Original Article

Histopathological Comparison of Various Tongue Base Reduction Processes

SB Cobden, İ Ozcan, S Altıparmak[1], A Kuru[2], F Senel[3], Y Kantekın, A Kaya

Departments of Otolaringology, Head and Neck Surgery and [3]Pathology, Kayseri City Education and Training Hospital, Kayseri, [1]Department of Otolaringology, Head and Neck Surgery, TC Sağlık Bakanlığı Erzincan Binali Yıldırım Üniversitesi Mengücek Gazi Eğitim ve Araştırma Hastanesi, Erzincan, [2]Department of Otolaringology, Head and Neck Surgery, Yozgat City Hospital, Yozgat, Turkey

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Abstract

Background and Aim: Tongue base reduction surgery is the only minimally invasive technique that can be performed under local anesthesia as an outpatient procedure, especially to treat obstructive sleep apnea caused by hypopharyngeal obstruction. Studies reported that various devices could be used for tongue base reduction, but comparisons of these methods are limited in the literature. Our study aimed to compare the histological effects of tongue base reduction methods performed with the Celon radiofrequency, monopolar cautery, Coblator, and Sutter devices on the tissue. **Methods:** This study included 23 female rats (aged 4–8 months). Rats were divided into five groups. Tongue base reduction was performed with monopolar cautery in the first group (5 rats), then Celon radiofrequency in the second group (5 rats), the Coblator in the third group (5 rats), and the Sutter in the fourth group (5 rats). The fifth group was the control group, which comprised three rats. The rats' tongues were resected for histological examination 1 week after procedures. **Results:** While the highest amount of fibrosis was seen in the Sutter group, fibrosis was also relatively high in the Coblator group. A significant difference was observed in all groups when compared with the control group regarding tissue thickness. While the average tissue thicknesses of the monopolar, celon rf, and Coblator groups were almost the same, tissue reduction was more marked in the Sutter group. **Conclusion:** Although we observed that all the methods used were safe, the method that produced the most fibrosis and tissue reduction was the Sutter method.

Keywords: *OSAS, radiofrequency, reduction, tongue base*

Introduction

Obstructive sleep apnea syndrome (OSAS) is characterized by repetitive nocturnal complete collapses (apneas) or partial collapses (hypopneas) of the upper airway, associated with oxygen desaturation and/or arousal during sleep.[1] OSAS is the most common chronic respiratory disorder after chronic obstructive pulmonary disease and asthma.[2] Due to recurrent asphyxia, OSAS has serious risks, especially for cardiovascular and cerebrovascular diseases, and carries the risk of sudden death. Polysomnography is the gold standard for diagnosing OSAS, and continuous positive airway pressure (CPAP) is the gold standard for treatment. Surgical treatments are however indicated in patients who cannot tolerate CPAP. A detailed examination should also be performed to determine the obstruction area. Determining the anatomical and physiological sites of obstruction is crucial for matching a patient to the appropriate surgical intervention. OSAS results from the multilevel collapse of the upper airway. Approximately 70% of subjects have a collapse at the tongue base, which contributes significantly to obstruction during sleep.[3] Tongue base reduction surgery is the only minimally invasive technique that can be performed under local anesthesia as an outpatient procedure, especially to treat obstructive sleep apnea

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Address for correspondence: Dr. SB Cobden, Department of Otolaringology, Head and Neck Surgery, Kayseri City Education and Training Hospital, Kayseri, Turkey.
E-mail: dr.srpblt@gmail.com

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caused by hypopharyngeal obstruction. It has been shown that tongue-base reduction surgery is accompanied only by a minor percentage of postoperative morbidity and complications. When it is performed as a single procedure in obstructive sleep apnea, 40% cure rates have been reported.[4] Tongue base reduction surgery was first reported by Powell in 1998, Powell when he utilized the Somnus system.[5] This system principally comprised a monopolar device. Subsequently, many other devices were introduced that utilized bipolar technology, with some functioning in a wet medium, such as the Coblator, Celon, Sutter, and Ellman.[6] Studies have reported that various devices could be used for tongue base reduction, but comparisons of these methods are limited in documented literature.[4,5,7] Our study aimed to compare the histological effects of tongue base reduction methods performed with the Celon radiofrequency, monopolar cautery, Coblator, and Sutter devices on the tissue.

