ORIGINAL RESEARCH ORİJİNAL ARAŞTIRMA

DOI: 10.5336/dentalsci.2024-107182

Knowledge and Perception Levels of Intern Dental Students About Virtual Reality and Augmented Reality Applications in Oral and Maxillofacial Surgery: A Cross-Sectional Study

Diş Hekimliği Stajyer Öğrencilerinin Oral ve Maksillofasiyal Cerrahide Sanal Gerçeklik ve Artırılmış Gerçeklik Uygulamaları Hakkındaki Bilgi ve Algı Düzeyleri: Kesitsel Çalışma

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ABSTRACT Objective: Virtual reality (VR) and augmented reality (AR) technologies are used successfully in medicine, especially in minimally invasive surgery applications. This study aims to assess the knowledge, opinions, and perceptions of dentistry students related to VR and AR applications in oral and maxillofacial surgery. **Material and Methods:** A descriptive, observational survey study was designed. A 47-question survey was designed to measure dentistry students' knowledge and perceptions about VR and AR applications in oral and maxillofacial surgery, their advantages and disadvantages. The survey was administered face-to-face to 4th and 5th-grade students doing internships at a dentistry faculty in Türkiye. **Results:** A total of 143 students (83 female, 60 male; mean age 23±0.89 years) responded to the survey with a response rate of 96.62%. 80.4% of the students reported that they did not have basic knowledge of VR/AR concepts, and 71.3% reported that they were not aware of the utilization of VR/AR in oral and maxillofacial surgery. Participants cited social media (29.79%), media (24.74%), and web browsing (21.96%) as the top 3 sources of information about VR/AR, respectively. 93% of the students stated that they wanted to receive training on the utilization of VR/AR in oral and maxillofacial surgery and that they wanted to use it in the future. **Conclusion:** Even though the students had insufficient knowledge about VR/AR technologies, they were very willing to learn and use these technologies. Therefore, VR/AR applications should be added to the dentistry undergraduate and maxillofacial surgery postgraduate specialty training curricula in Türkiye.

Keywords: Virtual reality; augmented reality; dentistry; oral and maxillofacial surgery; dental student

ÖZET Amaç: Sanal gerçeklik (SG) ve artırılmış gerçeklik (AG) teknolojileri tıpta, özellikle minimal invaziv cerrahi uygulamalarında başarıyla kullanılmaktadır. Bu çalışma, diş hekimliği öğrencilerinin oral ve maksillofasiyal cerrahide SG ve AG uygulamalarına ilişkin bilgi, görüş ve algılarını değerlendirmeyi amaçlamaktadır. **Gereç ve Yöntemler:** Tanımlayıcı, gözlemsel bir anket çalışması tasarlanmıştır. Diş hekimliği öğrencilerinin oral ve maksillofasiyal cerrahide SG ve AG uygulamaları, avantajları ve dezavantajları hakkındaki bilgi ve algılarını ölçmek için 47 sorudan oluşan bir anket tasarlanmıştır. Anket, Türkiye'deki bir diş hekimliği fakültesinde staj yapan 4 ve 5. sınıf öğrencilerine yüz yüze uygulandı. **Bulgular:** Toplam 143 öğrenci (83 kadın, 60 erkek; ortalama yaş 23±0,89 yıl) %96,62'lik bir yanıt oranıyla ankete yanıt verdi. Öğrencilerin %80,4'ü SG/AG kavramları hakkında temel bilgiye sahip olmadıklarını ve %71,3'ü SG/AG'nin oral ve maksillofasiyal cerrahide kullanımından haberdar olmadıklarını bildirdi. Katılımcılar sırasıyla sosyal medyayı (%29,79), medyayı (%24,74) ve web taramasını (%21,96) SG/AG hakkında bilgi edinmenin en önemli 3 kaynağı olarak gösterdi. Öğrencilerin %93'ü SG/AG'nin oral ve maksillofasiyal cerrahide kullanımı konusunda eğitim almak istediklerini ve gelecekte kullanmak istediklerini belirtti. **Sonuç:** Öğrenciler SG/AG teknolojileri hakkında yeterli bilgiye sahip olmasalar da bu teknolojileri öğrenmeye ve kullanmaya çok isteklidiler. Bu nedenle, SG/AG uygulamaları Türkiye'de diş hekimliği lisans ve maksillofasiyal cerrahi lisansüstü uzmanlık eğitim müfredatlarına eklenmelidir.

