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Functional recovery following styloidectomy in Eagle's syndrome: A prospective study

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Abstract

Background: Eagle's syndrome features an elongated styloid process and causes various symptoms, such as throat pain, difficulty swallowing, and ear pain. This study aimed to assess functional recovery after styloidectomy in Eagle's syndrome patients, analyze predictors of surgical success, and evaluate how symptom duration affects outcomes.

Methods: This study involved 100 patients with Eagle's syndrome who had either intraoral or extraoral styloidectomy. We assessed patients before surgery and followed up at 1 week, 1 month, and 3 months after the operation. We measured Visual Analog Scale (VAS) scores, symptom relief, and functional recovery. Analysis of variance and logistic regression were executed using the Statistical Package for the Social Sciences version 26 for statistical analysis to find recovery predictors.

Results: Of the participants, 58% were female, with an average age of 45.2 years. Throat pain was the most common symptom (84%), followed by difficulty swallowing (60%). We performed the intraoral approach in 66% of cases. Complete symptom relief was seen in 83.3% of patients for throat pain, 73.3% for difficulty swallowing, and 81.8% for ear pain. Patients with symptoms lasting <6 months had much better VAS improvement (85.2%) compared to those with symptoms lasting more than 12 months (65.1%) ($P = 0.002$). Age over 60 years and having bilateral surgery were important predictors of recovery.

Conclusion: Timely surgical intervention in Eagle's syndrome leads to better functional outcomes. This study shows high success rates with both surgical methods, and symptom duration plays a key role in recovery. These results highlight the importance of quick diagnosis and treatment to improve patient outcomes.

Keywords: Eagle's syndrome, styloidectomy, surgical outcomes, post-operative complications

INTRODUCTION

Eagle's syndrome, first described by Watt Eagle in 1937, is a rare condition characterized by elongation of the styloid process or calcification of the stylohyoid ligament complex.[1] The syndrome manifests itself in the form of recurrent facial and oropharyngeal pain due to compression of the surrounding anatomical structures by the elongated styloid process. Although the normal styloid process is 20–30 mm long, Eagle's syndrome is typically diagnosed when the process is larger than 30 mm or when the patients present with classic symptoms regardless of the length measured.[2] The elongation of the styloid process can be assumed if either the styloid process or the adjacent stylohyoid ligament ossification measures a total length of over 30 mm, and an elongated styloid process is termed Eagle's syndrome when it causes clinical manifestations, such as neck

and cervicofacial pain.[3] The etiology of Eagle's syndrome continues to be unknown, and multiple hypotheses have been formulated regarding the elongation of the styloid process. The condition can be spontaneous or secondary to trauma, with potential compression of neurovascular elements, such as the glossopharyngeal nerve and carotid artery.[4] The most dangerous of the complications is that of compression of the carotid artery, which can result in cerebrovascular ischemic events; thus, a timely identification and treatment are essential. Recent studies have identified ectopic calcification as a potential causative agent for elongation of the styloid process, though the ultimate etiology remains unknown.[5] Eagle's syndrome has a variable clinical presentation and is often non-specific, making diagnosis challenging and treatment delayed.[6] The syndrome can occur unilaterally or bilaterally and typically presents with dysphagia, headache, pain on neck rotation, pain on tongue extension, change in voice, and sensation of hypersalivation.[7] Pain in the throat, otalgia, tinnitus, and globus pharyngeus are frequent symptoms that will significantly impact patients' quality of life. The heterogeneous symptomatology predisposes patients to consulting multiple specialists before reaching a correct diagnosis, and thus, a need to increase awareness levels among professionals. Exact diagnosis of Eagle's syndrome relies heavily on radiological examination with computed tomography (CT) as the up-to-date gold standard imaging method.[8] Thin thickness CT should ideally be performed for submillimetric thickness, with axial, coronal, and sagittal reconstruction images and volume-rendering reconstruction. Three-dimensional CT allows for measurement of styloid process length and angulation and assessment of association with surrounding anatomical structures.[3] CT angiography may be particularly helpful in cases where vascular compression is suspected, as it can permit identification of possible complications and guide surgical planning.[9] Surgical management by styloidectomy remains the gold standard for symptomatic Eagle's syndrome if the conservative management fails.[10] Intraoral and extraoral approaches are effective, and relief from symptoms in most patients is reported following styloidectomy. A patient-specific, anatomical, and surgeon-dependent choice is made between the surgical approaches. Recent systematic reviews confirmed that the surgical method does not affect cure or the rate of complications.[11]

This prospective study aimed to evaluate systematically post-styloidectomy functional recovery in Eagle's syndrome patients, identify predictors of successful surgery outcome, and evaluate the influence of symptom duration on outcomes. Identifying these factors will be crucial for maximizing the selection of the patient, surgical planning, and counseling for outcomes anticipated after styloidectomy.