Material and Methods

All experimental protocols were approved by the Erciyes University Animal Experiments Ethics Committee (reference number: 22/005, date of approval: 05.01.2022). We confirm that all methods were reported in accordance with Animal Research Reporting of *In Vivo* Experiments (ARRIVE) guidelines. All methods were also carried out in accordance with relevant guidelines and regulations. The study was conducted in the animal experiments laboratory of Erciyes University. This study included 23 female rats (aged 4–8 months). The rats were maintained in an environment at 21° on a 12-h light/dark cycle and given access to food and water *ad libitum*. Rats were divided into five groups. Tongue base reduction was performed with monopolar cautery in the first group (5 rats), with radiofrequency in the second group (5 rats), with the Coblator in the third group (5 rats), and with the Sutter in the fourth group (5 rats). The fifth group was the control group which, consisted of 3 rats. All reduction procedures were performed under general anesthesia. Each rat in both groups was sedated with an intramuscular injection of ketamine hydrochloride (15 mg/kg) and xylazine hydrochloride (6 mg/kg). All reduction procedures were performed at the same point where circumvallate papillae intersected, located at the midline of the tongue base in all rats [Figure 1]. In the monopolar cautery reduction process, the cautery tip was placed submucosally. Cauterization was applied at 20 watts for 15 seconds. The Celon radiofrequency reduction process was performed with a bipolar RFA device (Celon AG Medical Instruments, Teltow/Berlin, Germany), while the bipolar power control unit (CelonLabENT) was used with an applicator (CelonProSleep) specifically designed for the base of the tongue. The power setting was 6 and applied for 15 seconds.

The Coblator reduction process was performed using the coblation wand (Reflex 4855, AnthrocareCorp., Austin, TX, USA) with the ablation-5 mode for 15 seconds. The reduction procedure with the Sutter was performed with a bipolar-tipped tongue root probe at 12 watts for 15 seconds (Sutter, CURIS 4 MHz radio frequency generator, RaVoR™ Bipolar Electrodes, Germany). The rats were euthanized via intracardiac air 1 week after the reduction procedures, and their tongues were resected for histological examination [Figure 2]. Specimens of extracted tongues were fixed in 10% formaldehyde in the pathology laboratory and then embedded in paraffin. Slices of 5–6 μm thickness were cut, deparaffinized, and stained with hematoxylin–eosin. All stained samples were evaluated under a light microscope by the same pathologist.

The tongues were evaluated regarding fibrosis, inflammation, vascularization, submucous gland changes, and tissue thickness [Figures 3-6]. All pathological examinations were performed by the same pathologist. Tissue tickness was measured microscopically. Parameters like fibrosis, inflammation, vascularization, and submucous gland changes were semiquantitatively evaluated using the following scale: absent (0), light (1), moderate (2), and severe (3), and the parameters were compared among groups.

Results

Histological examination revealed no significant difference between the groups regarding thrombosis and ulceration. While ulceration was not observed in any of the procedures, mild thrombosis was observed in the celon group. Our results showed that the number of submucosal glands was the same in all groups as in

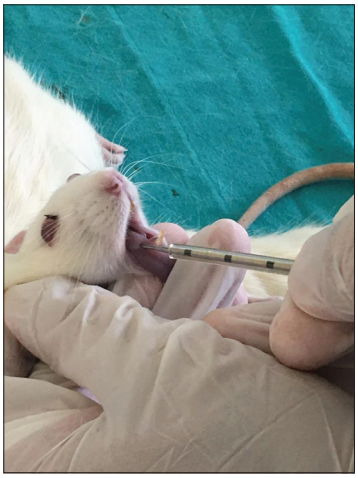

Figure 1: Reduction procedure

Table 1: Histological results of all groups

Variable	Monopolar	Celon Radiofrequency	Coblator	Sutter	Control	*P*
Ulceration	0	0 (0–1)	0 (0–1)	0 (0–1)	0	0.186
Submucosal gland	1±0	1±0	1±0	1±0	1±0	N
Thrombosis	0 (0–1)	1 (0–1)	0 (0–1)	0 (0–1)	0	0.444
Vascularity	1±0[a]	1.8±0.4[b]	1.8±0.4[b]	1.6±0.5[b]	0[c]	<0.001
Inflammation	1.4±0.5[a]	2.6±0.5[b]	1.8±0.8[a]	2.2±0.4[b]	0[c]	<0.001
Fibrosis	1±0[a]	1±0[a]	1.2±0.4[b]	1.6±0.5[c]	0[a]	<0.001
Tissue thickness	3.9±0.1[a]	3.8±0.1[a]	3.7±0.2[a]	3.3±0.2[b]	4±0[c]	<0.001