Anahtar Kelimeler: Sanal gerçeklik; artırılmış gerçeklik; diş hekimliği; oral ve maksillofasiyal cerrahi; diş hekimliği öğrencisi

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Peer review under responsibility of Turkiye Klinikleri Journal of Dental Sciences.

Received: 02 Dec 2024 ***Received in revised form:*** 22 Jan 2025 ***Accepted:*** 27 Feb 2025 ***Available online:*** 04 Jun 2025

Virtual reality (VR) is a collection of technology that allows people to interact with virtual entities in real-time. Immersion and interaction are 2 key characteristics of virtual reality. Immersion describes the sensation of being present in a virtual world whereas interactivity is the ability of the user to make changes.[1] With this, augmented reality (AR) is a technology that enhances an environment by superimposing computer-generated virtual material over the actual structure, hence improving the sensory experience of reality.[2] AR might be considered a subtype of VR. However, unlike a VR system, which only delivers a computer-generated world that triggers the user's sensation of presence, an AR system integrates real and virtual aspects to improve sensory awareness in the actual environment.[1] From a medical standpoint, VR is the art and science of building a virtual world that provides standard, safe, and adaptable platforms for evaluating various anatomical parts of the body for inspection, diagnosis, planning, and surgical training.

Advances in computing power have allowed for considerably faster generation of realistically generated visuals. VR and AR have been used in business, tourism, marketing, care, architecture, education, and medical fields thus far.[3] Surgeons are early users of AR and are always on the lookout for new technology to enhance patient outcomes. AR has been investigated in several medical surgical specialties, including neurosurgery, endoscopic surgery, and laparoscopic surgery, as well as in treating cognitive, psychological, and motor rehabilitation problems, and medical education, including anatomy and surgery.[4-8] Dentistry is another field where AR technology has been utilized successfully to improve diagnostic, therapeutic, and instructional results.[9] Various three-dimensional (3D) imaging technologies have been developed for analysis and surgical planning, including cone beam computed tomography, laser scanner, structured light scanner, and stereophotogrammetry, to capture dental, facial, and orofacial soft tissue and hard tissue data.[10] These technological advances in VR and AR have allowed the methods to be applied in dentistry.

Oral and maxillofacial surgery is the key application area in dentistry for VR and AR.[9] VR and AR are being used in oral and maxillofacial surgery for surgical planning, patient education, resident training, and surgical assistance.[11] VR/AR is used in orthognathic surgery, dental implantology, maxillofacial taruma, cancer resection and reconstruction of the maxillofacial region, resection and reconstruction of bone and soft tissue pathologies in maxillofacial region, repair of cleft lip and palate, transplantation of facial dermal grafts, in distraction osteogenesis, and visualization of alveolar nerve bundles in maxillofacial surgery.[12-20] It has been used in oral and maxillofacial surgery for pain and anxiety management through the creation of virtual environments that immerse people in a simulated World.[21] VR has also been used to improve the delivery and quality of education in dentistry and oral and maxillofacial surgery.[22,23] A review conducted in 2019 reveals that maxillofacial surgery is the primary application area of AR-based technologies compared to all other dental specialties.[11] However, the potential and use of VR and AR applications in oral and maxillofacial surgery are not well known. As far as the researcher is aware, there is no survey study in the literature regarding VR and AR applications in oral and maxillofacial surgery to determine the perspective of dentists or dentistry students. Dentistry students need to be aware of the areas of use of these new technologies in their future practices and specialty selection. This study aims to evaluate the knowledge and perception levels of trainee dentists at a faculty of dentistry regarding the use, advantages and disadvantages of VR and AR applications in oral and maxillofacial surgery. The study also evaluated whether the students' knowledge and perceptions on the subject differed in terms of gender and grade.

MATERIAL AND METHODS

STUDY DESIGN AND ETHICS

A descriptive, observational survey study was designed. Permission was received for the research from the administration of the Afyonkarahisar Health Sciences University (Afyonkarahisar, Türkiye) Faculty of Dentistry. The study was approved by Afyonkarahisar Health Sciences University, Clinical Research Ethics Committee (date: June 1, 2023; no: 2023/8) and was run by the principles of the Decla-

ration of Helsinki. Participation was completely voluntary and data collection was completely anonymous by design. All participants were given informed consent on the objective and scope of the study, and they were given the option to withdraw at any time.

