DOI: https://orcid.org/10.17650/2222-1468-2023-13-4-27-36

Ultrasound diagnostics: assessment of tumor thickness and depth of invasion in squamous cell carcinoma of the oral cavity

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Introduction. Squamous cell carcinoma is the most common oral tumor. The head and neck area is a functionally and socially significant area of the human body. Underestimation of the extent of oral tumors during surgery leads to the need for additional treatment methods, which worsens the quality of life of patients. The depth of invasion of squamous cell carcinoma of the tongue has great prognostic significance. The revision of T category of the Tumor, Nodus and Metastasis (TNM) classification of the 8th edition of the American Joint Committee on Cancer (AJCC) prompted the search for additional diagnostic methods that most accurately determine the depth of invasion of an oral tumor and, accordingly, preoperative clinical staging.

Aim. to evaluate the capabilities of ultrasound using various approaches in determining the depth of invasion of squamous cell carcinoma of the oral cavity and to compare the results obtained with data obtained by the use of other diagnostic methods.

Materials and methods. In our reserch, ultrasonography was performed on 193 patients with primary malignant tumors of the mobile part of the tongue, floor of the oral cavity and tumors of rare locations (mucous membranes of the lip, cheek, alveolar processes). The age of the patients ranged from 15 to 85 years. In all patients, tumors were squamous cell carcinoma. Ultrasound was performed using submandibular, intraoral and transbuccal approaches. Ultrasonic data were compared with the results of pathomorphological examination, as well as of X-ray computed tomography and of magnetic resonance imaging with contrast.

Results. A statistically significantly high correlation was obtained for all ultrasound approaches (submandibular, intraoral and transbuccal) with the depth of invasion of the oral tumor determined pathomorphologically ($r = 0.78$; $r = 0.89$; $r = 0.93$; $p < 0.001$).

Ultrasound using all approaches shows statistically significantly better results in determining the thickness of tumors of the tongue and mouth floor in comparison with X-ray computed tomography and magnetic resonance imaging ($p < 0.001$). All diagnostic methods are characterized by an overestimation of the tumor invasion depth (overdiagnosis) as compared with pathomorphological examination. For exophytic tumors and oral cavity tumors of mixed growth with an exophytic component, the depth of invasion was less than the tumor thickness.

Conclusion. Ultrasound is an accessible, easily reproducible, radiation-free method, the resolution of which makes it possible to accurately determine not only the depth of invasion of oral tumors, but also the distance from the tumor to the midline of the tongue, that represents an important information when choosing the extent of surgical intervention.

Keywords: depth of invasion, tumor thickness, intraoral ultrasound, ultrasonography, squamous cell carcinoma of the oral cavity

For citation: Allakhverdieva G.F., Dronova E.L., Danzanova T.Yu. et al. Ultrasound diagnostics: assessment of tumor thickness and depth of invasion in squamous cell carcinoma of the oral cavity. Head and Neck Tumors 2023;13(4):27–36. DOI: https://doi.org/10.17650/2222-1468-2023-13-4-27-36.

Ультразвуковая диагностика: оценка толщины опухоли и глубины инвазии при плоскоклеточном раке полости рта

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Введение. Плоскоклеточный рак является самой распространенной опухолью полости рта. Область головы и шеи представляет собой функционально и социально значимую зону человеческого организма. Недооценка распространенности опухоли полости рта во время хирургического вмешательства ведет к необходимости применения дополнительных методов лечения, что ухудшает качество жизни пациентов. Глубина инвазии плоскоклеточного рака языка имеет большое прогностическое значение. Пересмотр категории T классификации Tumor, Nodus and Metastasis (TNM) 8-го издания Американского объединенного комитета по раку (American Joint Committee on Cancer, AJCC) послужил поводом для поиска дополнительных методов диагностики, наиболее точно определяющих глубину инвазии опухоли полости рта и, соответственно, дооперационное клиническое стадирование.

Цель исследования – оценить возможности ультразвукового исследования (УЗИ) с применением различных доступов в определении глубины инвазии плоскоклеточного рака полости рта, сравнить полученные результаты с данными других методов диагностики.

Материалы и методы. В нашей работе УЗИ проведено 193 пациентам с первичными злокачественными образованиями подвижной части языка, дна полости рта и опухолями редких локализаций (слизистой губы, щеки, альвеолярных отростков). Возраст больных варьировал от 15 до 85 лет. У всех пациентов опухоли были представлены плоскоклеточным раком. Ультразвуковое исследование выполнялось с применением подчелюстного, трансорального и трансбуккального доступов. Данные УЗИ сравнивали с результатами патоморфологического исследования, а также рентгеновской компьютерной томографии и магнитно-резонансной томографии с контрастированием.

Результаты. Получена достоверно высокая корреляция всех доступов УЗИ (подчелюстного, трансорального и трансбуккального) с глубиной инвазии опухоли полости рта, определенной патоморфологически ($r = 0{,}78$; $r = 0{,}89$; $r = 0{,}93$; $p < 0{,}001$).

Ультразвуковое исследование с использованием всех доступов показывает статистически значимо лучшие результаты при определении толщины опухолей языка и дна полости рта по сравнению с рентгеновской компьютерной томографией и магнитно-резонансной томографией ($p < 0{,}001$)). Для всех диагностических методов характерно завышение оценки глубины инвазии опухоли (гипердиагностика) по сравнению с патоморфологическим исследованием. Для экзофитных опухолей и образований полости рта смешанного роста с экзофитным компонентом глубина инвазии оказалась меньше толщины опухоли.