[a,b,c]statistically significant

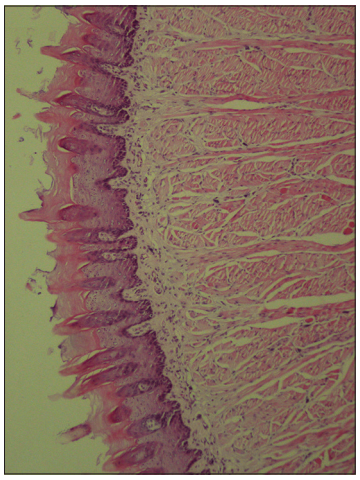

Figure 2: Resected tongue

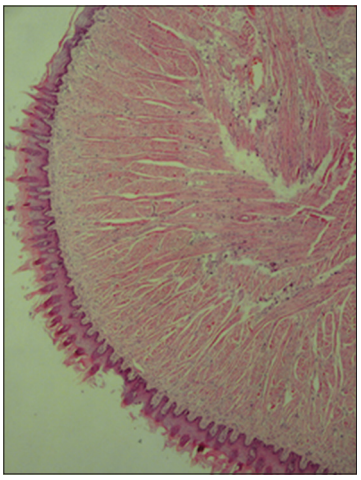

Figure 3: Control group histopathology

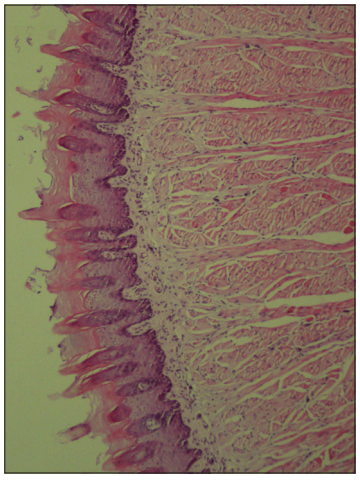

Figure 4: Fibrozis

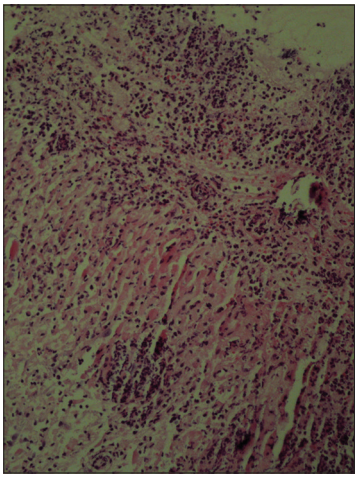

Figure 5: İnflammation

the control group. There was a significant difference however in observed vascularization between the groups when compared with the control group. While there was more vascularization in the monopolar group than the control group, there was more vascularization in the Celon, Sutter, and Coblator groups than in the monopolar group. In addition, inflammation was higher in all groups than in the control group. Inflammation in the Celon and Sutter groups was higher than in the monopolar and Coblator groups. There was also a significant difference between the groups regarding fibrosis. While the highest amount of fibrosis was seen in the Sutter group, fibrosis was also higher in the Coblator group than in the control group. In the monopolar and Celon groups, no significant difference was observed compared with the control group regarding fibrosis. A significant difference was observed in all groups when compared with the control group regarding tissue thickness. While the average tissue thicknesses of the monopolar, Celon, and Coblator groups were almost the same, we observed that

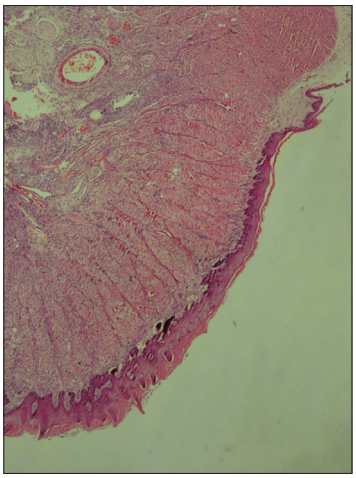

Figure 6: Vascularization

the lowest tissue thickness, the highest tissue reduction, was in the Sutter group [Table 1].

Discussion

The effectiveness of OSAS surgery is based on preventing the collapse of the upper respiratory tract without disturbing its normal functions. Although the focus was on the soft palate when OSAS surgery was first started, the importance of multilevel and obstruction-oriented surgeries has been emphasized in recent years. The tongue root is an essential component of this multilevel surgery and is extremely important in OSAS surgery.

