SPEECH DEFECTS AFTER ORAL CANCER SURGERY
Functional and acoustic analyses of retrospective data

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ABSTRACT
Fourteen speakers were studied for speech motor functions 10-144 months after resection of oral structures. Twelve speakers still had speech defects ranging from mild articulatory problems to severe unintelligibility. The most severe defects correlated with the most deviant F1/F2 distributions showing either generally centralised formant values or lowered F2-frequencies, especially for the front vowels.

INTRODUCTION
Surgical operations in the oral structures alter speech and other oral motor functions. However, our knowledge of long-lasting effects of oral cancer surgery is limited [1,2]. Also, the need for systematic and multidiciplinary evaluation of patients with operated oral cancer has not been recognised until recently in Finland. The present study belongs to the retrospective part of a research project which aims to evaluate functional consequences of oral cancer treatment.

The aim of the present study was to examine the correlation between intelligibility ratings and acoustic features of vowels [1,3,4] To reach this aim clinically evaluated speech defects were compared with psychoacoustical F1/ F2 charts.

METHODS
Fourteen speakers (8 women and 6 men) were studied about four years (range 10-144 months) after resection of oral structures due to oral cancer. The mean age of the speakers was 59 years (range 22-82). The lesions involved the mandible in seven speakers, the maxilla in three, the tongue in two, and the floor of mouth in two speakers. Lesions after surgery were largest following resections of the bony structures in mandible and maxilla. Nine subjects had radiation therapy postoperatively and also nine subjects had mandibular reconstructions or obturator prosthesis to compensate the structural defects.

Clinical evaluation of speech and oral motor functions
Two qualified speech therapists estimated the adequacy of speakers' oral motor functions and speech intelligibility with the Frenchay Dysarthria Assessment (FDA) [5], a sentence repetition task from the Finnish version of Speech Examination [6,7], a text reading task [8], a nasality assessment [9], and finally, with a story telling task [10]. Oral motor examinations were videotaped for reliability testing, and speech samples were audiotaped in a soundproof room with a Revox-A77 tape recorder.

The data consists of the results from FDA profiles converted to points (max. 224 points). In addition, the severity of speech defect was estimated on a 4-point scale (0=none and 3=severe) by the first two authors.

Acoustic analysis of vowel quality
A task of reading the eight Finnish vowels (both short and long) was also recorded. The test items consisted of 96 words in which each vowel type occurred in six different contexts (e.g. *tippa* 'drop', *piha* 'courtyard'; *piina* 'agony', *tiili* 'brick'). The speakers were asked to read each word three times without interword pauses, i.e. as a sentence-like utterance (e.g. *tippatippatippa*) [11].

To estimate deteriorations in vowel quality, a psychoacoustical F1/ F2 chart was applied utilising the LPC-analysis in the ISA-program [12, 13]. The formants were measured at the temporal midpoint (when possible) of the first vowel of the second word in each three-word sequence. The mean values of the six measurements per each vowel class were then calculated in order to compute the final F1/F2 charts for each speaker.

RESULTS
All speakers claimed that, acutely after the operation, they had had speech difficulties. At the time of the present study all but two speakers still had articulation deficits and/or hypernasal voice quality. In four speakers, a problem severe enough (ratings 2 or 3) to affect speech intelligibility was detected.

Clinical findings
The most severe oral motor and speech defects were found in speakers with partial glossectomy or mandible resections due to the fact that, in many cases, the operation reduced mobility of lingual muscles in addition to the structural changes in the oral cavity. Nasal voice quality characterised speakers with maxilla resections due to insufficient velopharyngeal functions, even when they were wearing an obturator prosthesis. Table 1 shows the essential findings of the functional analysis.

Table 1. Mean scores from FDA (max. scores are mentioned in parentheses). Mand, Max, Tong and Floor refer to lesions of mandible, maxilla, tongue, and floor of mouth, respectively. Palate, Intell and Total refer to palatal functions, intelligibility scores, and total scores of the functional assessment, respectively.

