

Cine MRI data of Korean Affricates: Implications for their Place of Articulation

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ABSTRACT

A cine magnetic resonance imaging (MRI) experiment of the Korean lenis, aspirated and fortis affricates /c, c^h, c'/ and plosives /t, t^h, t'/ was conducted to examine where the tongue contact and constriction occur during and after oral closure of the affricates in comparison with those of the plosives and how the apex and the blade position are made, as a function of time, in the production of the consonants. Based on the results of the MRI experiment, we propose that the affricates are alveolar like the plosives with the difference in apicality/laminality which is not distinctive in Korean.

1. INTRODUCTION

Recent articulatory studies have shown that the place of articulation of the Korean lenis, aspirated and fortis affricates /c, c^h, c'/ is “alveolar” like that of the coronal plosives /t, t^h, t'/ in static palatograms and linguograms ([2], [5], [6]) in support of [11] or “postalveolar” in EPG studies ([1], [9], [10]) (see [3] for review). In addition to the discrepancy in the place of articulation of the affricates in the traditional and the EPG data, two questions still remain at issue: one is of where the tongue constriction occurs for the fricative part of the affricates after the release of their oral closure; the other is of whether the affricates are the same as the coronal plosives in their tongue body position during and after the oral closure. In relation to these issues, an acoustic study of Korean lenis affricate and the consonants /t, s/ in intervocalic position [5] needs our attention to its results that, while the consonants are all “alveolar” in terms of the location of the tongue contact or constriction in the analysis of LPC spectra, the frequency of F2 at the offset and onset of the affricate was higher than that at those of the other consonants /t, s/ across her four subjects. Given that the tongue shape, rather than place of articulation, is more relevant to F2 [7], the higher F2 values for the affricate are attributed to a somewhat higher and more front tongue body position of the consonant, that is, the more laminal articulation in the affricate than in the consonants /t, s/. In order to articulatorily verify the acoustic data and also investigate not only where the tongue contact occurs during oral closure but also where the narrowest tongue constriction occurs for the fricative part of the affricates after their oral closure, we conducted an MRI experiment of the affricates /c, c^h, c'/ and the plosives /t, t^h, t'/, because midsagittal MRI data can provide us with a clear-

cut access to seeing the movement of the tongue as well as its contact and constriction as a function of time.

2. CINE MRI DATA

The MRI experiment was performed on a Shimadzu Marconi Eclipse Power Drive 250 (=1.5[T]) at Advanced Telecommunications Research Institute, Kyoto, Japan. Two middle-aged native speakers (one male and one female) commanding the Seoul dialect participated in the experiment. Each MRI image for midsagittal data of our two subjects' head and neck has a 256 mm x 256 mm field of view with a 10 mm slice thickness, mapped on to 256(x) x 256(y) pixels. Each trigger pulse signals the MRI controller to begin the field echo scans (TR=16.5 ms, TE=3 ms, NEX=1) repeated 52 times every 16.7 ms (60 frames/sec) for one of the 128 gradient magnetic field conditions which is maintained for each 1000 ms period and changed at each trigger pulse. During data acquisition, the subjects repeated the six test words in (1) 128 times and thus 128 MR scans for each of 52 sequential midsagittal frames were collected. The obtained images were displayed on a computer screen with 8-bit gray-scale resolution for analysis.

- (1) /mata/ ‘every’ /maca/ (nonsense word)
 /mat^ha/ (nonsense word) /mac^ha/ ‘cart’
 /mat^ha/ (nonsense word) /mac^ha/ (nonsense word)

Figure 1 shows the midsagittal images of /t, t^h, t'/ and /c, c^h, c'/ from our subjects when the longest linguopalatal contact is made during the oral closure of the consonants. We can note that the lenis plosive has apico-dental contact, whereas the aspirated and the fortis plosive have apico-laminal contact from behind the upper teeth to postalveolar with the fortis one having longer tongue contact than the aspirated one. In contrast, the affricates have all laminal contact with the tongue body being raised relatively high: lamino-alveolar contact in the lenis affricate, laminal contact (from the alveolar ridge to postalveolar (a) or at the alveolar ridge (b)) in the aspirated and the fortis affricate with the latter having longer tongue contact than the former in our female subject. Of interest is the difference in tongue contact and position between the plosives and the affricates in our two subjects. The tongue rises higher and moves more front in the affricates than in the plosives. This is due to the laminality of the affricates, not due to the difference in place of articulation between the affricates and the plosives, as shown in Figure 1.