Заключение. Ультразвуковое исследование является доступным, легко воспроизводимым, не несущим лучевой нагрузки методом, разрешающая способность которого позволяет с высокой точностью определять не только глубину инвазии опухолей полости рта, но и расстояния от новообразования до средней линии языка, что является важной информацией при выборе объема хирургического вмешательства.

Ключевые слова: глубина инвазии, толщина опухоли, трансоральное ультразвуковое исследование, плоскоклеточный рак полости рта

Для цитирования: Аллахвердиева Г.Ф., Дронова Е.Л., Данзанова Т.Ю. и др. Ультразвуковая диагностика: оценка толщины опухоли и глубины инвазии при плоскоклеточном раке полости рта. Опухоли головы и шеи 2023;13(4): 27–36. (На англ.). DOI: https://doi.org/10.17650/2222-1468-2023-13-4-27-36

Introduction

Cancer of the oral cavity and tongue is an endemic disease. The highest incidence rates have been reported in South Asian countries due to the use of betel quid, chewing tobacco and smoking [1, 2].

The incidence of oral cancer is increasing every year, especially in young people, particularly young women [3]. Squamous cell carcinoma is the most common type of oral tumor [3, 4]. The reason for its growth remain a matter of debate. The role of human papillomavirus in the occurrence of squamous cell carcinoma of the oral cavity and tongue is not completely clear since there are not very many studies to confirm this theory and their results often indicate that the presence of human papillomavirus is not associated with development of this pathology [5].

Surgical removal of the primary tumor with or without cervical lymph node dissection has long been considered the best approach to treating squamous cell carcinoma of the oral cavity and tongue. The invasive nature of squamous cell carcinoma makes it difficult to determine tumor boundaries and, in practice, undesirable consequences of close or positive resection margins are quite common [6, 7]. The non-ablative surgical intervention creates the need for additional treatment, in particular radiation therapy, which worsens the quality of life of patients.

Metastasis to cervical lymph nodes (LN) determines clinical staging, affects the prognosis of the disease, and depends on the depth of tumor invasion in patients with oral cancer. Occult lymph node metastases are present in 23.9–26.4 % of cases of oral cancer of clinical stages II and III and depend on depth of invasion of the primary tumor, determining the prognosis of the disease [8, 9].

Tumor thickness (TT) and depth of invasion (DOI), determined using ultrasound (US) with or without fine needle aspiration biopsy (FNA), are important indicators for predicting the risk of metastases and locoregional relapse [10–12]. The depth of invasion of squamous cell carcinoma of the tongue has great prognostic significance. This fact led to the revision of the T category in the Tumor, Nodus and Metastasis (TNM) classification of the 8th edition of the American Joint Committee on Cancer (AJCC) [13, 14].

The interchangeable use of terms "tumor thickness" and "depth of invasion" is incorrect. The term "tumor thickness" is defined as the distance from its surface to the deepest level of invasion and is usually used in preoperative imaging, while the term "depth of invasion" refers to the distance from the surface of the mucosa or basement membrane to the deepest level of invasion, and this parameter, in fact, is a histopathomorphological result [15].

T.J. Nulent et al. have analyzed studies using intraoral US (IOUS) to measure oral TT during period of 1997–2016 and found a significant correlation between IOUS and histopathomorphological methods [16].

Since the appearance of TNM 8th edition, there has been great interest in the preoperative assessment of tumor DOI, in the search for optimal diagnostic methods for tumor determination, and, in general, in the clinical staging of squamous cell carcinoma of the tongue.

Aim. to evaluate the capabilities of US using various approaches in determining of depth of invasion of squamous cell carcinoma of the oral cavity and to compare results obtained with data obtained by the use of other diagnostic methods.

Materials and methods

In our work, the US was performed in 193 patients with primary malignant tumors of the mobile part of the tongue (144 (74.6 %) cases), floor of the oral cavity (32 (16.6 %) cases) and tumors of rare locations (17 (8.8 %) cases: tumor in the alveolar processes ($n = 5$), cheek ($n = 6$), lip ($n = 3$)) (table 1).

The age of the patients ranged from 15 to 85 years. The ratio of men to women was 1.4 : 1. Histological verification of the diagnosis was carried out in all the cases. Among patients with lesions of floor of the oral cavity, there were statistically significantly more men.

In all 193 patients, tumors were squamous cell carcinoma. Well-differentiated squamous cell carcinoma with signs of keratinization accounted for 76 (39.4 %) of 193 cases, moderately differentiated – 103 (53.4 %), and poorly differentiated – 14 (7.2 %).

The distribution of patients depending on the clinical stage and T-stage of the disease is presented in tables 2 and 3. Patients in the general group were distributed fairly evenly across stages, while the TT more often met the T3 criterion for all tumor locations. In rare tumors, stage T4 disease was diagnosed statistically significantly more often ($p = 0.008$ as compared with tumors of the tongue; $p = 0.041$ as compared with tumors of floor of the oral cavity).

All 193 patients with tumors of the tongue, floor of the oral cavity, and tumors of rare locations underwent 152 (78.8 %) IOUS, 106 (54.9 %) US from the submandibular approach, and 36 (18.7 %) – US from the transbuccal approach (table 4).

