

舌癌周術期における構音障害の経時的変化に対する音響学的検討

Phonologic and acoustic analysis of speech following glossectomy and the effect of rehabilitation on speech outcomes

Purpose: The changes in acoustic features in the perioperative phase for elucidating the mechanisms of articulation disorder, and the effect of perioperative rehabilitation were studied prospectively.

Methods: The 62 tongue cancer patients were divided into 2 groups: a partial glossectomy group (n=40), and a reconstruction group (n=22). Acoustic characteristics were analyzed during the preoperative and postoperative periods, and after rehabilitation, using the following: the first and second formant (F1 and F2) of the vowels /a/, /i/, and /u/; the triangular vowel space area (tVSA); and the slopes of formant transitions.

Results: In both groups, a reduction in the tVSA and formant slopes was demonstrated between the preoperative and the postoperative periods; and the acoustic characteristics of the reconstruction group especially improved to the preoperative values after rehabilitation. Analysis of the postoperative period revealed acoustic characteristics to be altered at the site of surgical resection.

Conclusion: The changes of acoustic variables are related to excision size and site, suggesting the distinctive tongue portion for articulation of each speech sound. Perioperative rehabilitation may activate the articulators, and increase the range of movement of the remaining tongue, especially preserved anterior tongue.

Table 1. Profiles of patients with partial glossectomy.

Patient No.	Age at operation (years)	Gender	TNM				Excision extent of tongue		
			Tumor category	Node category	Metastasis category	Stage	Anterior	Posterior	Tongue base
1	54	F	2	2c	0	IVA			+
2	32	M	2	2c	0	IVA	+	+	+
3	72	M	2	2b	0	IVA		+	
4	67	M	2	2b	0	IVA	+		
5	35	M	2	1	0	III		+	
6	77	F	2	0	0	II	+	+	+
7	64	M	2	0	0	II		+	+
8	46	F	2	0	0	II	+		
9	65	M	2	0	0	II		+	+
10	42	M	2	0	0	II		+	+
11	51	M	2	0	0	II		+	
12	62	M	2	0	0	II	+		
13	55	F	2	0	0	II	+		
14	34	F	2	0	0	II		+	
15	46	M	2	0	0	II	+		
16	66	M	2	0	0	II	+		
17	64	M	2	0	0	II	+		
18	52	F	2	0	0	II	+		
19	57	M	2	0	0	II		+	+
20	66	F	2	0	0	II		+	
21	69	F	2	0	0	II		+	
22	69	M	2	0	0	II	+		
23	67	M	2	0	0	II	+		
24	71	M	2	0	0	II		+	
25	56	M	2	0	0	II	+		
26	50	M	2	0	0	II	+		
27	60	M	2	0	0	II	+		
28	42	M	2	0	0	II	+		
29	45	F	2	0	0	II	+		
30	39	F	2	0	0	II		+	+
31	65	M	2	0	0	II		+	
32	47	M	2	0	0	II		+	
33	55	M	2	0	0	II		+	
34	55	M	2	0	0	II		+	
35	68	M	1	0	0	I	+		
36	66	M	1	0	0	I		+	
37	77	M	1	0	0	I	+		
38	62	M	1	0	0	I		+	
39	30	M	1	0	0	I	+		
40	33	F	1	0	0	I	+		

Excision extent of tongue is defined as the main site of resection (anterior or posterior tongue), including resection of the tongue base.

Table 2. Profiles of patients with reconstruction following glossectomy.