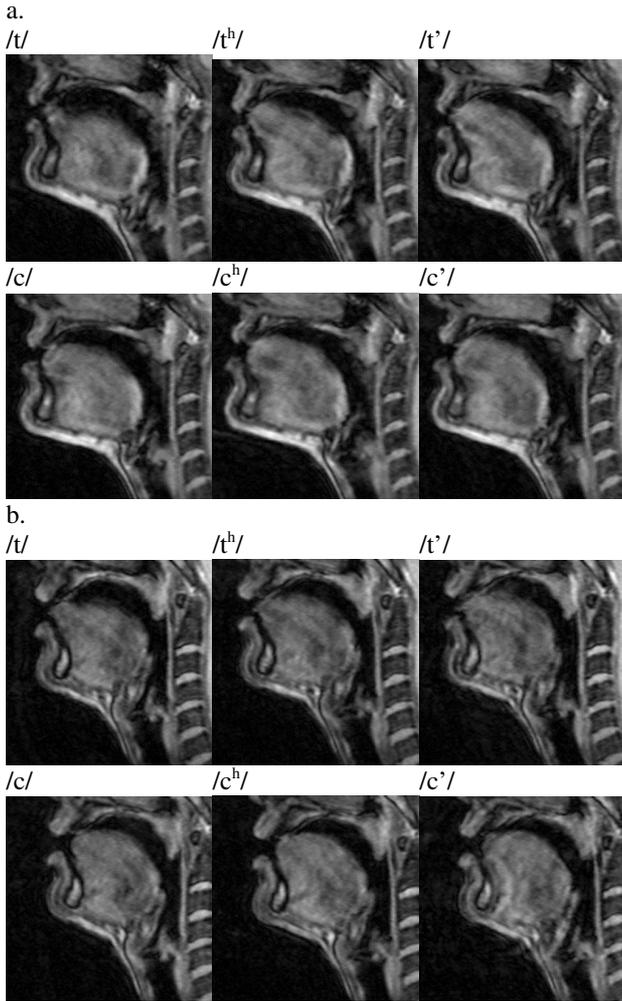


Figure 1. The midsagittal images of /t, t^h, t'/ and /c, c^h, c'/ from our female (a) and male (b) subject with the longest linguopalatal contact during the closure of the consonants.

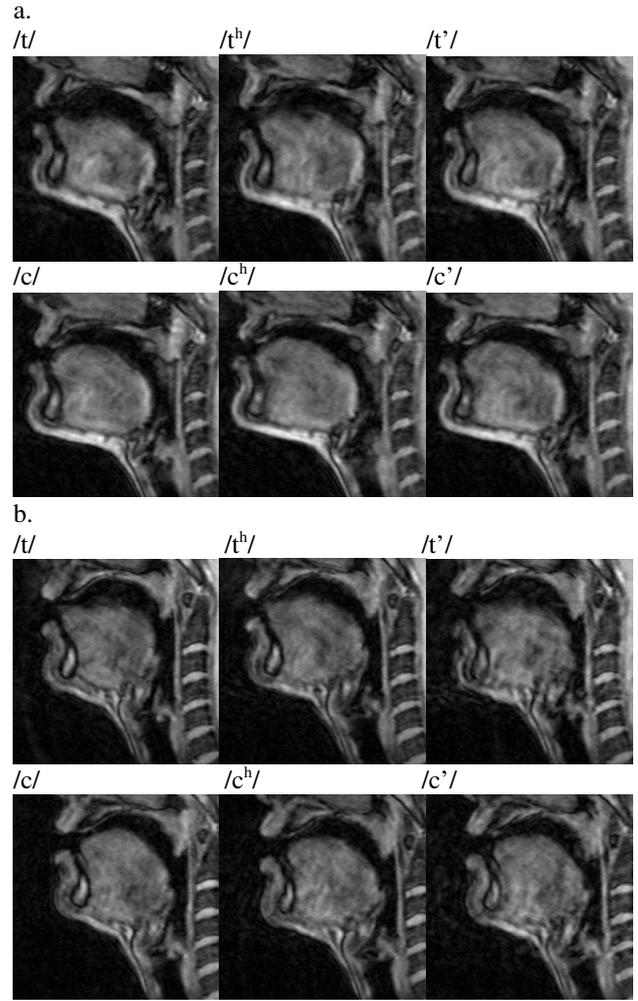


Figure 2. The midsagittal images of /t, t^h, t'/ and /c, c^h, c'/ from our female (a) and male (b) subject just after the oral closure of the consonants.

Figure 2 presents the midsagittal images of /t, t^h, t'/ and /c, c^h, c'/ from the same subjects just after the oral closure of the consonants. The comparison of the midsagittal data in Figure 2 reveals that there is the narrowest constriction before or at the alveolar ridge. The difference lies in which part of the tongue is involved and in how high the tongue body rises at the oral release: a) the narrowest constriction is made by apicality in the lenis plosive, by apico- laminality in the aspirated and fortis plosives and by laminality in the affricates; b) the tongue position is a little higher and more front in the affricates due to the laminality.

