (Right: 0.155; Left: 0.99) is NS. This indicates that even though there is a trend among female patients in this sample toward having a medialized styloid process (i.e., medial orientation of the styloid process), gender is not a reliable biological variable for explaining the angulation of the styloid process when comparing gender using Eagle's Syndrome.

Table 3: Gender-based statistical comparison of medial angulation via 3d computed tomography

Angulation Parameter	Gender	Mean (°)	SD (°)	p-value
Medial Angulation (Right SP)	Males	31.3	11.06	0.155 (NS)
	Females	41.7	5.72	
Medial Angulation (Left SP)	Males	34	9.84	0.99 (NS)
	Females	42.8	7.83	

Patient-reported pain levels were used to track the effectiveness of the transoral styloidectomy from the immediate post-operative period to a maximum of 12 weeks following surgery (Table 4). The pain experienced on the day of surgery (Day 0) was reported by 40% of the patient population due to surgical trauma resulting from the transoral approach and tonsillar bed dissection; however, the amount of morbidity (pain) continued to decrease significantly over time (to 26.7% of participants in the first week and to 3.3% of participants by the end of 3 months). The p-value obtained (<0.05) provides evidence of a statistically significant reduction in symptoms and verifies that the surgical resection of the elongated styloid process is an efficacious definitive method of eliminating the chronic pain associated with this pathophysiology (Table 4).

Table 4: Longitudinal assessment of post-operative pain and recovery progression

Post-Operative Follow-Up Period	Patients Reporting Pain (n=30)	Percentage (%)
Day 0 (Immediate Post-Op)	12	40.00%
1st Week Post-Operative	8	26.70%
4th Week Post-Operative	3	10.00%
12th Week Post-Operative	1	3.30%

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DISCUSSION

The epidemiological research has identified this disparity between the number of people radiographically diagnosed with elongated styloid processes or Eagle's syndrome. Studies conducted in both years of 2023-24 reflected that 4.26-4.5% of the radiographic cohorts have an ESP elongated stylopid measuring greater than 30 mm; however, these individuals, for the most part, are not symptomatic [10,11]. For example, of the total 3962 with a recorded explication of dysphasia, only 21.6% of those presenting with measured ESPs had a diagnosis of ESP [10]. Therefore, although there is a significant variation in the measured bone length associated with each demographic range (i.e. 16-80 years of age; all genders without significant difference), the majority of all symptomatic manifestations occur within specific sub-groups of ENT-related patients [10,11]. In synergy, these sources do show that within the symptomatic group, the majority of patients are between the ages of 30 and 50 years (mostly female) and have a prior history of trauma following tonsillectomy [10].

Eagle's Syndrome and Odynophagia occur when the styloid process is elongated or deviated and comes into contact with the pharyngeal mucosa or the glossopharyngeal nerve (CN IX), causing pain during swallowing [10]. The symptom review conducted on 179 radiographic cases showed a wide range of secondary symptoms: Headaches ipsilateral to the styloid process were seen in 58% of patients; neck and shoulder pain were seen in 52.3%; throat pain in 31.8%; referred otalgia to 30.7%; globus to 22.7%; dysphagia to 21.6% [10]. Physicians must consider these symptoms when evaluating patients for Eagle's Syndrome; the possibility of odynophagia should be taken into account when evaluating the palatable area of the tonsil for tenderness [3]. Anatomical elongation of the styloid process (> 3.0 cm) is quite frequently seen; however, only 4% to 10% of patients with elongated styloids develop symptoms. Final confirmation of diagnosis is made utilising three-dimensional CT mapping of angulation. CT angiography is only used if there is compression of vascular structures due to position/elongation [3].

Patients receiving non-surgical treatment options, including analgesics, neuromodulators, and local steroid/lidocaine injection, will see some reduction in their level of pain, typically around 70% after three months; however, pain symptoms may often return after this time frame [12]. On the other hand, patients undergoing surgical procedures will have nearly 99% of lessened post-operative pain three months post-surgery and report no recurrence of pain [12,13]. Morphometric and metabolic imaging show that symptoms typically associated with Eagle's syndrome are the result of abnormal angulation, sometimes referred to as bone hypertrophy, and improper inclination more than simply absolute length [13,14]. Histological and positron emission tomography/computed tomography (PET/CT) evaluations demonstrate that patients with elongated processes measuring approximately 52.1 ± 15.6 mm exhibit evidence of active endochondral ossification (formation of bone via cartilage), mature (cortical-like) bone, fractured callus and pseudarthrosis at the surgical site [14]. The structural variability of these elongated processes indicates that they are mature bones with dynamic functional properties and capable of localised remodelling; this information will be useful in determining the best surgical intervention for shortening styloids [13,14].

There are multiple factors affecting the pathogenesis of reactive hyperplasia after trauma (i.e., from surgical scarring such as that seen with tonsillectomy) or chronic osteitis versus the embryologic metaplasia of the stylohyoid ligament complex. These factors can include (but are not limited to) the variation in anatomical structure (continuously or segmented or pseudoarticulated calcifications), which can impact the complexity and degree of success of surgical procedures performed for this condition; for example, as well as the complications that arise from delayed surgical intervention. Despite limitations due to sample size, single-centre study design, and the short time frame between surgery and patient follow-up, additional research is needed using dynamic multi-slice CT angiography to visualise vascular insufficiency due to positional change and create standardised diagnostic algorithms between tertiary ENT clinics.

CONCLUSIONS

The study infers that an elongated styloid process is more likely to affect females between the ages of 40 and 60, and is usually accompanied by odynophagia, otalgia and dysphagia to varying degrees. An orthopantomogram is an adequate method for initial assessment; however, 3D computed tomography is much

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more accurate when determining length and angulation with regard to the prevention of neurovascular complications as well as preoperative planning for surgery. While medial angulation plays a role in the clinical picture, it is not a predictive factor on its own for symptom severity, thus indicating a multifactorial process (i.e., local anatomical compression) as the reason for symptoms. The transoral tonsillectomy approach will demonstrate the best outcomes as shown by a statistically significant reduction in long-term postoperative pain. The above conclusions are limited by a small, single-centre sample size; however, they demonstrate a need to combine thorough clinical assessment with advanced imaging. Larger multicentre studies utilising technological advancements such as 3D printing are needed to continue to optimise multidisciplinary management and patient outcomes in Eagle's syndrome.

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