Patient No.	Age at operation (years)	Gender	TNM			Stage	Glossectomy	Reconstruction	Anterior tongue	First rehabilitation (POD)	Last rehabilitation (POD)	Rehabilitation period (days)
			Tumor category	Node category	Metastasis category							
1	21	M	4a	2c	0	IV A	Total	TRAM	—	16	43	28
2	37	M	4a	2c	0	IV A	Total	TRAM	—	13	14	2
3	42	M	4a	2c	0	IV A	Total	TRAM	—	34	127	94
4	25	M	4a	1	0	IV A	Total	TRAM	—	4 (7)	31	28
5	49	M	4a	2c	0	IV A	Subtotal	TRAM	Excised	7 (8)	25	19
6	67	F	4a	0	0	IV A	Subtotal	TRAM	Excised	6 (14)	29	24
7	41	M	4a	2c	0	IV A	Subtotal	ALT	Preserved	8	30	23
8	67	F	4a	2c	0	IV A	Subtotal	ALT	Excised	20	103	84
9	60	M	4a	2b	0	IV A	Subtotal	ALT	Excised	16	37	22
10	46	F	4a	2b	0	IV A	Subtotal	ALT	Excised	20	45	26
11	41	F	4a	1	0	IV A	Subtotal	ALT	Preserved	13	29	17
12	69	F	4a	0	0	IV A	Subtotal	ALT	Preserved	14	37	24
13	33	M	4a	0	0	IV A	Subtotal	ALT	Excised	14	64	51
14	46	M	3	2b	0	IV A	Subtotal	ALT	Preserved	14	28	15
15	32	F	3	1	0	III	Subtotal	ALT	Preserved	8	29	22
16	61	M	2	0	0	II	Subtotal	ALT	Preserved	12	23	12
17	41	M	1	1	0	III	Subtotal	ALT	Preserved	20 (23)	37	18
18	67	M	4a	0	0	IV A	Hemi	ALT	—	12	23	12
19	45	M	3	0	0	III	Hemi	ALT	—	10	31	22
20	51	F	2	2b	0	IV A	Hemi	ALT	—	5 (18)	50	46
21	38	M	2	2b	0	IV A	Hemi	ALT	—	11	21	11
22	66	M	2	0	0	II	Hemi	ALT	—	13 (15)	30	18

TRAM : Transverse Rectus Abdominis Myocutaneous Flap, ALT : Anterolateral Thigh Flap.

In the patients with subtotal glossectomy, but not total and hemi glossectomy, excised or preserved anterior portion of tongue is indicated. POD: Postoperative day. Recorded speech samples: In the postoperative period, it is recorded at the same day of the first rehabilitation (Patient No. 4, 5, 6, 17, 20, 22 are recorded at the different day as in parentheses). In the period after rehabilitation, it is recorded at one day before the last rehabilitation.

Table 3. tVSA, F1, F2, F1 slope, and F2 slope in the partial glossectomy group during preoperative and postoperative periods.

Variables	Preoperative (N=40)		Postoperative (N=40)	
		Mean±SD		Mean±SD
tVSA (Hertz ²)		253856.2±119068.9		119068.9±91664.4**
F1(Hz)	/a/	744.2±126.0		717.5±106.7
	/i/	331.7±58.7		342.5±62.6
	/u/	359.0±56.5		365.7±55.9
F2(Hz)	/a/	1239.9±171.9		1241.3±156.8
	/i/	2428.2±302.3		2132.0±304.7***
	/u/	1161.6±203.4		1180.0±185.3
F1 slope (Hz/msec)	/tai/	3.9±1.1		3.2±1.1**
	/sai/	3.3±1.2		2.9±1.0
	/kai/	3.7±1.2		3.1±1.1*
	/sui/	1.4±1.0		1.2±1.0
F2 slope (Hz/msec)	/tai/	7.4±2.4		5.2±1.7***
	/sai/	6.3±1.8		4.7±1.5***
	/kai/	7.7±2.1		5.9±1.9***
	/sui/	6.0±1.9		4.8±2.0***

Each value of the selected variables is compared between the preoperative and postoperative periods. * $p < .05$, ** $p < .01$, *** $p < .001$

Table 4. tVSA, F2 for /i/, and F2 slope for /tai/, /kai/ in the anterior, posterior, and tongue base groups of the partial glossectomy group during the preoperative and postoperative periods.

