# Glottal and Epiglottal Stop in Wakashan, Salish, and Semitic

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## ABSTRACT

Direct laryngoscopic articulatory evidence from four languages in three unrelated families demonstrates the existence of epiglottal stop in the pharyngeal series. In each language, Nuuchahnulth (Wakashan), Nlaka'pamux (Salish), Arabic (Semitic), and Tigrinya (Semitic), glottal stop also exists in the glottal series as a complement to epiglottal stop, and in three of the languages, a voiceless glottal fricative and a voiceless pharyngeal fricative are also found. In Nlaka'pamux, a pair of voiced pharyngeal approximants (sometimes realized as pharyngealized uvulars) is found instead of the voiceless pharyngeal fricative. As the most extreme stricture in either the glottal or the pharyngeal series, epiglottal stop is a product of full constriction of the aryepiglottic laryngeal sphincter and functions as the physiological mechanism for optimally efficient complete airway occlusion. In this sense, glottal stop represents only slight engagement of the sphincter and functions physiologically as only minimum protective closure, as specified by Gauffin [1].

## 1. INTRODUCTION

It has long been surmised that stop closure is possible at the pharyngeal place of articulation. Catford discussed the phonetic nature of 'epiglottopharyngeal' articulation in the Caucasian languages, including the category 'stop' as a possibility [2,3,4], and Kodzasov described this same auditory quality as an 'epiglottalized glottal stop' [5], citing the term 'epiglottals' as already in use by Soviet Arabists in the tradition of Troubetzkoy's term 'emphatic laryngeals'. At the same time, Wakashan and Salish scholars including Kinkade were describing the so-called voiced pharyngeal as a 'pharyngeal stop' [6,7]. Research into Arabic was also considering the auditorily motivated hypothesis that the non-fricative member of the pair of pharyngeal consonants has a stop component [8,9,10]. Laufer and Condax and Baer investigated this theme in order to show that the Semitic pharyngeals involve the epiglottis and not only the tongue in their articulation [11,12,13]. In Thelwall and Sa'adeddin's illustration of Arabic in 1999, /ʕ/ is in fact described as a glottal stop with a secondary voiced pharyngeal offglide [ʔˤ] [14]. The present paper answers questions that no prior research has been able to demonstrate conclusively: that a second kind of stop articulation is occurring in parallel to glottal stop, and that its articulatory parameters relate to the production of glottal stop in a systematic physiological way.

## 2. RESEARCH APPROACH

We have examined the laryngeal physiology involved in the production of glottal, glottalized, and pharyngeal consonants in Nuuchahnulth (Wakashan), Nlaka'pamux (Salish), Arabic (Semitic), and Tigrinya (Semitic) to identify the role of the aryepiglottic sphincter mechanism. In general, we wish to discover how sounds originating in the lower pharynx are produced and how they are related to each other articulatorily. Specifically, we wish to demonstrate how stop articulations in the laryngeal and pharyngeal regions are produced and to document the production of epiglottal stop. The key element in this research is to document linguistic examples from native speakers of the cardinal consonantal categories predicted in prior studies of laryngeal and pharyngeal articulatory possibilities [15,16]. The fibreoptic laryngoscopic research methodology used to obtain the photographs illustrated here includes the Kay 9100 RLS and VCR (30 frames/s), the Olympus ENF-P3 flexible nasendoscope, 28mm wide-angle lens, and Panasonic KS152 camera, as described in detail elsewhere [17,18]. Data from the above languages will illustrate the differentiation between glottal stop and epiglottal stop articulatory maneouvres in still photographs taken from consonant-medial positions in words spoken as prepared items in laryngoscopic recording sessions lasting approximately 20 min. each.