During US, the TT was measured using different approaches and different sensors and techniques.

Tumor thickness was compared with pathomorphological findings. The measurement error accepted as the condition under which the coincidences between pathomorphological and US was considered as correct was ± 15 %. The percentage error was calculated as the percentage difference between pathomorphological and ultrasonic measurements (the histological value was taken as 100 %; the module of the percentage error was used in the analysis).

All patients underwent surgical treatment to one extent or another. The US results were compared with pathomorphological examination data.

Ultrasound was performed with Acuson S-2000 device (Siemens, Germany) using a standard linear US probe (transducer) 9L4 (frequency range 4–9 MHz) and an intraoperative high-frequency probe (transducer) 14L5SP (frequency range 5–14 MHz), as well as with Philips device EPIQ 7 with standard linear transducer eL 18-4 (frequency range 4–18 MHz) using submandibular, transbuccal and intraoral approaches.

During the IOUS to determine the tumor thickness (TT), the probe was installed on the back of the tongue, the tumor was visualized and its thickness was measured from the lateral surface of the tongue (a typical tumor location) to the deepest tumor part in the thickness of the tongue

Table 1. *Distribution of patients with oral tumors depending on age and tumor location (n = 193)*

Tumor location	Number of patients, abs. (%)	
	Men	Women
Tongue (n =144)	81 (56.3)*	63 (43.7)
Floor of the oral cavity (n = 32)	24 (75.0)	8 (25.0)
Rare tumors (n = 17)	7 (41.2)*	10 (58.8)
Total (n =193)	*112 (58.0)*	*81 (42.0)*

**Statistically significant differences as compared with tumors of floor of the oral cavity (p <0.05).*

Table 2. *Distribution of patients with oral tumors depending on the stage of the disease and tumor location (n = 193), abs. (%)*

Stage	Tumor of the tongue (*n* =144)	Tumors of floor of the oral cavity (*n* =32)	Rare tumors (*n* =17)	Total (*n* =193)
I	45 (31.2)	3 (9.4)*	2 (11.8)	50 (25.9)
II	39 (27.1)	10 (31.2)	2 (11.8)	51 (26.4)
III	21 (14.6)	11 (34.4)*	7 (41.2)*	39 (20.2)
IV	39 (27.1)	8 (25.0)	6 (35.2)	53 (27.5)

**Statistically significant differences as compared with tongue tumors ($p < 0.05$).*

Table 3. *Distribution of patients with oral tumors depending on the T-stage of the Tumor, Nodus and Metastasis (TNM) classification and tumor location (n = 193), abs. (%)*

T-stage	Tumors of the tongue (*n* =144)	Tumors of floor of the oral cavity (*n* =32)	Rare tumors (*n* =17)	Total (*n* =193)
T1	34 (23.6)	3 (9.4)	2 (11.8)	39 (20.2)
T2	37 (25.7)	9 (28.1)	4 (23.5)	50 (25.9)
T3	64 (44.4)	18 (56.2)	6 (35.3)	88 (45.6)
T4	9 (6.3)	2 (6.3)	5 (29.4)*†	16 (8.3)

**Statistically significant differences as compared with tongue tumors ($p < 0.05$).*
†Statistically significant differences as compared with tumors of floor of the oral cavity ($p < 0.05$)..

Table 4. *Distribution of patients depending on ultrasound (US) access type and tumor location, abs. (%)*

US access	Tumors of the tongue (*n* =144)	Tumors of floor of the oral cavity (*n* =32)	Rare tumors (*n* =17)	Total (*n* =193)
Intraoral	132 (91.7)	18 (56.3)	2 (11.8)	152 (78.8)
Submandibular	74 (51.4)	29 (90.6)	3 (17.6)	106 (54.9)
Transbuccal	20 (13.9)	–	16 (94.1)	36 (18.7)

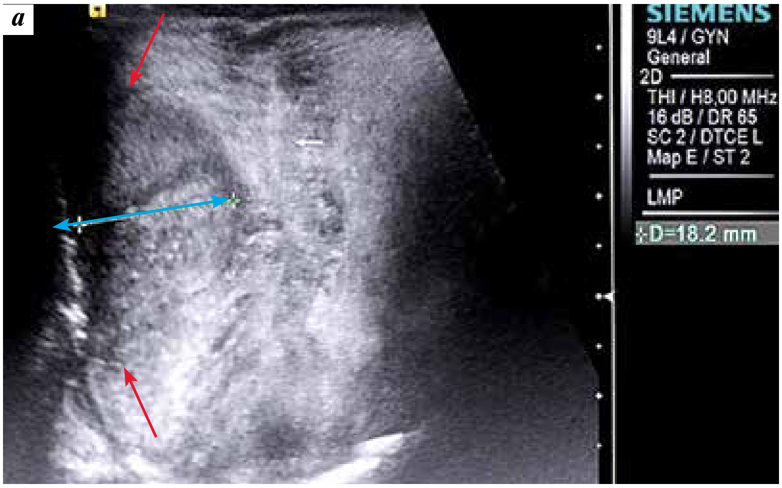

Fig. 1. *Intraoral ultrasonography of the tongue (transverse scanning): a – echogram of moderately differentiated squamous cell carcinoma of the right lateral surface of the tongue (indicated by red arrows), tumor thickness 18.2 mm (indicated by blue arrow), T3 (TNM) b – transverse scanning using a linear probe in the frequency range 4–9 MHz, intraoral access*