Variables		Anterior (N=19)	Posterior (N=13)	Tongue base (N=8)	
		Mean±SD	Mean±SD	Mean±SD	
tVSA (Hertz ²)	Preoperative	264594.8±135514.8	250100.3±101038.8	234455.4±100047.0	
	Postoperative	198565.6±111316.0	173647.9±50876.6	112039.8±55743.8	
F2 (Hz) /i/	Preoperative	2446.1±327.5	2357.7±272.8	2500.2±259.3	
	Postoperative	2252.4±344.6	2044.7±161.2	1987.7±268.7	
F2 slope (Hz/msec)/tai/	Preoperative	7.8±2.7	6.7±1.4	7.6±2.4	
	Postoperative	5.4±1.7	5.2±1.8	4.4±1.2	
	/kai/	Preoperative	7.3±1.6	8.4±2.5	7.6±2.3
		Postoperative	6.2±1.8	6.0±1.9	4.7±1.4

Excised site: anterior, posterior, and tongue base. The patients in which anterior, posterior, and tongue base excisions overlapped were classified as the tongue base group. There were no significant differences in the variables among three sub-groups.

Table 5. tVSA, F1, F2, F1 slope, and F2 slope in the reconstruction group during the preoperative and postoperative periods, and the period after rehabilitation.

Variables		Preoperative (N=22)	Postoperative (N=22)	After rehabilitation (N=22)
		Mean±SD	Mean±SD	Mean±SD
tVSA (Hertz ²)		205990.2±132821.2	74194.1±57599.1***	107627.8±106539.5
F1(Hz)	/a/	727.0±121.4	646.7±107.3*	694.4±132.1
	/i/	366.0±66.0	410.6±78.7	417.7±100.8
	/u/	370.3±56.8	386.9±72.0	387.8±57.7
F2(Hz)	/a/	1225.4±167.9	1161.3±107.1	1189.0±134.2
	/i/	2323.5±349.9	1613.4±339.5***	1772.1±448.7
	/u/	1238.0±206.6	1047.4±140.5**	1139.9±131.9
F1 slope (Hz/msec)	/tai/	3.2±0.8	2.2±0.7***	2.4±0.8
	/sai/	3.4±1.3	2.2±1.2**	2.5±1.0
	/kai/	3.5±0.8	2.0±1.0***	2.5±0.8
	/sui/	1.1±0.9	1.0±1.1	1.2±0.9
F2 slope (Hz/msec)	/tai/	6.9±2.8	3.6±2.3***	3.9±1.7
	/sai/	5.5±1.8	3.2±1.9***	3.4±1.5
	/kai/	7.4±2.5	3.5±1.4***	4.2±2.1
	/sui/	4.3±2.0	2.5±1.4**	3.5±2.3

Each value of the selected variables is compared between the preoperative and postoperative periods. There were no significant differences in the variables between the postoperative period and the period after rehabilitation. * $p < .05$, ** $p < .01$, *** $p < .001$

Table 6. tVSA, F2 for /i/, and mean F2 slope between total, subtotal, and hemi glossectomy.

Variables		Total (N=4)	Subtotal (N=13)	Hemi (N=5)
tVSA (Hertz ²)	Preoperative	102564.0	196335.2	313834.3
	Postoperative	8208.4	73261.4	129407.9
	After rehabilitation	19488.8	98096.9*	202919.4*
F2 (Hz) /i/	Preoperative	2179.6	2305.2	2486.2
	Postoperative	1144.4	1618.5	1974.8
	After rehabilitation	1244.4	1789.0*	2150.1*
F2 slope (Hz/msec)	Preoperative	7.1	5.8	6.4
	Postoperative	1.9	3.3	4.0
	After rehabilitation	2.2	3.7	5.4*

F2 slope :Mean values of the F2 slope for the vowels /a/, /i/, and /u/, including /taiko/, /tʃ isai/, /kaiko/, and /suika/. Each value of the selected variables is compared between total and hemi glossectomy groups, and between total and subtotal glossectomy groups. There was no significant difference in the variables between subtotal and hemi glossectomy groups. * $p < .05$

Table 7. tVSA, F2 for /i/, and F2 slope between excised and preserved anterior tongue in subtotal glossectomy group.

