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Non-Contact Fabrication of a Lingual Retainer During the COVID-19 Pandemic: Case-Control Study

COVID-19 Pandemi Sürecinde Temassız Lingual Retainer Yapımı: Olgu Kontrol Araştırması

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ABSTRACT Objective: Lingual retainers are used to stabilize the results of orthodontic treatment in the anterior region for aesthetic purposes. The fabrication of lingual retainers involves plaster models, the cost of impression materials, shipping procedures, and a laboratory stage. With advances in digital technology, intraoral scanning can be used in dentistry for additive manufacturing to eliminate contamination during the coronavirus disease-2019 (COVID-19) period. The use of 3D printers to make lingual retainers shortens production steps and lowers costs. In addition, eliminating the impression stage reduces chairside time, and minimizes orthodontist-patient contact. This analytic study aims to compare the conventional and digital fabrication of intraoral retainers regarding time and cost. **Material and Methods:** A total of 20 jaws were selected, and indirect retainers were fabricated by two different methods on 10 jaws in each group. The conventional method was comprised of impression and gypsum models, whereas the digital method made use of intraoral scanning and 3D printing. The time consumption was recorded, and the cost of the materials was calculated. **Results:** The mean of total cost and time were 7.04+/-0.9 dollars and 68+/-1.8 minutes, respectively, for the conventional method. Meanwhile, the digital method had 33+/-2.7 minutes for the total time and 1.15+/-0.3 dollars for the total cost. The results, which were obtained from both methods, were observed to be statistically significant (p<0.001). **Conclusion:** The digital method has advantages in terms of time and cost. With the 3D technique, the risk of cross-infection has been reduced due to factors such as the shorter duration of jaw opening during the COVID-19 period.

Keywords: Lingual retainer; cross-infection; 3D printing

ÖZET Amaç: Lingual retainerlar, estetik amaçlı olarak ağızda ön bölgede ortodontik tedavi sonuçlarını sabitlemek için kullanılır. Lingual retainer üretimi, alçı modeli yapımını, ölçü malzemelerinin maliyetini, nakliye prosedürlerini ve bir laboratuvar aşamasını içerir. Dijital teknolojideki ilerlemelerle ağız içi tarama, diş hekimliğinde koronavirüs hastalığı-2019 [coronavirus disease-2019 (COVID-19)] döneminde kontaminasyonu ortadan kaldırmak amacıyla aditif üretim için kullanılabilir. Üç boyutlu yazıcıların lingual retainer yapımında kullanılması üretim adımlarını kısaltır ve maliyetleri düşürür. Ayrıca, ölçü aşamasının ortadan kaldırılması, dişçi koltuğunda geçirilen süreyi azaltır ve ortodontist-hasta temasını en aza indirir. Bu analitik çalışma, intraoral tutucuların geleneksel ve dijital üretimini zaman ve maliyet açısından karşılaştırmayı amaçlamaktadır. **Gereç ve Yöntemler:** Toplam 20 çene seçildi ve her grupta 10 çenede iki farklı yöntemle indirekt tutucular üretildi. Geleneksel yöntem, ölçü ve alçı modellerinden oluşurken, dijital yöntemde, ağız içi tarama ve 3D baskıdan yararlanıldı. Zaman tüketimi kaydedildi ve malzemelerin maliyeti hesaplandı. **Bulgular:** Geleneksel yöntem için toplam maliyet ve süre ortalaması sırasıyla 7,04+/-0,9 dolar ve 68+/-1,8 dk idi. Bu arada dijital yöntemde toplam süre için 33+/-2,7 dk ve toplam maliyet için 1,15+/-0,3 dolar olarak gerçekleşti. Her iki yöntemden elde edilen sonuçların istatistiksel olarak anlamlı olduğu görüldü (p<0,001). **Sonuç:** Dijital yöntemin zaman ve maliyet açısından avantajları vardır. 3D tekniği ile COVID-19 döneminde ağzın açık kalma süresinin daha kısa olması gibi etkenlerden dolayı çapraz enfeksiyon riski azaltılmıştır.