## 3. WAKASHAN AND SALISH DATA

The consonant inventory of Nuuchahnulth (referred to as Nootka in the research literature) includes glottal stop as an independent phoneme and as a secondary component of the preglottalized resonants [19,18].

| | | | | | |
|---|---|---|---|---|---|
| bilabial | p | p' | | m | **ˀm** |
| denti-alveolar | t | t' | | | |
| | ts | ts' | s | | |
| apico-alveolar | tɬ | tɬ' | ɬ | n | **ˀn** |
| postalveolar | tʃ | tʃ' | ʃ | | |
| palatal | | | | j | **ˀj** |
| velar | k | k' | x | w | **ˀw** |
| | $k^w$ | $k^w$' | $x^w$ | | |
| uvular | q | | (χ) | | |
| | $q^w$ | | ($χ^w$) | | |
| pharyngeal | | | **ħ** | ʕ | |
| glottal | **ˀ** | | **h** | | |

**Table 1:** Consonant inventory of Nuuchahnulth.


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Our focus is on pharyngeal /ʕ/ (listed here in a voiced series), on its phonetic components, and how it differs phonetically from /ʔ/. The consonants of Nlaka'pamux (Thompson in the research literature) also include /ʔ/ as an independent phoneme and as a secondary component of postglottalized resonants [20]. The issue here is not only to distinguish the pharyngeals from phonetic [ʔ] but also to distinguish plain /ʕ, ʕʷ/ phonetically from glottalized /ʕ', ʕʷ'/, all of which are listed as voiced.

| | | | | | |
|---|---|---|---|---|---|
| bilabial | p | p' | | m | **mˀ** |
| alveolar | t | (t') | | n | **nˀ** |
| | ts | ts' | s | z | **zˀ** |
| | | tɬ' | ɬ | l | **lˀ** |
| postalveolar | tʃ | | ʃ | | |
| palatal | | | | j | **jˀ** |
| velar | k | k' | x | (ɣ) | (**ɣˀ**) |
| | kʷ | kʷ' | xʷ | w | **wˀ** |
| uvular | q | q' | χ | | |
| | qʷ | qʷ' | χʷ | | |
| pharyngeal | | | | **ʕ** | **ʕ'** |
| | | | | **ʕʷ** | **ʕʷ'** |
| glottal | **ʔ** | | **h** | | |

**Table 2:** Consonant inventory of Nlaka'pamux.

The two pharyngeals of Nuuchahnulth are both a function of constriction of the aryepiglottic laryngeal sphincter mechanism. The mechanics of the laryngeal sphincter are moderately well known anatomically [21,22] but are less well incorporated into phonetic explanations of pharyngeal sounds. Articulatorily, with the glottis either adducted or abducted, the aryepiglottic sphincter closes first, beginning with slight aryepiglottic-fold adduction with the cuneiform tubercles moving in a posterior-to-anterior direction, followed by progressive larynx raising and sphincteric adduction against the base of the epiglottis, followed by extreme tongue retraction back into the pharyngeal cavity. Perhaps the most striking aspect of the sphinctering mechanism for producing pharyngeal/epiglottal sounds is that it moves upwards and forwards against the root of the tongue and epiglottis, whereas in the rest of the oral vocal tract the tongue is the active articulator. In Nuuchahnulth, both pharyngeals /ħ/ and /ʕ/ have extreme concomitant tongue retraction and are difficult to see over the epiglottis, but occasionally the tongue advances to a point where full aryepiglottic occlusion is visible, as in Fig. 1.

In Interior Salish, epiglottal stop appears in the glottalized phonological series [23]. The non-glottalized pharyngeals /ʕ, ʕʷ/ and glottalized pharyngeals /ʕ', ʕʷ'/ differ in that glottalization entails laryngeal closure at some point in the sound. The degree of closure in /ʕ', ʕʷ'/ is greater than glottal stop because a pharyngeal articulation is already more sphinctered than glottal stop. For the pre-pharyngeal glottalized resonants, glottal stop closure is adequate to effect a phonological distinction; but where resonant quality is pharyngeal, epiglottal stop closure is required. Thus, the glottalized series in Salish warps from glottal stop to epiglottal stop as a natural phonetic property of back-vocal-tract articulations [24].