Variables		Anterior tongue	
		Excised (N=6)	Preserved (N=7)
tVSA (Hertz ²)	Preoperative	186765.5	204537.8
	Postoperative	58447.5	85958.9
	After rehabilitation	58880.3	131711.1
F2 (Hz) /i/	Preoperative	2145.8	2441.8
	Postoperative	1529.0	1695.1
	After rehabilitation	1504.4	2033.0*
F2 slope (Hz/msec)	Preoperative	4.2	6.9
	Postoperative	2.3	4.2
	After rehabilitation	2.3	4.8**

F2 slope: Mean values of the F2 slope for the vowels /a/, /i/, and /u/, including /taiko/, /tʃ isai/, /kaiko/, and /suika/. Each value of the selected variables is compared between excised and preserved anterior tongue groups. * $p < .05$,

** $p < .01$

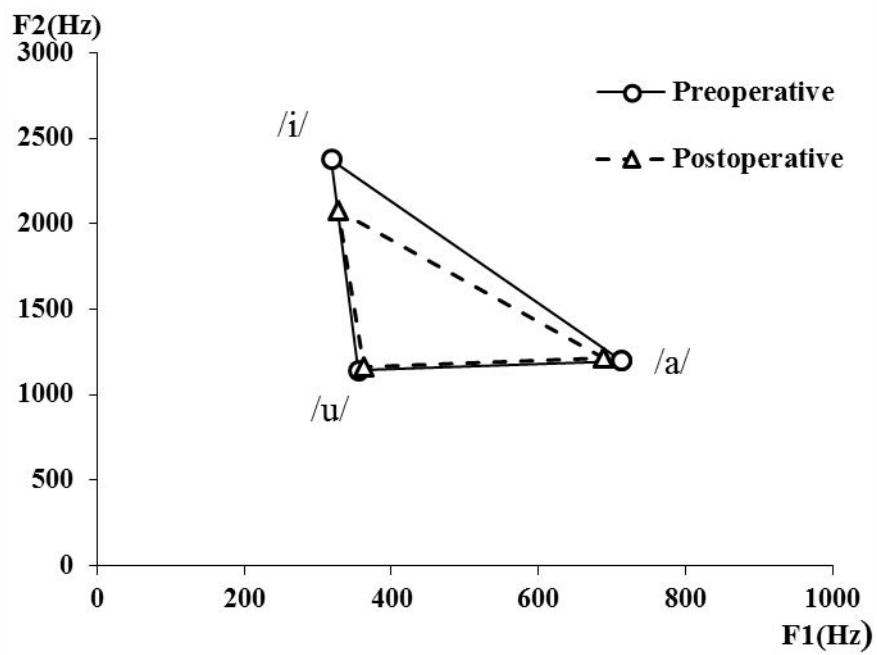


Figure 1. tVSA in the partial glossectomy group during the preoperative and postoperative periods.