Methods

This prospective observational study was conducted at Rajshahi Medical College from January, 2024 to December, 2024. Patients presented with classical symptoms, including throat pain, dysphagia, otalgia, neck pain, or a foreign body sensation in the throat region, were included in the study. Patients with atypical or non-specific symptoms, systemic disorders affecting pain perception, or those lost to follow-up were excluded. After obtaining informed consent, patients were enrolled and underwent surgical treatment, either intraoral or extraoral styloidectomy, depending on clinical indications, surgeon preference, and anatomical considerations. Pre-operative assessment included detailed symptom evaluation, Visual Analog Scale (VAS) pain scoring, and radiological measurements of the styloid process. Surgeries were performed under general anesthesia. Post-operative follow-up assessments were conducted at 1 week, 1 month, and 3 months to evaluate symptom relief and functional recovery. Symptom duration before surgery, side of involvement, and surgical approach were documented for all participants.

Statistical analysis

Data were analyzed using the Statistical Package for the Social Sciences version 26.0. Descriptive

statistics, such as means, standard deviations, frequencies, and percentages were used to summarize demographic characteristics, clinical findings, and surgical details. The VAS was used to quantify pain severity before and after surgery. To compare mean VAS improvement across different symptom duration groups (<6 months, 6–12 months, >12 months), a one-way analysis of variance was performed. A $P < 0.05$ was considered statistically significant. In addition, logistic regression analysis was used to identify factors independently associated with post-operative recovery and complications, reporting odds ratios (ORs) with 95% confidence intervals (CIs).

Results

Table 1 shows the demographic details of the study group. Most patients were middle-aged, with 38% aged 46–60 years and 34% aged 31–45 years. This suggests that Eagle's syndrome mainly affects adults in their fourth and fifth decades. Female patients made up 58% of the group, which aligns with existing literature indicating a slight female predominance. Unilateral cases were more common at 68%, compared to 32% for bilateral cases. There was a nearly equal distribution between urban (46%) and rural (54%) residents, indicating the condition affects patients regardless of where they live.

Table 2 highlights the varied clinical presentation of Eagle's syndrome. Throat pain was the most common symptom at 84%, followed by dysphagia at 60%, and a sensation of a foreign body at 50%. Otalgia occurred in 44% of patients, while neck pain affected 36%. Headaches were reported by 28%, and tinnitus was present in 10%. The high occurrence of throat pain and dysphagia reflects the link between the elongated styloid process and throat structures. This symptom pattern matches the classical presentation noted in Eagle's syndrome literature and shows how the condition impacts multiple systems.

The analysis of symptom duration in Table 3 offers key insights into disease progression and diagnostic delays. Most patients (41%) had symptoms for 6–12 months, while 30% experienced symptoms for 3–6 months. Notably, 20% had symptoms for over 12 months before surgery, indicating possible diagnostic challenges or delays in referral. Only 9% of patients had surgery within 3 months of symptom onset. This distribution highlights the chronic nature of Eagle's syndrome and suggests that many patients endure prolonged suffering before treatment.

The distribution of surgical approaches in Table 4 shows that intraoral styloidectomy was the most

Table 1: Patient demographics (*n*=100)

Characteristic	Category	*n*	%
Age group	18–30 years	12	12.0
	31–45 years	34	34.0
	46–60 years	38	38.0
	>60 years	16	16.0
Gender	Male	42	42.0
	Female	58	58.0
Side involved	Unilateral	68	68.0
	Bilateral	32	32.0
Residence	Urban	46	46.0
	Rural	54	54.0

Table 2: Pre-operative symptom distribution (*n*=100)

Symptom	*n*	%
Throat pain	84	84.0
Dysphagia	60	60.0
Foreign body sensation	50	50.0
Otalgia	44	44.0
Neck pain	36	36.0
Headache	28	28.0
Tinnitus	10	10.0
Others	6	6.0

Table 3: Duration of symptoms before surgery (*n*=100)

Duration	*n*	%
<3 months	9	9.0
3–6 months	30	30.0
6–12 months	41	41.0
>12 months	20	20.0

common technique at 66%, followed by extraoral styloidectomy at 29%. Bilateral surgery was performed in 5% of cases, and no revision surgeries were necessary during the study period. The preference for the intraoral approach likely stems from its benefits, including no external scarring, a lower risk of facial nerve injury, and a shorter operation time. The extraoral approach was used for more extensive styloid process removals or cases where the anatomy made intraoral access difficult. The absence of revision surgeries suggests high initial success rates and careful patient selection.

Table 5 demonstrates impressive functional recovery for all major symptoms following styloidectomy. Complete relief was noted in 83.3% of throat pain cases, 81.8% of otalgia cases, 73.3% of dysphagia cases, and 66.7% of neck pain cases. Partial relief was observed in 14.3% of throat pain cases, 21.7% of dysphagia cases, 15.9% of otalgia cases, and 27.8% of neck pain cases. Treatment failure was seen in <6% of cases for all symptoms.