In Fig. 1, Nuuchahnulth epiglottal stop is initial with a voiced pharyngeal approximant offglide, as in /ʕiħuː/ [ʢˤɪħˤuː] 'to cry after'. In Fig. 2, Nlaka'pamux epiglottal stop is syllable-final with a voiced pharyngeal onglide and followed by voiceless release, as in the labialized glottalized pharyngeal /npaʕʷ'/ [nːˈpaˤʢʷ̥] 'ice'. The view in Fig. 2 shows as much of the aryepiglottic sphincter as can be seen just after maximum [ʢ] occlusion.

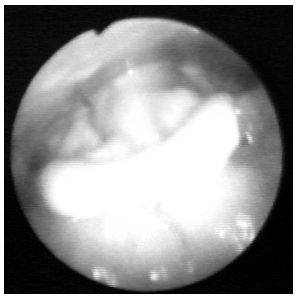

**Fig. 1:** Nuuchahnulth [ʢ]

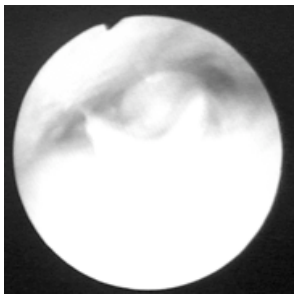

**Fig. 2:** Nlaka'pamux [ʢ]

It is instructive to look at another view of the same item, in Fig. 3, where the aryepiglottic folds are just beginning to make closure with the base of the epiglottis. In Fig. 4, also the same lexical item, the sphincter is opening up and the tongue advancing so that the epilaryngeal tube can be seen. The vocal folds and ventricular folds remain closed in [ʔ] posture for at least 120ms after the epilaryngeal tube opens after [ʢ] until the stricture is released into breath at the end of [nːˈpaˤʢʷ̥]. Fig. 4 represents a midway point between full occlusion for epiglottal stop and the slight degree of sphinctering required for plain glottal stop.

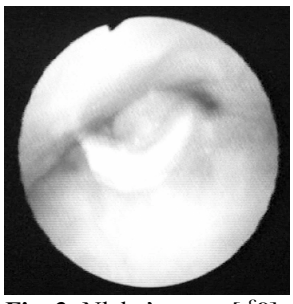

**Fig. 3:** Nlaka'pamux [-ˤʢ]

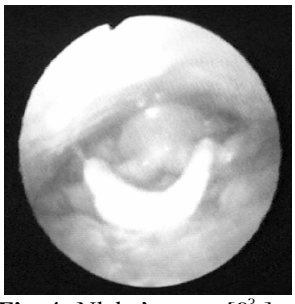

**Fig. 4:** Nlaka'pamux [ʢˤ-]

Comparing the process of release of [ʢ] in Fig. 4 with plain glottal stop, in Figs. 5–6, the epilaryngeal space for [ʔ] is clearly more open than in epiglottal stop, but it is slightly more sphinctered than it would be for vocalic voicing, where only adduction at the glottis is present. The ventricular folds, on the other hand, are adducted over the glottis to fill the epilaryngeal space. In the case of [ʔ], the adducted vocal folds (as in [i]) cease vibrating when the aryepiglottic folds advance slightly, making the epilaryngeal tube slightly narrower. As this happens, the ventricular folds can be seen to adduct partially over the glottis. The most likely explanation for this is that the ventricular folds, which have little muscle fibre of their

own, exert slight pressure on the vocal folds in response to slight sphincteric constriction, causing the vocal folds to stop vibrating. It is proposed here that the antero-posterior and the vertical fibres of the two thyroarytenoid muscles, particularly fibres running from the epiglottis to the cuneiform tubercles of the aryepiglottic folds, are responsible for initial constriction of the sphincter.

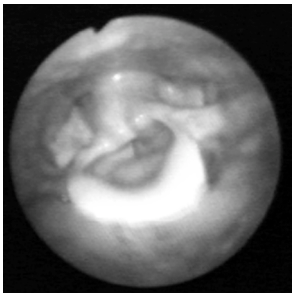

**Fig. 5:** Nuuchahnulth [ʔ]

**Fig. 6:** Nlaka'pamux [ʔ]

Fig. 7 shows a modal voice /iː/ vowel in Nuuchahnulth, which can be taken as an example of a glottally adducted but non-sphinctered state. Full opening of the airway, with neither glottal adduction nor sphincteric constriction, is shown in an example of Nuuchahnulth /h/ in Fig. 8.