In order to measure values of displacement for the movement of the tongue, the outline of the upper teeth, the back of the upper teeth and the roof of the mouth of each subject was traced with two grid lines, one for tracking the apex position (i) and the other for tracking the blade position (ii), as shown in Figure 3 [7], and then was transposed upon a midsagittal image of a target consonant.

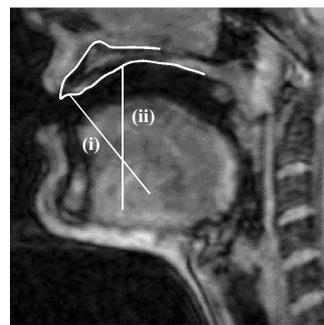


Figure 3. The sagittal measurement for the movement of the apex (i) and the blade (ii) taken from [7].

Figures 4 and 5, which are also taken from [7], present the movement of the apex and the blade during the production of the plosives /t, t^h, t'/ and the affricates /c, c^h, c'/, respectively, as a function of time. The frame interval in the x-axis in Figures 4 and 5 is 16.7 ms long (60 frames/sec) and values along the y-axis refer to the distance from the mouth roof to the tongue (mm). Zero

value in the y-axis indicates the tongue apex/laminal contact against the mouth roof whose sequence is articulatorily correlated with the closure duration of a target consonant, and negative values along the y-axis in the figures refer to how far the tongue apex or blade is below the mouth roof, thus their absolute values indicating the distance from the mouth roof. It is noteworthy from Figure 4 that the blade position is much lower in the lenis plosive than in the aspirated and the fortis counterpart: the distance from the mouth roof to the tongue blade, when the latter rises the highest during oral closure, is 7.7 mm for /t/, 2.8 mm for /t^h/ and 0.7 mm for /t'/. The lower tongue blade position in /t/ throughout its oral closure can be attributed to the apicality of the consonant, and the relatively high tongue blade position in /t^h, t'/ to their apico-laminality, as already shown in Figure 1.

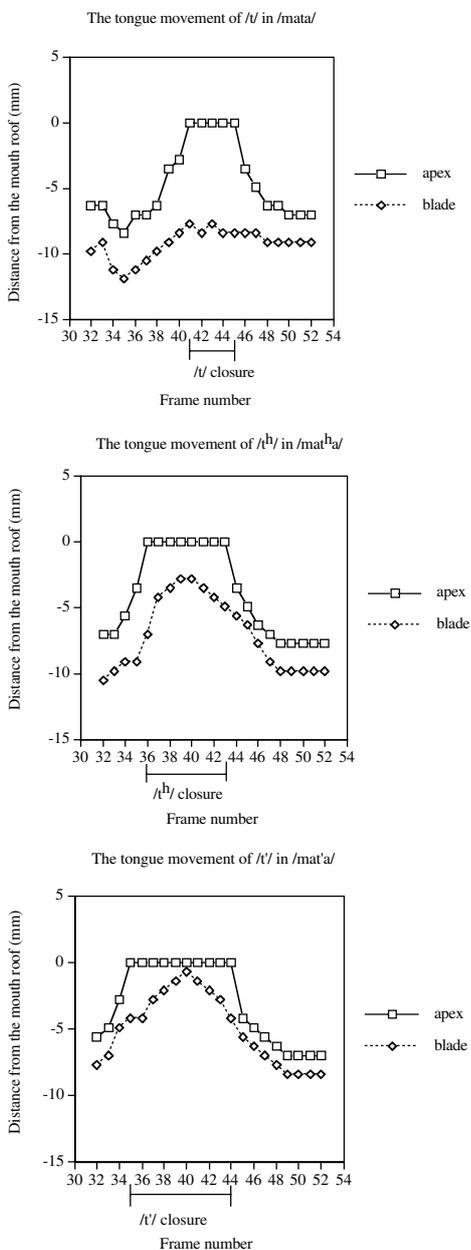


Figure 4. The tongue movement of the plosives /t, t^h, t'/ of our female subject [7].

On the other hand, the blade position is relatively high in the affricates, as shown in Figure 5: the distance from the mouth roof to the tongue blade, when the latter rises the highest during oral closure, is 2.8 mm for /c/, 1.4 mm for /c^h/ and 0.7 mm for /c'/. The higher blade position in the lenis affricate than in its plosive counterpart can also be attributed to the laminality of the affricate like its aspirated and fortis counterparts, as shown in Figure 1.