STUDY POPULATION

The total sample size was calculated as 102 volunteers with the assumption of medium effect size, 0.05 error probability and 80% power (G*Power version 3.1.9.7 program, Heinrich-Heine University, Düsseldorf, Germany). In dentistry education, oral, dental and maxillofacial surgery courses start from the 3rd grade, and advanced surgical topics are mainly included in the 4th-5th grade curriculum. Only 4th-5th grade students were included in the study because they had sufficient maxillofacial surgery knowledge to answer the survey questions. The study aimed to reach the entire universe and within this scope, 148 students studying in the 4th grade (n=77) and 5th grade (n=71) were included.

DATA COLLECTION

A survey was designed following an extensive literature review regarding the utilization of VR and AR in oral and maxillofacial surgery. The survey included 47 questions aimed at measuring the knowledge and perception levels of the participants, and in addition to demographic data (age, gender), the survey consisted of three subsections:

1. In this section, the following questions were asked: Whether they have heard of the concepts of VR and AR, their awareness of the use of VR/AR in maxillofacial surgery, sources of information about VR/AR, branches of dentistry where VR/AR is/can be used the most, and requests to use VR/AR in the future and receive training on VR/AR. There were 9 questions in this section, and the answers to the questions were designed with 2 or more options.

2. Areas of utilization of VR/AR in oral and maxillofacial surgery: This section included 14 questions about the utilization of VR/AR in oral and maxillofacial surgery.

3. Advantages and disadvantages of VR/AR: There were 13 questions about the positive contributions of VR/AR to oral and maxillofacial surgery, and 12 questions about the difficulties and limitations in the use of VR/AR in oral and maxillofacial surgery.

The answers to the questions in the 2nd and 3rd sections are designed in a 5-point Likert-type format. The survey was pretested and developed on a sample of 20 dental participants. The surveys were administered face-to-face in December 2023. Participants were given 10 minutes to answer the surveys.

DATA ANALYSIS

All data were analyzed with IBM SPSS 27.0 software (SPSS Inc., Chicago, IL, USA). Cronbach's was calculated to assess the internal consistency of the questions in both the uses of VR/AR and the advantages and disadvantages of VR/AR sections of the survey (=0.85 and =0.73, respectively). The suitability of quantitative data for normal distribution was examined with the Kolmogorov-Smirnov test. Independent samples t-test was utilized to examine normally distributed data, while The Mann-Whitney U test was employed to compare non-normally distributed data. The chi-square test was used to assess the categorical data. For quantitative data, the analysis findings were displayed as mean±standard deviation, and for categorical data, as frequency (%). Statistical significance was attained when the p value was less than 0.05.

RESULTS

In total, 143 of 148 participants completed the survey (response rate 96.62). Three of the students did not participate in the survey at all, and the surveys of 2 students were deemed invalid because they did not answer more than half of the questions in the survey. Participants were 21-25 years old (mean age 23±0.89 years), 83 female and 60 male. 73 of the participants were 4th-grade students and 70 were 5th-grade students.

11.9% of the students reported that they had never heard of VR/AR concepts, and 31.5% did not know what these concepts were. 80.4% of the students reported that they did not have basic knowledge about VR/AR concepts, and 71.3% reported that they were not aware of the utilization of VR/AR in oral and maxillofacial surgery. However, 93% of the students stated that they wanted to receive training on

the utilization of VR/AR in oral and maxillofacial surgery and that they wanted to use these applications in oral and maxillofacial surgery practices in the future (Table 1).

Participants cited social media (29.79%), media (24.74%) and web browsing (21.96%) as the top 3 sources of information about VR/AR, respectively (Figure 1). Participants also stated that oral and maxillofacial surgery (26.11%), prosthetic dentistry (22.13%) and orthodontics (19.15%) are the top three branches of dentistry where VR/AR is/can be used the most (Figure 2).

The students' agreement rate with the statements regarding the uses of VR/AR in oral and maxillofacial surgery varied between 67.8-94.3%. Students stated that VR/AR can be used most frequently in head and neck anatomy training (94.3%) and oral and maxillofacial surgery training (92.3%), respectively. The statement that the students agreed with the least (67.8%) was "VR/AR can be used in salivary gland operations" (Table 2).