**Fig. 7:** Nuuchahnulth [i]

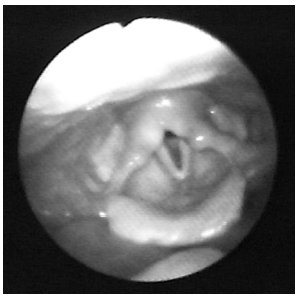

**Fig. 8:** Nuuchahnulth [h]

## 4. SEMITIC DATA

In laryngoscopic observations of Arabic and Tigrinya, the two glottal /h, ʔ/ and two pharyngeal /ħ, ʕ/ phonemes are observed directly in various close-vowel contexts and reviewed using video software with synchronous acoustic displays. As in Wakashan and Salish, it appears that the two sounds usually transcribed in Arabic and Tigrinya as /ʔ/ and /ʕ/ are in fact moderate glottal stop and complete epiglottal stop. The Arabic data, as in Fig. 9 (slightly after maximum occlusion in order to see behind the epiglottis), demonstrate this less clearly, probably because of a tendency to lower the larynx during the articulation of pharyngeals, at least in this Palestinian dialect; but the acoustic evidence suggests early closure bursts followed by silence, and the visual evidence suggests strong laryngeal sphincter occlusion. The phonemic glottal stop in Fig. 10 shows an adducted glottis but a non-sphinctered epilaryngeal tube by comparison. From these data, it is not clear that <'ain> is always an epiglottal stop in all Arabic, but the phonetic option to contrast epiglottal stop with glottal stop should be anticipated.

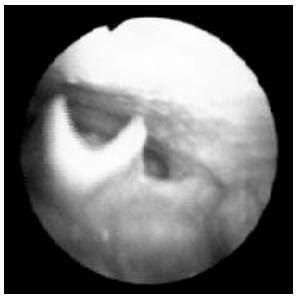

**Fig. 9:** Arabic [ʜ]

**Fig. 10:** Arabic [ʔ]

The data from Tigrinya are much clearer in corroborating the findings based on the Wakashan and Salish evidence. A syllable-initial epiglottal stop in Fig. 11 contrasts markedly with a syllable-initial glottal stop in Fig. 12. The distal end of the endoscope in Figs. 11–12 is closer to the larynx than in Arabic Figs. 9–10.

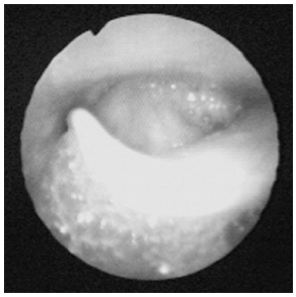

**Fig. 11:** Tigrinya [ʜ]

**Fig. 12:** Tigrinya [ʔ]

From the Tigrinya and Arabic laryngoscopic evidence, it is clear that glottal stop has a more open epilaryngeal space than epiglottal stop but less open than in the state of voice. While glottal stop requires slight sphinctering, epiglottal stop exercises maximum engagement of the sphincter mechanism, closing the epilaryngeal space under the epiglottis as the primary component of the pharyngeal articulation prior to tongue retraction. Although not commonly attested, epiglottal stop is a more prevalent articulation than once expected.

## 5. CONCLUSIONS

In states of closure, the glottis is closed at the level of the vocal folds by adduction of the vocal processes of the arytenoid cartilages at the posterior end of the glottis; but this is no different from the arytenoid adduction already present in voicing. To effect a glottal stop, and thereby to arrest voicing, it is also necessary to apply some slight stricture of the aryepiglottic sphincter mechanism, pulling the aryepiglottic angle forward slightly and causing the ventricular folds to press down on the vocal folds, thereby stopping vibration. The small degree of engagement of the sphincter for a glottal stop is the beginning of a process which culminates, at its most extreme degree, in the complete closure of the airway in the process of laryngeal sphinctering, tongue retraction, and larynx elevation that constitutes a full epiglottal stop.



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