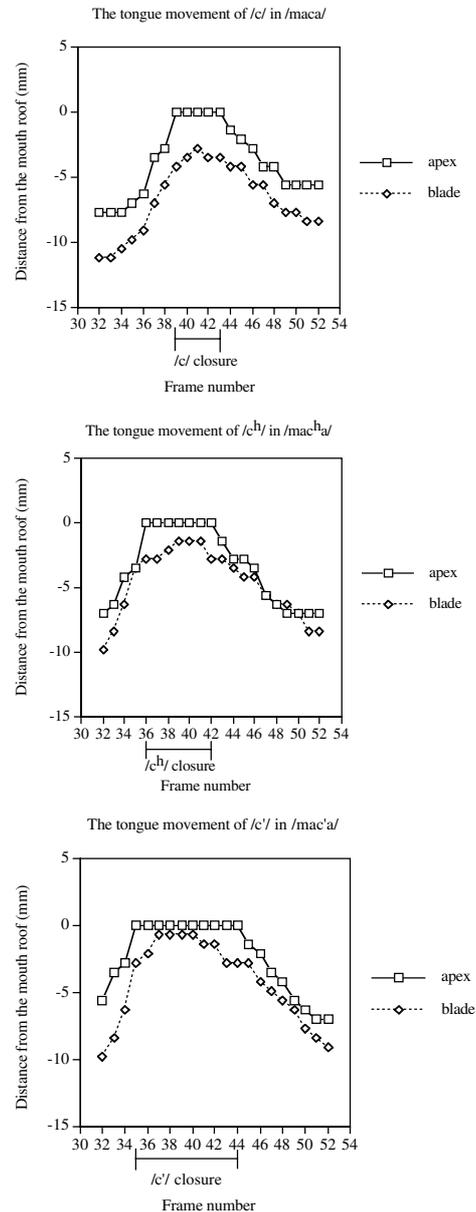


Figure 5. The tongue movement of the affricates /c, c^h, c'/ of our female subject [7].

3. DISCUSSION

If we confined ourselves to where the tongue contact occurs during the oral closure of the Korean consonants for their place of articulation, then the lenis ones would be considered as alveolar and the aspirated and the fortis ones as postalveolar, no matter whether the consonants are plosives or affricates. However, this cannot be supported

phonetically and phonologically. First, there is no case where aspirated and fortis consonants pattern together in opposition to their lenis counterparts in place of articulation in Korean. For example, in Umlaut, plosives and affricates pattern together in place of articulation, regardless of three-way phonation types [4]. Second, the fact that the narrowest constriction occurs at the alveolar ridge just after the release of the oral closure of the affricates /c^h, c'/ and the plosives /t^h, t'/, as shown in Figure 2, makes it inappropriate to classify the consonants as palato-alveolar. Third, not only in our MRI data but also in the conventional articulatory study of palatograms and linguogram [5], linguopalatal contact varies from short to long in the order of lenis, aspirated and fortis consonants, no matter whether they are plosives or affricates. For instance, in the same context /ma_a/, the fortis affricate was produced as palato-alveolar by 13 among the twenty subjects, the aspirated one as palato-alveolar by 8, and the lenis affricate as alveolar by 17 or as palato-alveolar by 3 subjects. The same tendency was found even in the plosives /t, t^h, t'/. As for the systematic difference in linguopalatal contact among the Korean three-way phonation consonants, however, we can refer to [7], according to which the difference is attributed to one of phonetic effects caused by the tongue and vertical larynx movement. In their account, in proportion to the movement of the tongue and the larynx, linguopalatal contact varies in such a systematic way and this is also true of the blade position which shows the same systematic variation. As in Figures 4 and 5, the tongue movement varies from low to high in the order of the lenis, aspirated and fortis consonants. Thus if we get rid of such phonetic effects derived from the laryngeal characteristics of the consonants from the actual manifestation of the consonants in tongue contact, then we can say that the aspirated and fortis consonants are not postalveolar but alveolar like their lenis counterparts in our MRI data.

Consequently, based on the present MRI data, we propose that the affricates /c, c^h, c'/ and the plosives /t, t^h, t'/ are alveolar, and that the difference between the affricates and the plosives lies in apicality/laminality which is not distinctive in Korean.

4. CONCLUSIONS

In the present study, we have looked into the contact, constriction and movement of the tongue during and after the oral closure of the plosives /t, t^h, t'/ and the affricates /c, c^h, c'/. From our MRI data we have noted that linguopalatal contact and tongue movement show a systematic variation in the order of the lenis, aspirated and fortis consonants, no matter whether it is a plosive or an affricate and that the tongue rises relatively high and moves more front in the affricates than in the plosives. Given that the systematic variation in linguopalatal contact and the blade position is attributed to phonetic effects caused by the tongue-vertical larynx movement [7], we

have proposed that the affricates and the plosives are alveolar with the difference in apicality/laminality, not in place of articulation.

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