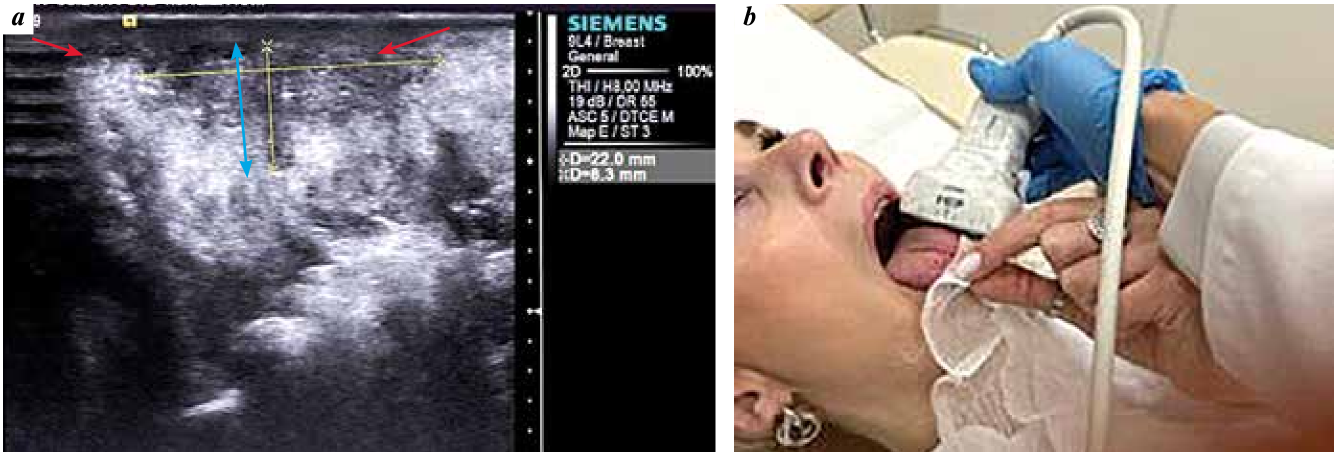

Fig. 2. *Intraoral ultrasonography of the tongue (longitudinal scanning): a – echogram of moderately differentiated squamous cell carcinoma of the lateral surface of the tongue (indicated by red arrows), tumor thickness 8.3 mm (indicated by blue arrow), T2 (TNM); b – longitudinal scanning with linear probe in the frequency range 4–9 MHz*

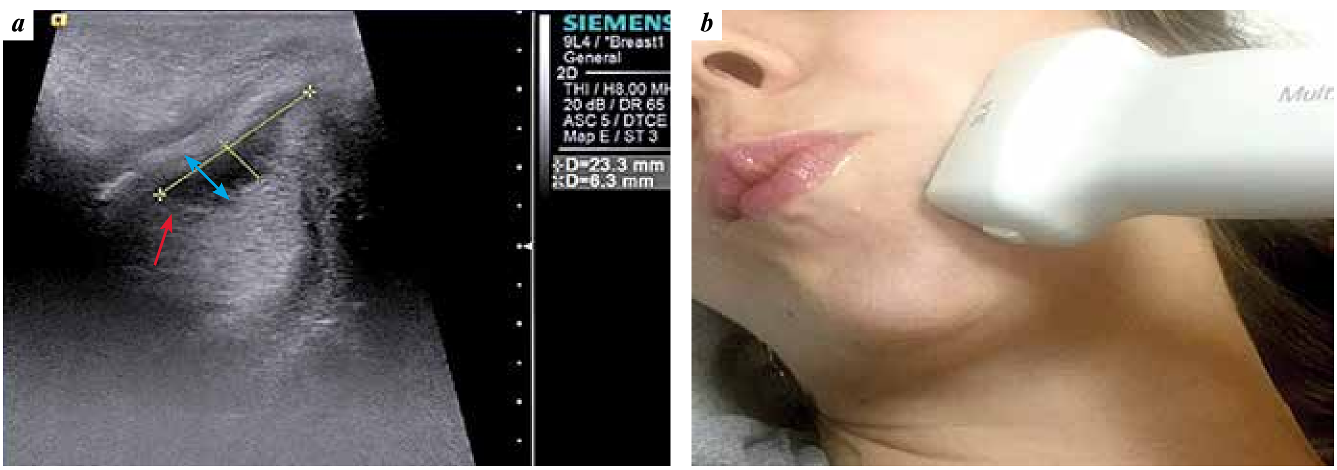

Fig. 3. *Transbuccal ultrasound (US): a – US-tomogram of the tongue lateral surface, moderately differentiated squamous cell carcinoma of the lateral surface of the tongue (indicated by a red arrow), tumor thickness is 6.3 mm (indicated by a blue arrow), T2 (TNM); b – scanning with linear probe (frequency range 4–9 MHz)*

muscle (fig. 1). For longitudinal scanning, the probe was placed directly on the surface of the tumor (fig. 2).