Anahtar Kelimeler: Lingual retainer; çapraz enfeksiyon; 3D baskı

A considerable number of the new coronavirus disease-2019 (COVID-19) related cases were reported by World Health Organization in Wuhan (China) on the 31st of December 2019, and subsequently, it was seen that the number of cases grew exponentially.[1] It is well known that COVID-19 can

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be transmitted from person to person through close contact and droplets. Furthermore, 91.7 percent of COVID-19 patients' saliva can contain the coronavirus.[2] While conducting face-to-face procedures in dentistry, the possibility of getting infected with COVID-19 due to exposure to saliva through aerosols, as well as exposure due to asymptomatic patients, is very high. This also constitutes an important transmission route for COVID-19. Thus, dentistry plays a critical role in the pandemic process, and hence, all possible safety measures must be taken.[3]

Orthodontics, as a branch of dentistry, has been significantly affected by the Coronavirus pandemic.[4] Therefore, the standard orthodontic approaches, which were applied before the pandemic, had to be revised in order to adapt to the circumstances.[5] Moreover, in order to minimize coronavirus infections during orthodontic treatment, existing protocols have been updated with new guidelines.

In addition, the recently developed digital workflow process, which uses intraoral scanners, minimizes the time spent on dental chairs during treatments and provides the least amount of contact between patients and orthodontists, which reduces the possibility of the coronavirus spreading.

These new methods should be considered for minimizing contact during the fabrication of an indirect lingual retainer in patients, whose orthodontic treatment has been completed. The conventional fabrication of a lingual retainer involves the following steps: Taking an impression of the patient's teeth with alginate, removing remnants of the impression material from the patient's face, creating a cast model by pouring the impression with gypsum, transporting the model to the dental laboratory, trimming the model, fabricating the lingual retainer, and transporting the lingual retainer back to the clinic. During these steps, both orthodontists and patients, as well as the other employees of the dental office, experience person-to-person contact. However, person-to-person contact can be decreased by producing the lingual retainer with the new techniques.

The results of orthodontic treatments show a noticeable tendency for upper and lower incisors to return to their initial positions unless suitable and permanent protections are applied.[6] Various retention protocols have been advised for long-term stabilization of outcomes. In contrast to removable appliances, fixed lingual retainers seem the most reliable way of avoiding undesirable post-treatment changes as these retainers require no patient cooperation. Current orthodontic practice prioritizes the retention protocol of the Zachrisson canine-canine bonded orthodontic lingual retainers made of round or angular steel. This protocol is used to stabilize the lower intercanine distances and positions.[7] Most practitioners recommend using permanent retention for one to five years.[8-10] Therefore, it is seen that the demands on using lingual retainers are on the rise.

With the objective of reducing the risk of cross-infection and contamination by using intraoral scanning and 3D printers for lingual retainer production, this study has aimed to clinically compare two methods of fabricating indirect lingual retainers: the conventional method and a new method including an intraoral scanning device and a 3D printer, in terms of total cost and time consumption. We hypothesized that the digital method would be less time-consuming and less expensive than the conventional method.

MATERIAL AND METHODS

In this study, 20 jaws were selected at the end of the active orthodontic treatment, and then they were divided into 2 groups as conventional and digital; 10 indirect retainers were produced for each group. Informed Consent Forms were taken from all patients. The criteria for inclusion were as follows: no missing teeth, prosthesis, malformed teeth, or spacing in the anterior area. The lingual retainer was fabricated from the canine to the contralateral canine.

Group 1: Conventional method

a. An impression was taken of the relevant region in vinyl polysiloxane (Imprint4, 3M ESPE, Germany) (Figure 1a).

b. After a two-minute setting time, impressions were removed from the mouth (Due to the brackets, the first impressions had to be discarded (Figure 1b).

c. Impressions were rinsed thoroughly with water spray, and then disinfected for 10 minutes before being sent to the laboratory.