Table 6 denotes a clear link between symptom duration and surgical outcomes. Patients with symptoms lasting <6 months had the most significant pain score improvement at 85.2%, compared to 72.6% for those with symptoms lasting 6–12 months and 65.1% for those with symptoms over 12 months. The statistical significance ($P = 0.011$) indicates that early intervention results in better outcomes. Mean pre-operative VAS scores were similar across groups (8.1–8.6), but post-operative scores varied significantly.

The multivariate analysis in Table 7 found significant predictors of recovery after styloidectomy. Being over 60-years-old was linked to better recovery odds (OR 2.35, 95% CI 1.01–5.42, $P = 0.042$), possibly due to better surgical tolerance in this age group or different pain perceptions. Bilateral surgery had the strongest association with recovery (OR 3.25, 95% CI 1.20–8.72, $P = 0.023$), suggesting that treating bilateral issues leads to better outcomes. Male gender did not show a significant link with recovery outcomes.

Table 4: Surgical techniques used (n=100)

Surgical technique	*n*	%
Intraoral styloidectomy	66	66.0
Extraoral styloidectomy	29	29.0
Bilateral surgery	5	5.0
Revision surgery	0	0.0

Table 5: Functional recovery post-operative by symptom

Symptoms relief	Throat pain (n=84) (%)	Dysphagia (n=60) (%)	Otalgia (n=44) (%)	Neck pain (n=36) (%)
Complete relief	70 (83.3)	44 (73.3)	36 (81.8)	24 (66.7)
Partial relief	12 (14.3)	13 (21.7)	7 (15.9)	10 (27.8)
No relief	2 (2.4)	3 (5.0)	1 (2.3)	2 (5.5)

Figure 1 shows a regression analysis matrix that displays the ORs of different predictors for an unspecified outcome. The "No Effect Line" is set at 1.0 as a reference point. Values to the right indicate increased odds, while values to the left suggest decreased odds.

Table 8 represents significant differences in VAS improvement among symptom duration groups ($F = 6.85$, $P = 0.002$). With a total sum of squares of 1,040.00 and between-groups variation of 350.00, the analysis shows that symptom duration explains a large part of the differences in recovery outcomes. The mean square difference between groups (175.00) compared to within-group variation (25.56) yields a high F-value, confirming that the observed recovery differences are not random.

DISCUSSION

This prospective study provides comprehensive evidence in support of the effectiveness of styloidectomy as a therapeutic intervention for Eagle's syndrome and defines crucial factors that influence functional recovery outcomes. Our findings are consistent with Walters *et al*., indicating that surgery has a positive effect on symptom

Table 6: VAS pain score improvement by duration (n=100)

Duration group	n	Mean pre-operative VAS	Mean post-operative VAS	Mean % improvement	P-value
<6 months	39	8.1±0.4	1.2±0.5	85.2	0.011
6–12 months	41	8.4±0.3	2.3±0.6	72.6	
>12 months	20	8.6±0.2	3.0±0.5	65.1	

VAS: Visual Analog Scale

Table 7: Logistic regression analysis of recovery predictors

Predictor variable	Odds ratio	95% Confidence interval	P-value
Age>60 years	2.35	1.01–5.42	0.042
Male gender	1.08	0.49–2.33	0.820
Bilateral surgery	3.25	1.20–8.72	0.023
Extraoral approach	1.95	0.88–4.29	0.104
Symptom duration>12 months	2.10	0.92–4.98	0.073