The students' agreement rate with the statements regarding the advantages of VR/AR in oral and maxillofacial surgery varied between 64.4%-92.9%. The statements that the students most agreed with were, respectively, "I think VR/AR applications will become widespread in maxillofacial surgery in the future" (92.9%) and "I think VR/AR applications will be used more in maxillofacial surgery training in the future" (90.6%) (Table 3).

The students' agreement rate with the statements regarding the disadvantages of using VR/AR in oral and maxillofacial surgery varied between 37.3-88.7%. The statements that students agreed with the most (88.79%) were "VR/AR technology requires expensive hardware" and "VR/AR requires a significant learning curve" The statement they agreed with the least (37.3%) was "VR/AR is insufficient to develop students' non-technical skills"(Table 4).

There was no significant difference between the student's total scale scores of the areas of utilization of VR/AR in oral and maxillofacial surgery, its advantages and disadvantages, in terms of grade and gender (Table 5).

DISCUSSION

To date, AR/VR is increasingly used in medicine, especially in surgical disciplines where minimally invasive approaches such as endo and laparoscopic surgery.[4] The intricate architecture of craniofacial structures necessitates meticulous

TABLE 1: Comparison of general knowledge and opinions about VR/AR between classes

	4th grade		5th grade		Total		
	Yes n (%)	No n (%)	Yes n (%)	No n (%)	Yes n (%)	No n (%)	p value
1. Have you heard of the concepts of VR/AR?	65 (89)	8 (11)	61 (87.1)	9 (12.9)	126 (88.1)	17 (11.9)	0.463
2. Do you know what the concepts of VR/AR?	50 (68.5)	23 (31.5)	48 (68.6)	22 (31.4)	98 (68.5)	45 (31.5)	0.568
3. Are you aware of the use of VR/AR in oral and maxillofacial surgery?	17 (23.3)	56 (76.7)	24 (34.3)	46 (65.7)	41 (%28.7)	102 (71.3)	0.102
4. Do you think you have basic knowledge about VR/AR technologies?	12 (16.4)	61 (83.6)	16 (22.9)	54 (77.1)	28 (19.6)	115 (80.4)	0.225
5. Would you like to benefit from VR/AR applications in maxillofacial surgery training?	68 (93.2)	5 (6.8)	66 (94.3)	4 (5.8)	134 (93.7)	9 (6.3)	0.527
6. Would you like to receive training on VR/AR applications in oral and maxillofacial surgery?	68 (93.2)	5 (6.8)	65 (92.9)	5 (7.1)	133 (93)	10 (7)	0.601
7. Would you like to use VR/AR applications in your oral and maxillofacial surgery practices?	67 (91.8)	6 (8.2)	66 (94.3)	4 (5.7)	133 (93)	10 (7)	0.399