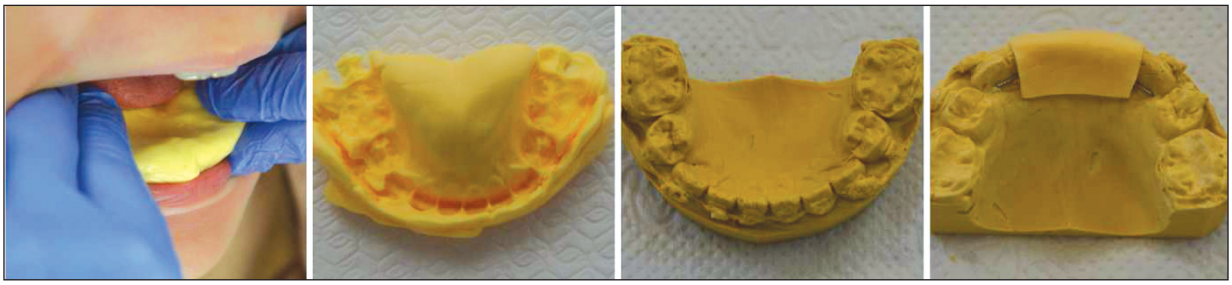

FIGURE 1: Steps of the conventional method: **a)** impression taking, **b)** impression, **c)** Gypsum model, **d)** indirect retainer wire.

FIGURE 2: Steps of the digital method: **a)** intraoral scanning with CEREC **b)** 3D model preparation with Tinker CAD online software **c)** 3D printed model **d)** indirect retainer wire.

d. At the laboratory, the impression was poured with gypsum according to the manufacturer's instructions (New Fujirock Type IV, GC, Japan) (Figure 1c).

e. The retainer wire (PentaOne, Masel, USA) was adapted to the gypsum model by a technician (Figure 1d).

f. The lingual retainer was sent to the orthodontist's clinic.

g. The lingual retainer was bonded in the patient's mouth.

Group 2: Digital method

a. The relevant region was scanned with an intraoral scanning device (CEREC, Sirona Dental Systems GmbH, Bensheim, Germany) (Figure 2a).

b. The result of the scan (STL format) was sent to a computer and edited via free software (Cura software program, Geldermalsen, Netherlands) to be printed in 3D (Figure 2b).

c. A model was created with a 3D printer (Anycubic 3D Printer, Guangdong, China) and sent to the laboratory (Figure 2c).

FIGURE 3: Applied lingual retainer.

d. Retainer wire (PentaOne, Masel, USA) was adapted for the model by technicians or clinicians; and the wire was sent to the orthodontist's clinic (Figure 2d).

e. The lingual retainer was bonded in the patient's mouth (Figure 3).

The cost and time calculations were made for each of the 10 patients in each group, mean values were calculated, and the results were statistically evaluated with the Wilcoxon tests. The global "www.amazon.com" website was used for obtaining the price of the materials used. The amount of material used was measured with precision scales. This study was carried out in accordance with the principles of the Declaration of Helsinki and approved with no: 2019/156 date: September 19, 2019 by İstanbul Aydın University. Patient release forms were taken from all patients in this study.

RESULTS

To compare both methods throughout the steps, cost and time loss were shown in Table 1.

For Group 1, the mean of the total time was calculated as 68+/-1.8 minutes and the mean of the total cost was calculated as 7.04+/-0.9 dollars.

For Group 2, the mean of the total time was calculated as 33+/-2.7 minutes and the mean of the total cost was calculated as 1.15+/-0.3 dollars.

Based on the Wilcoxon test, the mean total time used for the conventional method was 68+/-1.8 minutes, and for the digital method, it was 33+/-2.7 minutes. The results, which were obtained from both methods, were statistically significant ($p<0.001$).