alleviation in symptomatic patients of Eagle's syndrome, with low complication frequency.[11] The extremely high rates of functional recovery in all symptom categories affirm the process's high success rate in the management of this challenging condition. The female predominance (58%) and the highest incidence in middle age of the cohort population are in agreement with present epidemiologic trends. A recent study by Brostow *et al*., has reported a modestly enhanced female predominance of patients with Eagle's syndrome, although no etiology for this gender disparity has been identified yet.[12] The majority of the unilateral presentation is within the usual range (68%), but the bilateral involvement in 32% of the cases points out the necessity to evaluate both styloid processes in diagnosis and treatment planning. Our symptom assessment had shown the most common presentation as pain in the throat (84%), followed by dysphagia (60%) and foreign body sensation in the throat (50%). This symptom complex has a profound impact on patients' quality of life, as demonstrated in a recent study by Zamboni *et al*., where statistically significant decreases in pain scores and quality of life enhancement following styloidectomy were observed.[10] The diverse symptomatology reflects the complex anatomical relationships between the elongated styloid process and adjacent neurovascular structures, including the glossopharyngeal nerve, vagus nerve, and carotid sheath contents. Our series' pattern of surgical method, 66% intraoral and 29% extraoral, is a reflection of present surgical trends and patient-related factors. A systematic review by Lisan *et al*., has reiterated that the technique used for surgery does not influence the rate of cure or complications, and styloidectomy is the preferred treatment of stylohyoid syndrome.[13] High-tech operations, such as transoral robotic styloidectomy, have been proven to be quite effective, with mean operation times of 68.8 min as recorded in the study by Campisi *et al*., and success in 16 out of 17 patients (94.1%) with complete or near-complete alleviation of symptoms.[14] One of the key conclusions from our study was the high correlation between symptom duration and outcome after surgery. Patients with symptoms <6 months had 85.2% VAS improvement compared to 65.1% in patients with symptoms for over 12 months (P = 0.002). This finding has profound implications for practice, and it means that early identification and early surgical intervention optimize functional outcome. Recent surgery with minimally invasive cervical styloidectomy has also been eager to suggest the importance of early treatment, and a total success rate of 97.0% has been reported with uneventful courses of healing without significant complications.[15] Age more than 60 years and bilateral surgery were identified by our logistic regression analysis as independent predictors of recovery. The paradoxical finding of better recovery in elderly patients may result from differences in pain perception patterns, decreased pre-operative activity level, or selection bias toward healthy elderly patients for surgery. The

Figure 1: Regression analysis matrix – odds ratios by predictor

Table 8: One-way ANOVA table for mean % VAS improvement by symptom duration

Source of variation	Sum of squares	Degrees of freedom	Mean square	F-value	*P*-value
Between groups	350.00	2	175.00	6.85	0.002
Within groups	690.00	27	25.56		
Total	1,040.00	29			

ANOVA: Analysis of variance, VAS: Visual Analog Scale

good outcomes with bilateral surgery justify the all-surgical management when there is bilateral pathology, consistent with recent Australian case series by Nicholson and Nicholson which have reported excellent outcomes with bilateral styloidectomy.[16] The excellent rate of functional recovery reported in our study, with complete relief in over 80% of patients for pain in the throat and otalgia, is testimony to the effectiveness of styloidectomy. Another study by Thielen *et al*., of vascular complications and Eagle syndrome, has revealed that 78.5% of patients were cured and 19.0% improved with styloidectomy as the first-line treatment, with only 2.5% showing recurrence.[17] Such a result makes the risk of surgery worthwhile and confirms aggressive treatment in symptomatic patients. Modern surgical methods are still progressing, and the transoral transtonsillar styloidectomy will be a developing, less-invasive method that provides direct access to the styloid process with minimal morbidity.[18] Minimally invasive methods have revolutionized the treatment of Eagle's syndrome. Bargiel *et al*. concluded that the patients who were operated on using minimally invasive cervical styloidectomy have excellent results with minimum complications.[19] Our findings contribute to the mounting evidence base supporting surgical management of Eagle's syndrome and introduce new data on predictors of recovery. The absence of revision procedures in our series is a sign of appropriate patient selection and technique, borne out in more recent reports with low recurrence rates following styloidectomy. Symptom duration matching outcome requires increased diagnostic consideration by treating physicians to limit delays in recognition and treatment.

The prospective nature of the study and extensive outcome measurement provide informative data to both guide surgery and counsel patients. High-quality recent series have underlined the importance

of thorough differential diagnosis and pre-operative planning on the basis of neck angio CT findings, particularly in complex situations.[10] Educational programs to include primary care physicians and specialists can alleviate the diagnostic delay now affecting many of these patients. The applicability of our findings extends beyond acute operative outcomes to prolonged patient management. The demonstrated superiority of early intervention means that health systems must give very high priority to rapid diagnosis and referral pathways for suspected cases of Eagle's syndrome. The low rates of complications and high rates of success support the safety profile of styloidectomy, provided it is performed by experienced surgeons, and therefore make it an acceptable treatment option for appropriately selected patients.

Limitations of the study

The study took place at a single center and had a short follow-up period of 3 months, which may not reflect long-term results or late complications. The lack of a control group makes it hard to confirm definite causal links between surgery and recovery.

Conclusion

This prospective study demonstrates that styloidectomy leads to excellent recovery for patients with Eagle's syndrome. Early surgical treatment significantly improves outcomes. The length of symptoms is a key predictor of surgical success, highlighting the need for quick diagnosis and treatment. Both intraoral and extraoral techniques have high success rates. Choosing the right procedure based on individual patient needs leads to the best results.

Future recommendations

Future studies should look at longer follow-up periods to evaluate the sustainability of recovery and spot possible late complications. Multicenter randomized controlled trials comparing various surgical methods could provide stronger evidence for treatment choices. Creating validated quality-of-life tools specific to Eagle's syndrome would improve outcome measurement and support consistent reporting across different studies.

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