VR: Virtual reality; AR: Augmented reality

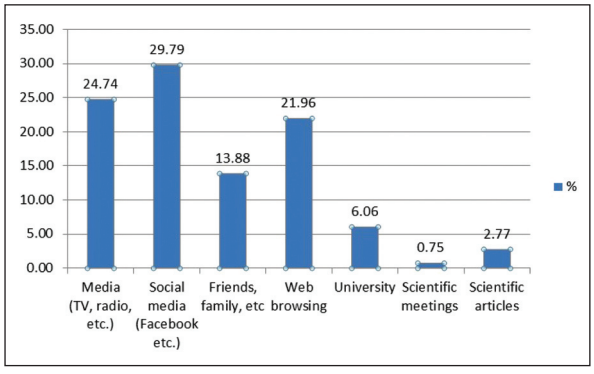

FIGURE 1: Distribution of students' VR/AR information sources

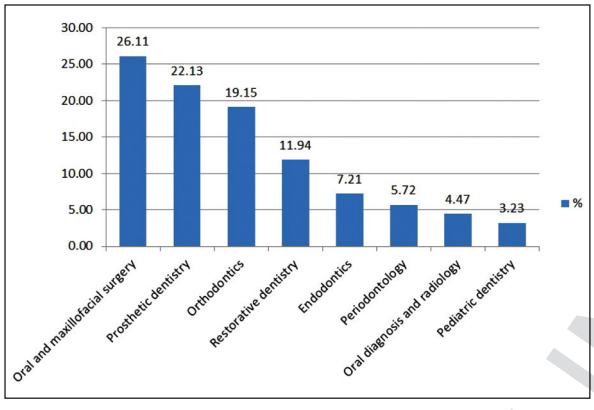

FIGURE 2: Departments of dentistry where VR/AR is most used/may be used

presurgical planning. VR and AR technologies are ideal for this purpose and align with the current minimally invasive philosophy of maxillofacial surgery.[24] However, the rate and prevalence of utilization of AR/VR technologies in oral and maxillofacial surgery are not fully known. This study, which evaluated, for the first time in the literature, the knowledge and awareness of dental students about VR/AR applications in oral and maxillofacial surgery, revealed that intern students did not know enough about these new technologies, but had a great interest in them.

Although 88.1% of the students in this study stated that they had heard of VR/AR concepts before, only 19.6% reported that they had basic knowledge about VR/AR technologies. 71.3% of the students reported that they were not aware of the utilization of VR/AR in oral and maxillofacial surgery. These findings revealed that the majority of students did not have sufficient knowledge about VR/AR technolo-

TABLE 2: Participants' knowledge levels regarding the use of VR/AR in oral and maxillofacial surgery

	I strongly disagree n (%)	I do not agree n (%)	I have no idea n (%)	I agree n (%)	I totally agree n (%)	X̄±SD
1. VR/AR can be used to position the maxilla and mandible during orthognathic surgery.	0 (0)	3 (2.1)	10 (7)	92 (64.3)	38 (26.6)	4.15±0.63
2. VR/AR can be used in dental implant positioning to determine implant size, position, orientation and proximity to vital structures.	0 (0)	1 (0.7)	10 (7)	93 (65)	39 (27.3)	4.18±0.58
3. VR/AR can be used in open reduction and internal fixation of maxillofacial fractures.	0 (0)	1 (0.7)	25 (17.5)	86 (60.1)	31 (21.7)	4.02±0.64
4. VR/AR can be used in maxillofacial region cancer resection and reconstruction.	0 (0)	4 (2.8)	28 (19.7)	82 (57.7)	28 (19.7)	3.94±0.71
5. VR/AR can be used in the resection and reconstruction of bone and soft tissue pathologies in the maxillofacial region.	0 (0)	5 (3.5)	16 (11.2)	94 (65.7)	28 (19.6)	4.01±0.67
6. VR/AR can be used in the repair of cleft lip and palate.	0 (0)	4 (2.8)	23 (16.1)	77 (53.8)	39 (27.3)	4.05±0.73
7. VR/AR can be used in TMJ surgery such as TMJ joint ankylosis.	0 (0)	4 (2.8)	22 (15.4)	79 (55.2)	38 (26.6)	4.05±0.73
8. VR/AR can be used in salivary gland operations.	0 (0)	8 (5.6)	38 (26.6)	73 (51)	24 (16.8)	3.79±0.78
9. VR/AR can be used in transplantation of facial dermal grafts.	0 (0)	6 (4.3)	25 (17.7)	81 (57.4)	29 (20.6)	3.94±0.74
10. VR/AR can be used for distractor positioning and guidance in distraction osteolysis.	1 (0.7)	2 (1.4)	12 (8.5)	95 (66.9)	32 (22.5)	4.09±0.65
11. VR/AR can be used to visualize alveolar nerve bundles in maxillofacial surgery.	0 (0)	5 (3.5)	18 (12.69	87 (60.8)	33 (23.1)	4.03±0.70
12. VR/AR can be used in head and neck area anatomy education.	1 (0.7)	1 (0.7)	6 (4.2)	81 (57)	53 (37.3)	4.29±0.65
13. Virtual simulations can be used in maxillofacial surgery training.	0 (0)	2 (1.4)	9 (6.3)	75 (52.4)	57 (39.9)	4.30±0.65
14. Virtual reality can be used to reduce patients' anxiety and pain related to the surgical procedure.	2 (1.4)	9 (6.3)	19 (13.3)	70 (49)	43 (30.1)	4±0.90

SD: Standard deviation; VR: Virtual reality; AR: Augmented reality; TMJ: Temporomandibular joint