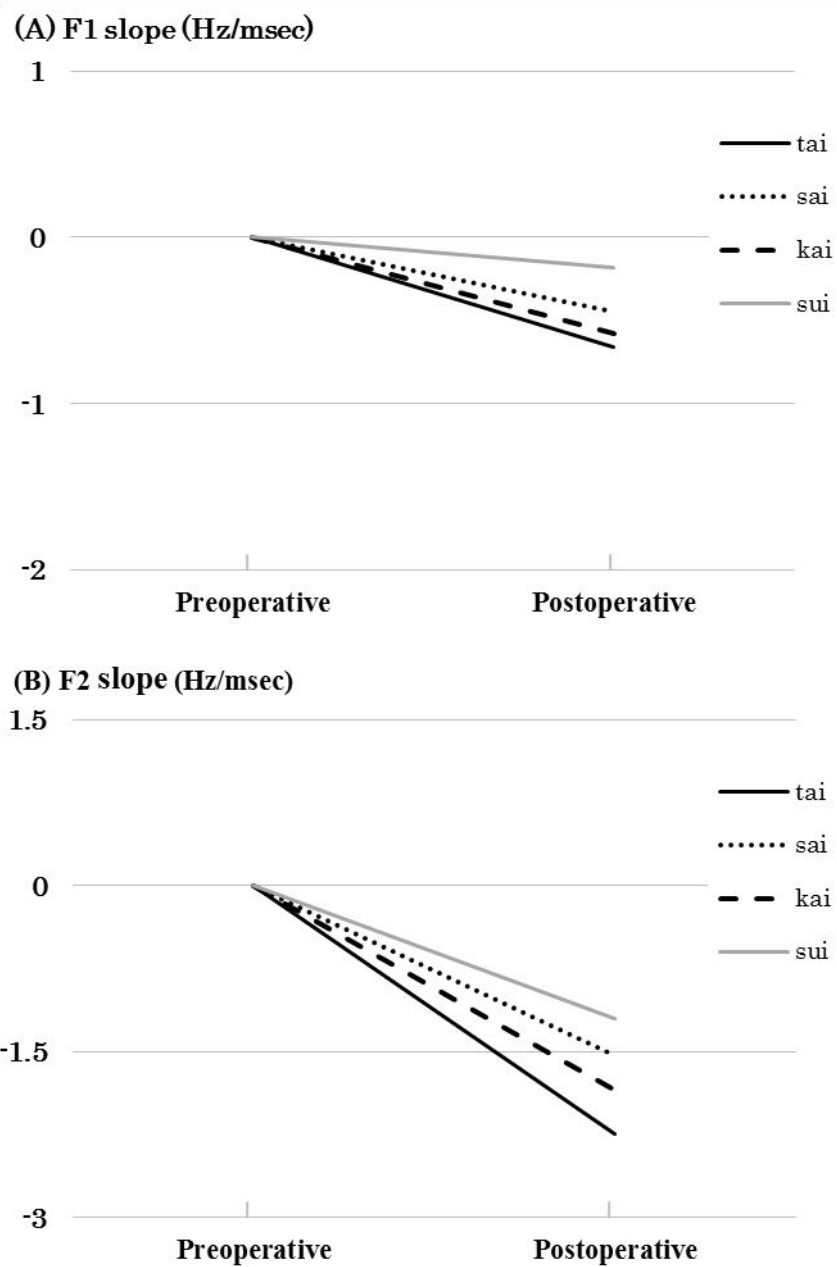


Figure 2. Mean decline values of the F1 slope and the F2 slope in the partial glossectomy group between the preoperative and postoperative periods.