For transbuccal access, the probe was installed transcutaneously on the cheek area. The patient brought his tongue to the probe from the inner cheek surface thus achieving its visualization through the cheek tissue (fig. 3). In some cases, when the patient could not reach the inner cheek surface with his tongue due to the extent? of the tumor process, water was used: the patient kept water in his mouth during the entire study to create an acoustic window and for better tumor visualization. This technique was developed and applied in our clinic. In some cases, this was the only possible way to visualize a tongue tumor in patients with severe pain and trismus.

In 37 patients, US results were compared with X-ray computed tomography (X-ray CT) data, and in 49 patients – with magnetic resonance imaging (MRI) data. X-ray CT was performed with spiral computed tomographs Somatom Emotion 6 and Sensation 4 (Siemens, Germany). The non-ionic radiopaque agent Omnipaque (300 or 350 mg/ml) (Nycomed) was used as a contrast agent, which was injected into the cubital vein using a Medrad automatic injector in a volume of 70–100 ml. For spiral computed tomography (SCT), the scanning step was 5 mm.

Magnetic resonance imaging of the neck was performed using Magnetom Harmony (Siemens, Germany) with magnetic field voltage of 1.0 T, Avanto and Espree (Siemens, Germany) with magnetic field voltage of 1.5 T The Omniscan (Nycomed) was used as a contrast agent. The contrast agent was injected into the cubital vein manually in an amount of 10–15 ml (depending on the patient's body weight).

X-ray CT and MRI were performed in all cases using intravenous contrast.

Statistical processing of the material was performed using the statistical software package Statistica for Windows v.10.

Quantitative parameters are presented as median, interquartile range and minimum – maximum values. The significance of differences between variables was calculated using the nonparametric Mann–Whitney U test. to compare qualitative parameters, Fisher's exact test and χ^2 test were used. Differences were considered as significant at p <0.05.

Results

The results of comparison of TT measured during pathomorphological examination and using various diagnostic methods, depending on the tumor location, are presented in tables 5–7.

The accuracy of US (the number of matches between US data and pathomorphological examination with an acceptable error of ± 15 %) in determining TT of oral squamous cell carcinoma using various approaches is presented in fig. 4.

For tongue tumors, the median value of the TT deviation between those determined during US and pathomorphological examination was 7.9–10.0 %, the error of IOUS was 9.1 %. For tongue tumors, US with transbuccal approach was the most accurate as compared with US with other approaches (median deviation – 7.9 %), and US with submandibular approach was the least accurate (deviation rate – 10 %).

The intraoral technique has proven itself well for tumors of rare locations, such as the mucous membrane of the alveolar processes, lips, cheeks (the frequency of deviations between US and pathomorphological examination data was up to 7.1 %). For tumors of the floor of the oral cavity, IOUS was less accurate than US with submandibular approach (the error was 10 % versus 8.3 %) (fig. 4). This is probably due to technical difficulties: the lack of geometric congruence between the US probe and the lower jaw, which did not allow

Table 5. *Tumor thickness according to pathomorphological examination and ultrasonography with intraoral access (using standard and intraoperative linear probe operating in frequency range of 4–9 and 5–14 MHz depending on tumor location (n = 152), median [25–75th percentile]; maximum–minimum value*

Tumor location	Tumor thickness, mm		Error, %
	Pathomorphological examination	Ultrasonography with intraoral access	
Tongue tumor (*n* =132)	10.0 [5.5–15.0]; 1–27	11.0 [6.0–15.5]; 2–27	9.1 [0–13.8]; 0.0–300.0
Floor of the oral cavity (*n* =18)	12.0 [10.0–15.0]; 2.5–25.0	13.0 [10.0–14.0]; 8.0–25.0	10.0 [8.3–13.3]; 0.0–460.0
Rare tumors (*n* =2)	14.5 [7.0 – 22.0]; 7.0–22.0	15.0 [8.0–22.0]; 8.0–22.0	7.1 [0–14.3]; 0.0–14.3

Table 6. *Tumor thickness according to pathomorphological examination and ultrasonography with submandibular access using a standard linear probe operating in frequency range of 4–9 MHz, depending on tumor location (n = 106), median [25–75th percentile]; maximum–minimum values*

Tumor location	Tumor thickness, mm		Error, %
	Pathomorphological examination	Ultrasonography with intraoral access	
Tongue (*n* =74)	13.0 [9.0–20.0]; 1.0–60.0	14.3 [10.0–20.0]; 0.0–60.0	10.0 [4.0–25.0]; 0.0–200.0
Floor of the oral cavity (*n* =29)	14.0 [10.0–15.0]; 4.0–25.0	15.0 [12.0–18.0]; 6.0–28.0	8.3 [8.3–13.3]; 0.0–140.0
Rare locations (*n* =3)	15.0 [15.0–18.0]; 15.0–18.0	14.0 [12.0–21.0]; 12.0–21.0	16.7 [6.7–20.0]; 6.6–20.0

Table 7. *Thickness of formations according to pathomorphological examination and ultrasonography with transbuccal access using linear sensor operating in the frequency range 4–9 MHz (n = 36), depending on tumor location (n = 106), median [25–75th percentile]; maximum–minimum values*