TABLE 3: Advantages of using VR/AR in oral and maxillofacial surgery according to participants

	I strongly disagree n (%)	I do not agree n (%)	I have no idea n (%)	I agree n (%)	I totally agree n (%)	$\bar{X}$±SD
1. VR/AR can reduce the risk of complications by enabling a more accurate surgical procedure.	0 (0)	5 (3.5)	17 (11.9)	94 (65.7)	27 (18.9)	4±0.67
2. VR/AR can increase patient safety by ensuring a more accurate surgical procedure.	0 (0)	5 (3.5)	19 (13.3)	94 (65.7)	25 (17.5)	3.97±0.67
3. VR/AR can make the surgical procedure easier and shorten the procedure time.	0 (0)	5 (3.5)	15 (10.5)	94 (65.7)	29 (20.3)	4.02±0.67
4. VR/AR can improve the quality of surgical treatment and patient care.	0 (0)	3 (2.1)	18 (12.6)	93 (65)	29 (20.3)	4.03±0.64
5. VR/AR can improve the quality of oral and maxillofacial surgery training.	0 (0)	0 (0)	12 (8.5)	83 (58.5)	47 (33.1)	4.24±0.59
6. VR/AR can increase communication and interaction with the patient by bringing all patient-related data and patient monitoring parameters to the surgeon's eyes.	1 (0.7)	4 (2.8)	7 (4.9)	91 (63.6)	40 (289)	4.15±0.69
7. VR/AR can increase surgical visibility and access, especially in minimally invasive surgical procedures.	0 (0)	1 (0.7)	11 (7.7)	87 (60.8)	44 (30.8)	4.21±0.6
8. AR guidance systems provide real-time intraoperative information to the surgeon.	0 (0)	1 (0.7)	30 (21.1)	63 (44.4)	48 (33.8)	4.11±0.75
9. VR headsets can reduce patients' anxiety and pain during surgery due to maxillofacial surgery procedures.	0 (0)	13 (9.1)	38 (26.6)	62 (43.4)	30 (21)	3.76±0.88
10. VR/AR applications should be a part of undergraduate education.	1 (0.7)	16 (11.2)	28 (19.6)	51 (35.7)	47 (32.9)	3.88±1.01
11. VR/AR applications should be a part of specialist training in oral and maxillofacial surgery.	1 (0.7)	6 (4.3)	26 (18.4)	56 (39.7)	52 (36.9)	4.07±0.88
12. I think that VR/AR applications will expand in maxillofacial surgery in the future.	0 (0)	1 (0.7)	9 (6.3)	79 (55.6)	53 (37.3)	4.29±0.61
13. I think that VR/AR applications will be used more in maxillofacial surgery training in the future.	0 (0)	2 (1.4)	10 (7)	72 (49.3)	59 (41.3)	4.31±0.66

SD: Standard deviation; VR: Virtual reality; AR: Augmented reality

TABLE 4: Disadvantages of using VR/AR in oral and maxillofacial surgery according to participants

	I strongly disagree n (%)	I do not agree n (%)	I have no idea n (%)	I agree n (%)	I totally agree n (%)	$\bar{X}$±SD
1. VR/AR technology requires expensive hardware.	0 (0)	1 (0.7)	15 (10.6)	69 (48.6)	57 (40.1)	4.28±0.67
2. VR/AR requires a significant learning curve.	2 (1.4)	2 (1.4)	12 (8.5)	74 (52.1)	52 (36.6)	4.21±0.77
3. VR/AR requires a meticulous intraoperative reference and orientation process.	2 (1.4)	2 (1.4)	20 (14.2)	76 (53.9)	41 (29.1)	4.07±0.78
4. During the navigation process, an interrupted surgical procedure may occur due to blocked sensors.	0 (0)	2 (1.4)	49 (34.8)	68 (48.2)	22 (15.6)	3.78±0.71
5. Image recording in AR can be difficult to do correctly.	3 (2.1)	10 (7)	49 (34.5)	62 (43.7)	18 (12.7)	3.57±0.87
6. VR/AR is insufficient to develop students' non-technical skills.	5 (3.5)	22 (15.5)	62 (43.7)	43 (30.3)	10 (7)	3.21±0.91
7. VR headsets can be too cumbersome for both patient and practitioner.	5 (3.5)	21 (14.8)	54 (38)	48 (33.8)	14 (9.9)	3.31±0.96
8. The close proximity between the oral cavity and the support surface of virtual reality helmets may interfere with asepsis rules.	2 (1.4)	13 (9.2)	58 (40.8)	53 (37.3)	16 (11.3)	3.47±0.86
9. AR may cause the surgeon to lose their perception of reality.	4 (2.8)	21 (14.9)	41 (29.1)	62 (44.0)	13 (9.2)	3.41±0.94
10. In procedures performed with local anesthesia, it may be difficult to prevent patient movements during the operation.	3 (2.1)	14 (10)	40 (28.6)	69 (49.3)	14 (10)	3.55±0.88
11. VR glasses and headsets may make communication with the patient difficult.	3 (2.1)	18 (12.7)	29 (20.4)	75 (52.8)	17 (12)	3.59±0.93
12. There are ethical and legal challenges regarding confidentiality of patient information and patient privacy.	3 (2.1)	15 (10.6)	39 (27.5)	56 (39.4)	29 (20.4)	3.65±0.98