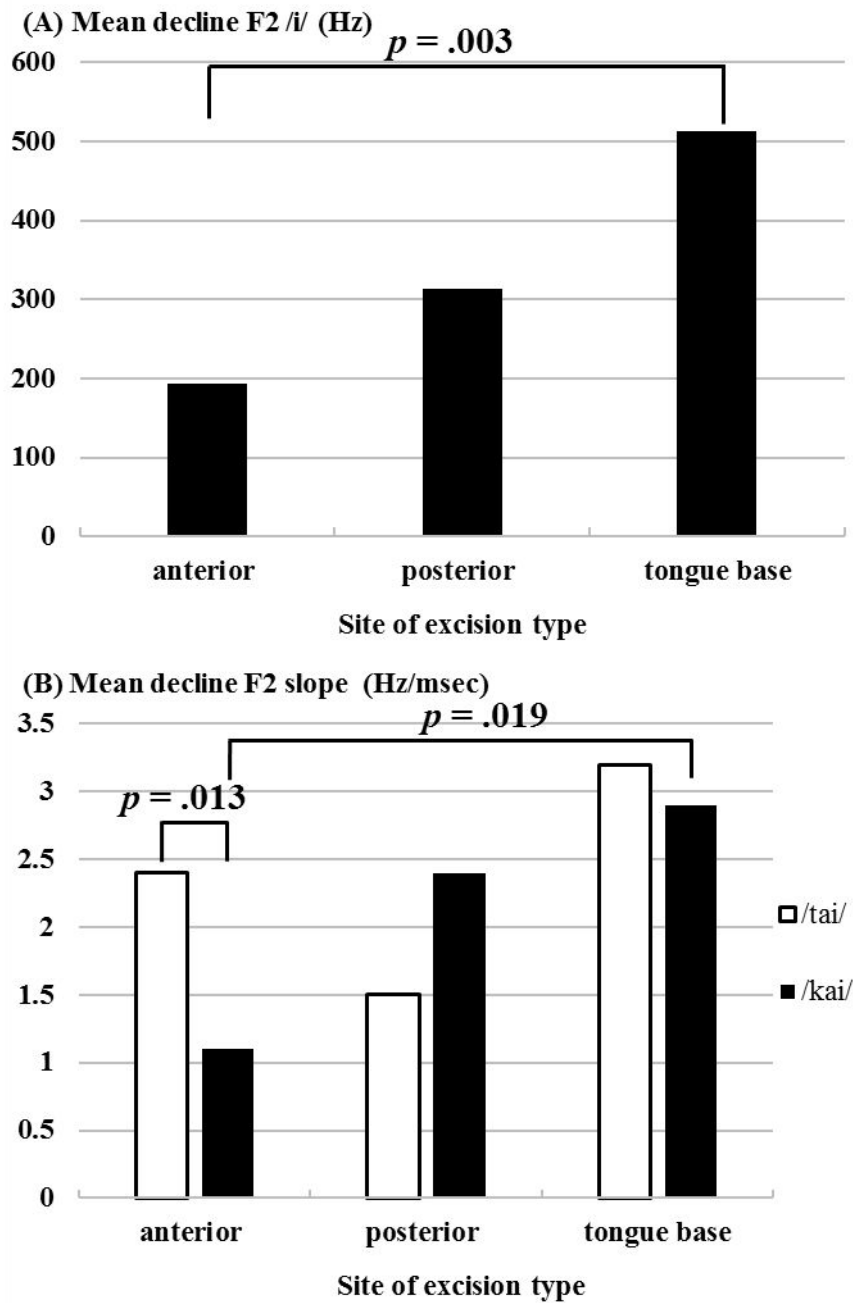


Figure 3. Mean decline values of F2 for /i/ and the F2 slope for /tai/ and /kai/ in anterior, posterior, and tongue base groups of the partial glossectomy group.

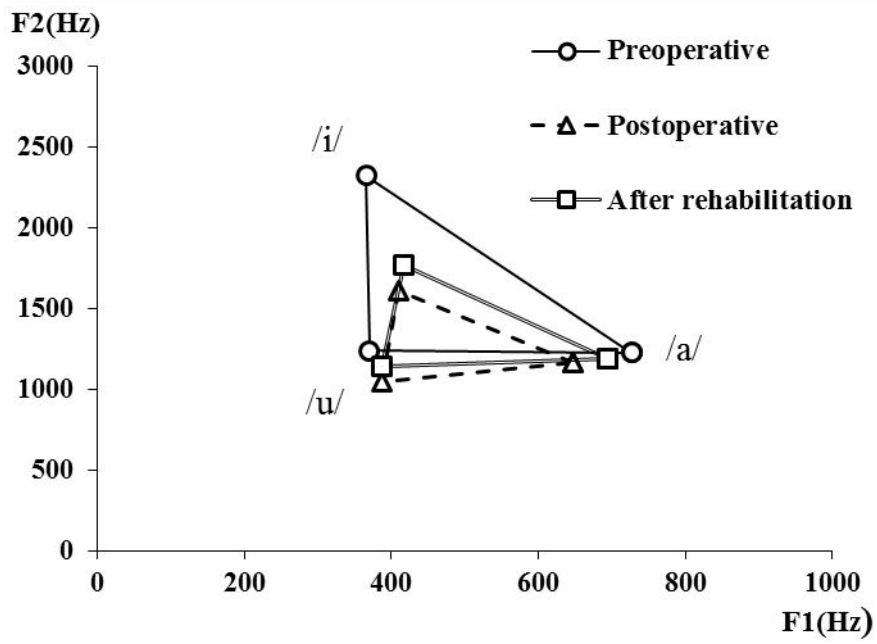


Figure 4. tVSA in the reconstruction group during the preoperative and postoperative periods, and the period after rehabilitation.