Tumor location	Tumor thickness, mm		Error, %
	Pathomorphological examination	Ultrasonography with intraoral access	
Tongue (*n* =20)	8.0 [5.0–11.0]; 4.0–16.0	10.0 [5.5–13.5]; 4.0–16.0	7.9 [0.0–22.5]; 0.0–180.0
Floor of the oral cavity (*n* =0)	–	–	–
Rare locations (*n* =16)	16.5 [7.0–23.5]; 5.0–50.0	14.5 [8.0–20.5]; 6.0–65.0	13.3 [0–26.8];0.0–51.4

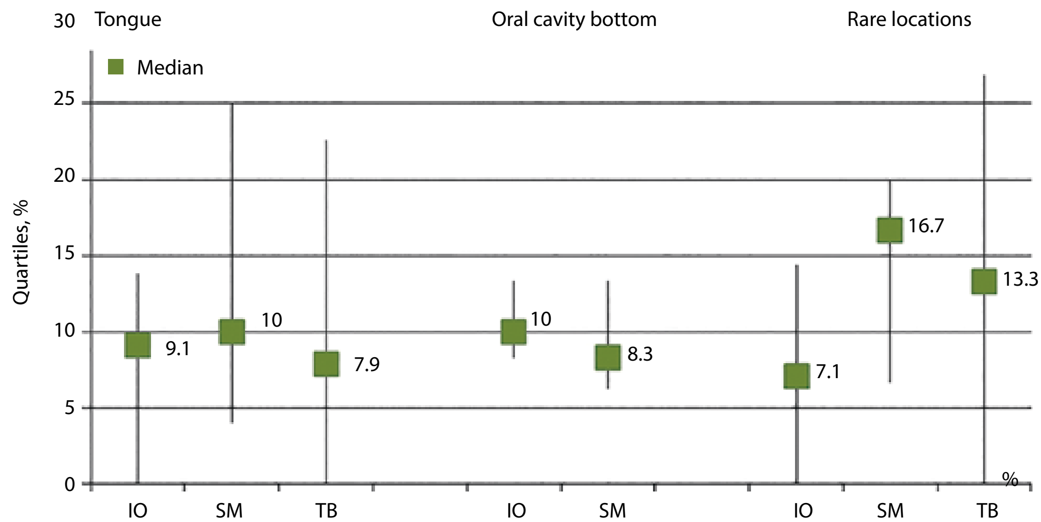

Fig. 4. *The magnitude of the deviation in tumor thickness measurements during pathomorphological and ultrasound investigation depending on the approach and location of the tumor, %. IO – intraoral access; SM – submandibular access; TB – transbuccal access*

Table 8. *Frequency of coincidence for parameters of tumors invasion depth in the oral mucosa of different location according to ultrasound (US) using various approaches and pathomorphological examination (indicated by slash), abs. (%)*

US access	Tumors of the tongue (*n* = 144)	Tumors of floor of the oral cavity (*n* =32)	Rare tumors (*n* =17)	Total (*n* =193)
Intraoral	106/132 (80.3)	14/18 (77.8)	2/2 (100)	122/152 (80.3)
Submandibular	50/74 (=67.6)*	18/29 (62.1)	1/3 (33.3)	69/106 (65.1)*
Transbuccal	14/20 (70.0)	–	8/16 (50.0)	22/36 (61.1)*
*Total***	*120/144 (83.3)*	*24/32 (75.0)*	*9/17 (52.9)****	*153/193(79.3)*

**Statistically significant differences as compared with the intraoral approach; p <0.05. **Cases when the tumor thickness in at least one approach coincides with the pathomorphological depth of invasion. ***Statistically significant differences compared with tongue tumors; p <0.05.*

complete comparison of the surface of the probe and the tumor, especially for small tumors.

The accuracy of US (the number of matches between data from US and pathomorphological studies with an acceptable error of ± 15 %) in evaluation of the TT of oral mucosa tumors when using various approaches is presented in table 8.

When measuring TT using IOUS, the highest frequency of coincidences with this parameter determined histologically (80.3 %) was observed, statistically significantly higher than with US with submandibular (65.1 %; $p = 0.006$) and transbuccal accesses (61.1 %; $p = 0.015$). For tongue tumors, the coincidence rate for IOUS was statistically significantly higher than for US with submandibular approach ($p = 0.041$). When using transbuccal US for tongue cancer, this value was 70 %, and for rare tumors – only 50 %, which is associated with the spread of the tumor to periosteum of the upper and lower jaws and of the inner surface of the alveolar processes. An analysis of the total accuracy of US depending on the tumor location has revealed the best results for tumors of the tongue, and the worse and statistically significantly lower ($p = 0.007$) for rare tumors (taking into account an error is up to ± 15 %)

Tumor thickness measured using submandibular (r = 0.78), intraoral (r = 0.89) and transbuccal (r = 0.93) approaches was significantly adjusted with the DOI determined by pathomorphological method ($p < 0.001$).

The high correlation coefficient was also obtained when comparing TT measured by MRI (r = 0.91) and X-ray CT (r = 0.72) with the DOI determined by pathomorphological examination ($p < 0.001$).

Ultrasound investigation using all approaches shows statistically significantly better results in determining the TT of the tongue and floor of the oral cavity as compared with X-ray CT and MRI. For neoplasms of rare locations, the comparison was impossible due to small group size (table 9).

The DOI variable was in agreement with X-ray CT and comparable to the literature data in which the results are considered as satisfactory, however if standard measurement protocol was used, a tendency towards overestimation of X-ray CT values was also noted [17, 18].