SD: Standard deviation; VR: Virtual reality; AR: Augmented reality

TABLE 5: Distribution of participants' scale scores by class and gender

	n	%	Useage areas X̄±SD	p value	Advantages X̄±SD	p value	Disadvantages X̄±SD	p value	Total X̄±SD	p value
Class										
4th class	73	51	56.3±5.9	0.339	53.2±4.7	0.679	44.7±7.9	0.083	154.2±12.8	0.552
5th class	70	49	57.3±6.8		52.8±6.4		42.7±5.4		152.8±14.8	
Gender										
Male	60	42	57.7±6.7	0.143	53.0±5.8	0.976	43.7±5.7	0.988	154.4±13.7	0.494
Female	83	58	56.1±6.0		52.9±5.5		43.7±7.6		152.8±13.9	

SD: Standard deviation

gies and their use in oral and maxillofacial surgery. It is seen that more than half of the students' information sources regarding VR/AR consist of internet-based information such as social media, media and web browsing. University, scientific meetings and articles constitute only approximately 10% of the information sources. Some of the information sourced from the internet may be inaccurate, biased or exaggerated due to content such as advertisements, promotions, etc. In recent years, the accuracy and reliability of internet-based information have been frequently questioned. This study revealed that intern dentistry students need accurate, reliable academic-level information sources about VR/AR technologies and their use in maxillofacial surgery.

The oral and maxillofacial areas comprise several surgically and anatomically essential structures, including major nerves and vessels. AR/VR applications have many potential uses for oral and maxillofacial surgery procedures that require precise planning and a minimally invasive approach. In this study, students showed oral and maxillofacial surgery as the branch of dentistry where VR/AR technologies are or can be used most, in line with the literature.[9]

In particular, areas such as head and neck anatomy training and maxillofacial surgery training were shown in this study as the areas where VR/AR technologies can be used the most. Traditional anatomy education frequently needs the use of an atlas and cadaver, which takes a lot of time and effort.[25] Especially in cases where cadavers are insufficient, AR allows the person to visualize his or her own body by presenting live anatomy and offers advantages such as including digital ultrasound or tomography images in these images.[26] VR has improved the delivery and quality of instruction in dentistry and oral and maxillofacial surgery.[23] With VR/AR simulations such as virtual apiectomy, tactile digital cephalometric analysis students performed surgical procedures in a realistic manner with immersive reality elements such as touch, pressure perception, cutting, drilling, and also had the opportunity to evaluate their own performance.[27,28]

The primary applications of VR are implantology and orthognathic surgery.[9] VR has found extensive application in the fields of implant dentistry and implant education.[29] VR can provide a relaxing preoperative environment for patients and can also be used during surgery to reduce stress and anxiety in local procedures.[30] In this study, more than 90% of the students stated that, in line with the literature, apart from surgery and anatomy education, AR/VR can be used in dental implant positioning and positioning the maxilla and mandible in orthognathic surgery. This was followed by the following surgical procedures: distractor positioning and guidance in distraction osteogenesis (89.4%), resection and reconstruction of bone and soft tissue pathologies in the maxillofacial region (85.3%), visualization of alveolar nerve bundles (83.9%) temporomandibular joint (TMJ) surgery such as TMJ joint

ankylosis (81.8%), open reduction and internal fixation of maxillofacial fractures (81.8%), repair of cleft lip and palate (81.1%), reduce patients' anxiety and pain related to the surgical procedure (79.1%), transplantation of facial dermal grafts (78%), maxillofacial region cancer resection and reconstruction (77.4%) and salivary gland operations (67.8%). As can be seen, the majority of students in this study agreed that VR/AR technologies can be applied in a wide variety of oral and maxillofacial surgery procedures.