Although the reduction of tongue base volume is one surgical method used to treat OSAS, little is known about the histological changes it causes in tissue. Our study is based on histological examinations comparing the changes made in tissue by different reduction models.

One histological study on this subject examined the excision materials of 13 patients who underwent excision of the tongue base with robotic surgery.[7] The study results revealed that the base of the tongue consists of four layers: epithelial, lymphoid follicular, glandular, and muscular layers, and these layers can be distinguished by computed tomography. In addition, the histological effect of radiofrequency on the tissue was studied on the palatine tonsils and inferior turbinates. In the study on the palatine tonsils, Nemati *et al*.[8] reported that RF surgery has significant effects on the size of the nodules, the thickness of the mucous layer, and the bacteriological characteristics of tonsil tissue. In studies on the inferior turbinates, vascular proliferation, and granulation tissue development, an increase in the number of chronic inflammatory cells and a slight decrease in the number of glands were observed in the early period, while a decrease in the number of inflammatory cells was observed in the late period. At the same time, there was an increase in vascular proliferation and a decrease in the number of glands, indicating a fibrotic process with increased granulation.[9] In our study, a histological examination was performed in the early period, and an increase in fibrosis, inflammation, and vascularity was observed in all study groups.

In their histopathological study, Ge *et al*. observed 15 seconds to be the most appropriate application time for radiofrequency. Their study compared the15-, 30-, and 60-seconds application times and reported that the lesion volume was stabilized in 15 seconds, obviating the need for a procedure longer than 15 seconds. In our study, in which we utilized 4 different methods, we used 15 seconds as the application time. Ge *et al*.[10] had reported that prolonged treatment did not produce bigger lesions nor cause uncontrolled damage to the surrounding tissue. This finding constitutes a safety feature of radiofrequency energy delivery through self-limited tissue destruction after excessive energy delivery. Cukurova *et al*.[11] also reported that radiofrequency did not cause damage to the conchal mucosa or submucosal glands in their study, in which they performed histopathological examination after lower turbinate radiofrequency on 6 patients.

Similarly, in the study of Kaplama *et al*.[9] on rabbits, the histological effects of radiofrequency applied to the inferior turbinate were investigated. It was reported that there was no difference in the radiofrequency group compared to the control group regarding ciliary loss, an increase in submucosal vascularity, inflammatory cellular infiltration, or epithelial injury. Our study did not observe any ulceration or submucosal gland changes in any of the groups. Thrombosis was seen only in the Celon radiofrequency group, but there was no significant difference when compared with the control group. Based on these results, we believe in the safety of these methods.

The primary purpose of the reduction operations on the tongue base is to reduce the thickness of the tissue by protecting the mucosa, submucosa, and submucosal glands. This tissue reduction is achieved by breaking down submucosal fat and connective tissue, with secondary fibrosis development subsequently ensuring it. In our study, fibrosis was marked in all study groups compared to the control group. We observed that the highest amount of fibrosis was in the Sutter group, followed by the Coblator group after Sutter. The fibrosis rate of Celon radiofrequency and monopolar was equal to each other and lower than those of the Sutter and

Coblator. If we evaluate it according to the fibrosis rate, the most successful method is the Sutter, followed by the Coblator. However, the more critical success criterion should be the reduction of tissue thickness. When we examined the tissue reduction, we observed that the Sutter achieved the most reduction, the reduction rates of the other three methods were equal, and the tissue thickness was significantly lower than that of the control group. In other words, it is possible that all four methods provide sufficient reduction and that the Sutter provides the most reduction. We have seen two studies by Powell *et al*. about reduction rates in tissue thickness in the literature. While they gave a reduction rate of 26.3% in their animal study, they reported this rate as 17% in their human study.[12,13] In our study, when we look at the reduction rates of the groups separately, we calculated it as 2.5% in the monopolar group, 4.5% in the radiofrequency group, 7% in the Coblator group, and 17.5% in the Sutter group. Our rates were lower than those of Powel *et al*.; only our rate in the Sutter group was close to theirs. This difference may be related to the difference in the animal models used.

Conclusion

Reduction methods to the base of the tongue, an essential region in OSAS surgery, are frequently used because they are minimally invasive and have less potential for side effects. Our study investigated the histopathological changes caused by various reduction methods in the tongue base. Although we observed that all the methods we used were safe, the method that caused the most fibrosis and most tissue reduction was the Sutter's.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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