Table 9. *Frequency of coincidence of thickness parameters of tumors of the oral mucosa according to ultrasound (US), magnetic resonance (MRI) and X-ray computed tomography (X-ray CT) and pathomorphological examination (indicated by slash) depending on the location of the tumor, abs. (%)*

Method	Tumor of the tongue (*n* =144)	Floor of the oral cavity (*n* =32)	Rare tumors (*n* =17)	Total (*n* =193)
MRI	19/29 (65.5)*	6/14 (42.9)*	2/6 (33.3)	27/49 (55.1)*
X-ray CT	12/21 (57.1)*	3/8 (37.5)*	4/8 (50.0)	19/37 (51.4)*
US (IO + SM + TB)	120/144 (83.3)	24/32 (75.0)	9/17 (52.9)	153/193 (79.3)

**Statistically significant differences as compared with US (p <0.05).*
***Note.** IO – intraoral access; SM – submandibular access; TB – transbuccal access.*

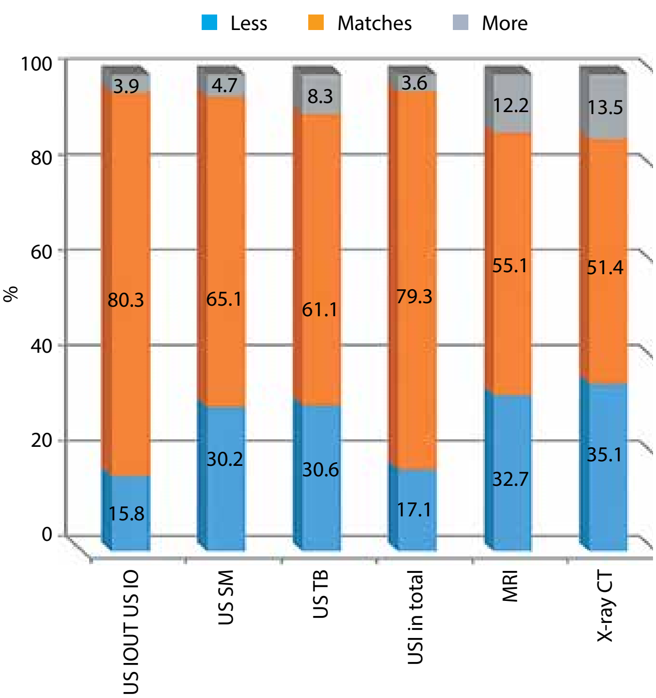

Fig. 5. *The relationship between tumor thickness determined using various diagnostic methods and depth of invasion identified during pathomorphological examination. US – ultrasound; MRI – magnetic resonance imaging; X-ray CT – X-ray computed tomography; IO – introral access; SM – submandibular access; TB – transbuccal access*

The higher tumor DOI values obtained with US is likely to be due to the fact that the study was performed by the same physician, experienced in examining patients with head and neck tumors and interested in more thorough examination, whereas X-ray CT and MRI were performed routinely, and their data were assessed by different specialists with different levels of training. In addition, technically it was not always possible to maintain the same time interval between preoperative diagnosis and pathomorphological examination. The relatively low informative content of MRI was also associated with the low power of the equipment (magnetic field voltage 1–1.5 T), which was used in our study. However, in one recent study of R. Noorlag et al. (2020), which used high-precision MRI devices (magnetic field voltage 3 T), it was demonstrated a significant correlation of TT parameters determined during MRI and IOUS, as well as with DOI identified by pathomorphological method [19] Tumor thickness measured by MRI (r = 0.72) and IOUS (r = 0.78) was significantly correlated with histopathomorphological DOI (p <0.001). However, in tumors with the DOI of 0–10 mm, corresponding to the T1 and T2 categories of the TNM classification, IOUS was more accurate and MRI tended to overestimate the DOI in both thin and thick tumors. At the same time, during IOUS access, the DOI parameters for tumors in which this parameter exceeded 10 mm often turned out to be underestimated [19].

All diagnostic methods are more often characterized by overdiagnosis: the DOI of the tumor according to pathomorphological examination is smaller. The overestimated the TT values are probably associated with inflammatory processes that accompany tumors in the oral cavity (fig. 5).

In the infiltrative-ulcerative form of tumor growth in the oral mucosa which were most common in our study, the TT (was considered equal to DOI) in 12 patients with tongue tumors, the tumors had exophytic and exophytic-endophytic types of growth with predominance of the exophytic component.

In these patients, during US we identified higher tumor DOI data as compared with pathomorphological examination, since the DOI was likely equated to the TT values. M. Filauro et al. in their study have also noted that with exophytic neoplasms of the tongue DOI of the tumor is always less than its thickness, most of which is located outside the basement membrane of the tongue epithelium [20].

In addition, in 10 patients with an exophytic type of tumor growth, well-differentiated squamous cell carcinoma was diagnosed, in 2 – moderately differentiated, which could probably indicate a more favorable prognosis and the choice in the future of a more sparing volume of surgical intervention or radiation therapy regimens.

For primary tumors of the tongue and floor of the oral cavity, the frequency of coincidences between US and pathomorphological examination data increases with increasing the TT; for rare tumors, the opposite is true. However, taking into account the permissible error of ± 15 % in the group with T1 tumors, the US results were underestimated, since 1 mm at the TT 0–5 mm exceeded the permissible error, and in groups with T3–4 tumors the values >15 mm data were, on the contrary, probably overestimated (fig. 6).