Digital applications such as 3D imaging as well as computer-aided design and manufacturing are widely employed in all dental specialties.[31] Today, computer simulations show great potential and stimulate increasing interest.[32] Virtual simulation applications provide additional information to the real environment and thus open new opportunities in clinical operational and training.[9,33] In this study, 91.6% of the students stated that VR/AR can increase surgical visibility and access, especially in minimally invasive surgical procedures. More than 80% of students stated that VR/AR can reduce the risk of complications by providing a more accurate surgical procedure, increase patient safety, and raise the standard of patient care and surgical treatment given to patients. More than 90% of the students stated that they thought that VR/AR could improve the quality of oral and maxillofacial surgery training, and therefore, VR/AR applications would be used more in maxillofacial surgery training in the future. Indeed, surgeons can lower risks and increase their chances of successful outcomes with intraoperative navigation. Since VR/AR offers significant opportunities for residency training, its integration into the curriculum will undoubtedly open new horizons for the development of these programs.[34]

Routine use of VR/AR technologies has not been possible due to the associated prohibitive cost factor and time-consuming learning curve. Moreover, there is a need to improve image quality for surgical procedures.[35] Current technological advancements demonstrate the potential to enhance clinical practice; however, significant progress is still required to achieve a fully integrated surgical experience.[34] In this study, the advantages of VR/AR applications as well as some difficulties and limitations in the use of these technologies were evaluated. In this study, 88.7% of the students stated that VR/AR technologies require expensive hardware and a significant learning process. More than 50% of the students stated that image registration in AR may be difficult to perform accurately and if any sensors are obstructed during the navigation process, the surgical operation might have to be stopped. More than half of the students also stated that VR glasses and helmets could be too cumbersome for both the patient and the practitioner, and that the close proximity between the oral cavity and the support surface could interfere with the rules of asepsis. 37.3% of the students stated that VR/AR may be insufficient to develop students' non-technical skills, and 53.2% stated that AR may cause the surgeon to lose their perception of reality. Finally, 59.8% of the students stated that there were ethical and legal difficulties regarding the confidentiality of patient information and patient privacy. In this study, no significant difference was observed between the students' knowledge and opinions regarding the use of VR'AR technologies in oral and maxillofacial surgery, their advantages and disadvantages, in terms of grade and gender.

This study has some limitations. This survey was conducted only on 4th-5th-grade intern students studying at a university in Türkiye. Even though they have similar educational curricula, the results cannot be generalized to the whole country. Multi-center, national-scale studies with larger sample sizes should be designed to evaluate the knowledge and attitudes of intern students studying at dentistry faculties in Türkiye regarding the use of VR and AR in maxillofacial surgery. Besides this, the answers given to the questions are limited to survey questions due to methodology; background questions about VR/AR applications were not asked. However, this is the first survey study in the literature to evaluate the use of VR/AR in oral and maxillofacial surgery.

CONCLUSION

Study findings revealed that although dental students did not have basic knowledge about VR/AR technologies, they were very willing to learn and apply these technologies. Students stated that VR/AR applications can be applied mostly in oral and maxillofacial surgery training, dental implantology and

orthognathic surgery. They showed a positive attitude towards these technologies, thinking that the advantages of VR/AR systems outweigh their disadvantages. They stated that these new technologies can be used in many oral and maxillofacial surgical procedures and will become more widespread in the future. However, it was seen that students needed academic-level information resources and training on VR/AR technologies and their applications in oral surgery. Students should be prepared for the future by providing undergraduate and postgraduate training on VR/AR technologies and their applications in oral and maxillofacial surgery.

Acknowledgments

The authors would like to thank all the dental students for their participation in this study.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

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

This study is entirely author's own work and no other author contribution.

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