	Palate (24)	Tong (48)	Intell (24)	Total (224)
Mand	22.4	27.6	20.4	183.7
Max	8.0	45.0	20.7	192.7
Tong	23.0	28.0	18.0	188.0
Floor	23.0	32.5	21.0	197.0

F1/F2 patterns
Different patterns of variability in formant frequencies were observed when speakers' F1/F2 charts were compared with a normative pattern (see figure 1) [14]. First, the relative distances between vowel classes were found to correspond the normal pattern in five cases. In four speakers the speech defect was rated either non-existent or mild. The fifth speaker was the oldest in this sample (82 years). She also produced a normal vowel pattern, but her moderate speech defect (rating 2) resulted both from effortful articulation due to lateral fixation of the tongue tip, and from phonatory problems; the latter was most obviously related to her high age

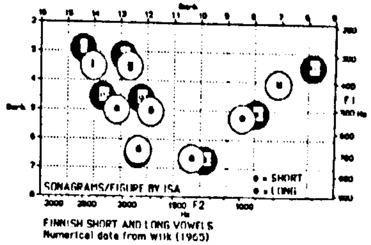

Figure 1. The psychoacoustical space of normal Finnish vowels [14, 15].

Centralisation of formants was found clearly in seven speakers, who also had more severe speech defects, in the average. However, a general F1/F2 reduction of formant variability was observed in two speakers only. The one had a moderate speech defect and the other a severe one (rating 3, see figure 2) as a result from hypernasality and severe reduction of tongue movements, respectively.

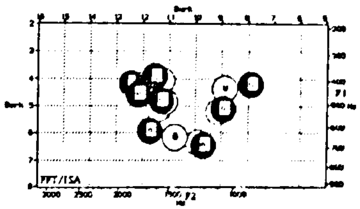

Figure 2. General centralisation of F1/F2 frequencies due to reduction of tongue movements after mandibular resection (case 14).

A third F1/F2 pattern was related to lowered F2-values for front vowels in two cases. Both speakers had difficulties in moving the tongue towards lips in clinical examination, but the one (with mild speech defect) was able to raise the tongue while the other (with severe speech defect) was not (case 5, figure 3).

Figure 3. Lowered F2 frequencies due to hemiglossectomy (case 5).

A fourth pattern was observed in three cases. It was characterised by reduced variability of F1-values (see figure 4), resulting from the speakers' difficulties in raising the tongue. This reduced the accuracy of pronunciation of tip-alveolar phonemes, especially the Finnish liquid [r]. On the whole, speech defect was rated mild in these three speakers.

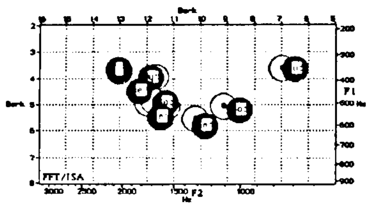

Figure 4. Reduced F1 frequencies after resection of the floor of the mouth (case 13).

In two cases, severe nasality decreased the reliability of the measurement of formants. Therefore these results are not presented here [1]. The speech defect was rated mild in both of them.

DISCUSSION

Long-lasting speech deficits and other oral motor disorders [16] were found in twelve of the fourteen subjects operated on oral cancer. In eight speakers, the mild speech defect had only minor effects on speech intelligibility. In four subjects a more severe deficit was found.

Speech intelligibility can be affected by several factors, e.g. phonatory problems, consonant distortions, hypernasality and deviations in vowel quality. In the present study, only vowel quality was examined. In spite of evident individual variation in acoustic data, four different patterns of F1/F2 charts were found. In one group, formant frequencies matched closely the normative chart. The speech difficulties were also mild in those speakers, expect for one subject with age-related phonatory changes. The restricted vertical tongue movement reduced the variability of F1 but did not affect speech intelligibility. However, consonant pronunciation was less accurate in that group. The most deviant F1/F2 distributions were marked lowering of F2 frequencies for front vowels or a general reduction of the relative distances between vowel classes on the F1/F2 chart. These formant patterns were found in four speakers with moderate to severe speech defects due to restricted mobility of the tongue. The relationship between speech intelligibility and F2 values has been reported also in dysarthric speakers [17]. In addition to deviant vowel pattern, the speakers in our study presented various problems in consonant pronunciation as well as hypernasality.

The number of speakers contributing each group was small in this preliminary study. However, the results support some earlier findings that front vowels are most vulnerable in oral surgery [1,4]. On the other hand, the speakers seem to sustain the formant pattern for back vowels better than for the front vowels, even with minor movements of the posterior part of the tongue.

To improve the external validity of our results, a larger group of subjects will be studied both retrospectively and prospectively during the present research.

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