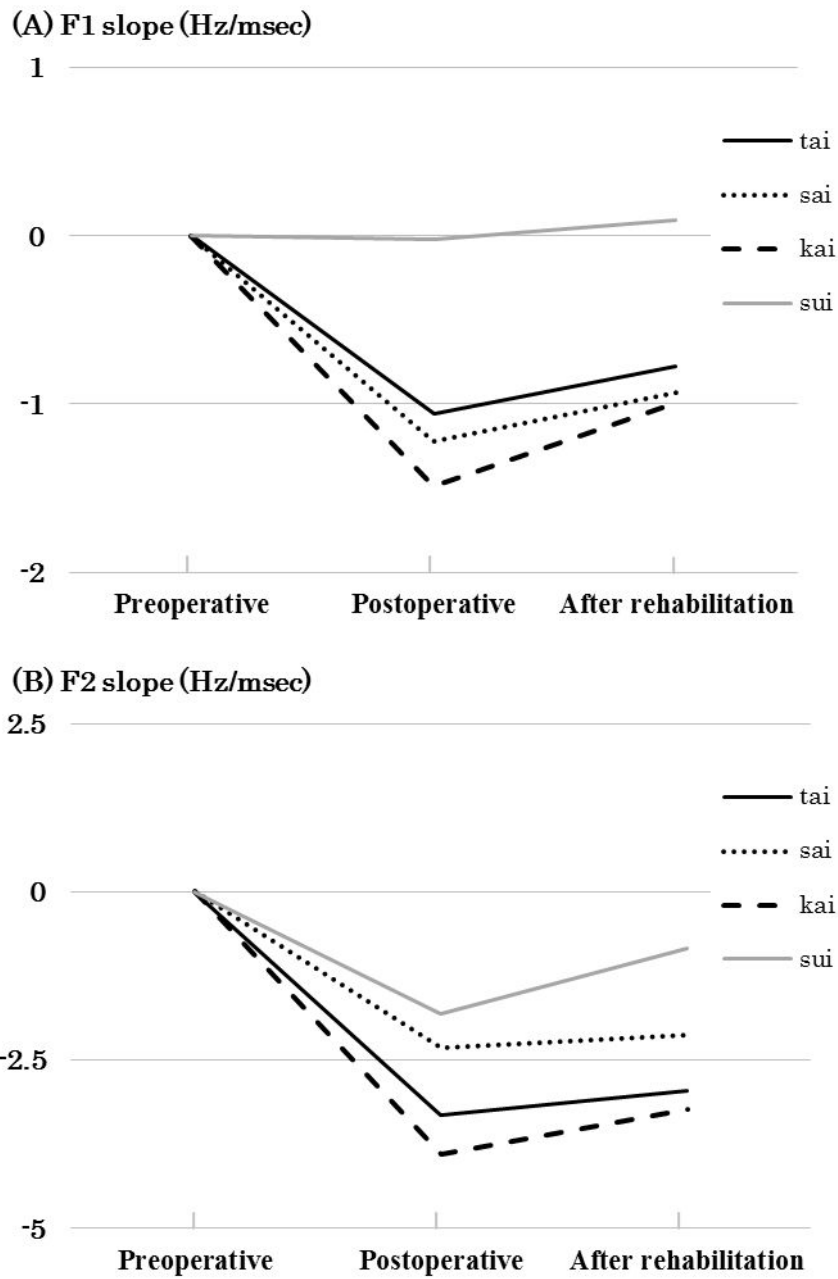


Figure 5. Mean decline values of the F1 slope and the F2 slope in the reconstruction group between the preoperative and postoperative periods, and the period after rehabilitation.