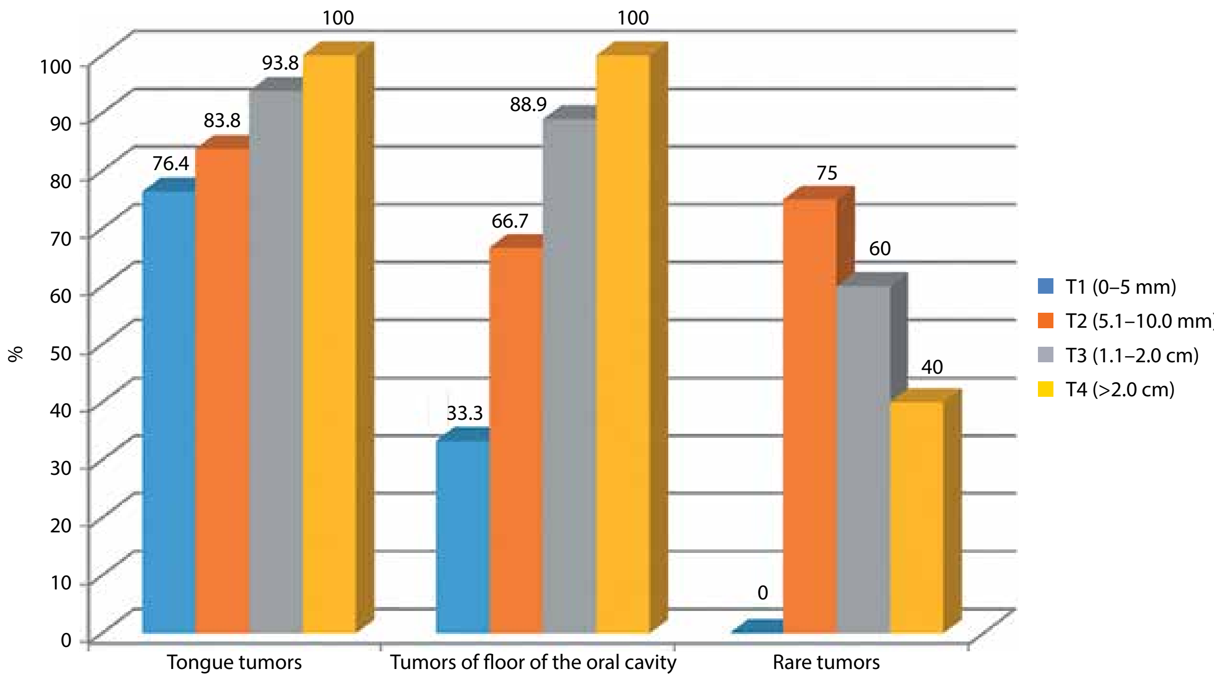

Fig. 6. *Accuracy of measuring of the tumor thickness in the oral mucosa during ultrasound investigation depending on the size of the tumor*

The most common procedure for tumors of the tongue is hemiglossectomy. Thus, the midline of the tongue becomes the line of resection, which in accordance with principles of ablative surgery should be away from the tumor. During US of the oral cavity, in addition to thickness and DOI of the tumor, it is also possible to assess the distance from the tumor to the tongue midline, which is important information when choosing treatment tactics and surgical volume.

Conclusion

When comparing the TT of the oral mucosa, a significantly high correlation was revealed for all US approaches (intraoral, submandibular and transbuccal) with the DOI determined histologically.

When determining the TT of the oral cavity using IOUS was significantly more accurate than using US with submandibular and buccal approaches (with an acceptable error of ± 15 %) ($p = 0.01$). During US with transbuccal access, the smallest error in deviation between tongue TT and pathomorphological examination data was obtained (7.9 %) which allows us to recommend the use of this method for tumors of the tongue, especially in the case of severe pain and trismus.

Ultrasonography using intraoral, submandibular and transbuccal approaches in determining the TT of the tongue and floor of the oral cavity was significantly more accurate as compared with X-ray CT and MRI ($p < 0.05$).

In exophytic and mixed types of oral tumor growth with an exophytic component, the DOI is always less than the TT.

Ultrasonography of the oral cavity is a highly informative method for determining not only the thickness and depth of invasion of the tumor, but also the distance from the tumor to the tongue midline, which is important information when choosing the extent of surgical intervention.

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A.F. Batsev: processing of the received data, editing;
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Conflict of interest. The authors declare no conflict of interest.

Конфликт интересов. Авторы заявляют об отсутствии конфликта интересов.

Funding. The work was performed without external funding.

Финансирование. Работа выполнена без спонсорской поддержки.

Compliance with patient rights and principles of bioethics

The study protocol was approved by the biomedical ethics committee of Lapino Clinical Hospital.
All patients gave written informed consent to participate in the study.

Соблюдение прав пациентов и правил биоэтики

Протокол исследования одобрен комитетом по биомедицинской этике Клинического госпиталя «Лапино».
Все пациенты подписали информированное согласие на участие в исследовании.

Article submitted: 20.11.2023. **Accepted for publication:** 19.12.2023.

Статья поступила: 20.11.2023. **Принята к публикации:** 19.12.2023.