The mean total cost of the conventional fabrication methods was 7.04+/-0.9 dollars, while that of the new method was 1.15+/-0.3 dollars (=5.9 dollars difference per jaw). Total cost results have been shown with statistical significance. ($p<0.001$)

The cost and time calculations were calculated per jaw, and the costs of the scanner and the 3D printer were excluded.

DISCUSSION

Substantial technological enhancements have been seen in the field of dentistry in the last decade, and digital technology has also been introduced into dental practices. The popularity of digital dentistry has grown gradually each year. Contemporary impression techniques, which use intraoral scanners digitally, or 3D printing applications, attract interest around the world.[11]

This study found that when intraoral scanning methods are used, lingual retainer fabrication is reduced in terms of time and cost. Workflow and cast/model fabrication have been simplified, and the comfort levels of dentists and patients have been raised by the utilization of 3D printers.[12] This method avoids the inaccuracies of the conventional impression approach, caused by silicones being prone to dimensional changes due to ongoing chemical reactions and secondary reactions that cause the dental stone to expand. The accuracy of the impression may be affected by various clinical factors, especially, the differences in clinicians' skills or patients' conditions. However, direct digital oral scanning is not associated with these dimensional changes. In the literature, some laboratory-based studies report that compared to conventional impressions in vitro, the contemporary method has excellent dimensional accuracy and acceptable precision for digital impressions.[13-15] Moreover, the intraoral scanning method was reported to be more patient-friendly than the conventional impression method.[16] The hypothesis was accepted when the results of the time consumption of the two methods were compared.

3D printing does not include the cost of the silicone impression material, the cost of plaster models,

TABLE 1: Comparison of the two methods as regards time and cost (mean value).

Procedure	Conventional method (time/cost)	Digital method (time/cost)
Impression/scanning	6 min/5.34 $ (9.5 mL)	10 min
Sending to lab	1 min	-
Fabrication of stone cast	45 min/0.6 $ (200 g)	-
Fabrication of indirect retainer	5 min/1.1 $	5 min/1.1$
Transporting to orthodontist	1 min	1 min
Applying retainer to patient	10 min	10 min
Send .STL format via mail	-	1 min
3D printing of lingual retainer	-	6 min/1.6 g filament (0.05 $)
Total ($p<0.01$)	68 min/7.04 $ ($p<0.01$)	33 min/1.15 $ ($p<0.01$)

or the transportation costs for dispatching to the laboratory. The results of this study present the major reasons why the subjects preferred the 3D printing technique over the conventional technique. The major advantages of 3D printing include reduced chair-side time, fewer steps of fabrication, and zero cost for impression materials, plaster models, or transportation. The 3D printing technique facilitates the process of scanning the relevant region and sending the data via email. Additionally, the data, which is obtained from the oral environment, can be recorded in a digital environment and reprinted. In line with the results of the cost of these two methods, the hypothesis was accepted.

CONCLUSION

The 3D printing technique was more economical than the conventional technique when calculated for a single jaw.

The 3D printing technique is more practical and there is less chance of contamination as compared to the conventional method. This may help both patients and orthodontists to feel more mentally comfortable, since the 3D technique reduces the risk of cross-infection during the pandemic period for the reasons explained in this article.

Source of Finance

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Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

***Idea/Concept:** Ufuk Ok, Sertaç Aksakallı; **Design:** Çağrı Temel; **Control/Supervision:** Ufuk Ok, Sertaç Aksakallı; **Data Collection and/or Processing:** Ufuk Ok, Ece Büyükbaşaran; **Analysis and/or Interpretation:** Ufuk Ok; **Literature Review:** Ufuk Ok; **Writing the Article:** Ufuk Ok, Ece Büyükbaşaran; **Critical Review:** Sertaç Aksakallı; **References and Fundings:** Ufuk Ok; **Materials:** Ufuk Ok.*

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