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Research / Araştırma Makalesi

Knowledge and Attitudes of Undergraduate Dental Students Toward Conventional and Digital Workflows in Maxillofacial Prosthetics: A Cross-Sectional Survey

Diş Hekimliği Lisans Öğrencilerinin Maksillofasiyal Protez Alanında Geleneksel ve Dijital İş Akışlarına İlişkin Bilgi ve Tutumları: Kesitsel Bir Anket Çalışması

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ABSTRACT

Background: Digital technologies are increasingly transforming the field of maxillofacial prosthetics; however, the extent to which undergraduate dental education has adapted to these developments remains unclear. Evaluating dental students' knowledge and attitudes toward conventional and digital workflows is essential for identifying potential educational gaps.

Methods: A cross-sectional questionnaire-based survey was conducted among 201 undergraduate dental students (99 fourth-year and 102 fifth-year) receiving clinical prosthodontic training. Data were collected using a 24-item structured questionnaire distributed online. Knowledge and attitudes were assessed using a 12-item Likert-type scale. Descriptive statistics were calculated, and comparisons between groups were performed using the Mann–Whitney U test and Chi-square test, where appropriate (α=0.05).

Results: Fourth-year students demonstrated significantly higher total knowledge and attitude scores than fifth-year students (p=0.012). They also reported greater clinical exposure to maxillofacial cases and higher involvement in impression procedures (p=0.018 and p=0.036). Conversely, fifth-year students showed significantly higher self-reported knowledge regarding the operating principles of digital scanners (p=0.002). Fourth-year students expressed stronger confidence in the accuracy and time-saving advantages of digital technologies (p<0.001 and p=0.001). Despite positive attitudes toward digitalization, awareness of specialized digital software such as craniofacial CAD and digital imaging platforms remained low among both groups.

Conclusions: Although dental students demonstrate positive attitudes toward digital technologies in maxillofacial prosthetics, gaps remain between theoretical awareness and practical knowledge. Integrating structured digital workflow training into undergraduate dental curricula may help improve clinical competence and better prepare future clinicians for digitally driven maxillofacial rehabilitation.

Keywords: Maxillofacial prosthetics, Digital dentistry, Dental education, Dental students, Digital workflow

ÖZ

Giriş: Dijital teknolojiler, maksillofasiyal protez alanını giderek daha fazla dönüştürmektedir; ancak, lisans düzeyindeki diş hekimliği eğitiminin bu gelişmelere ne ölçüde uyum sağladığı hâlâ belirsizdir. Diş hekimliği öğrencilerinin geleneksel ve dijital iş akışlarına ilişkin bilgi ve tutumlarını değerlendirmek, olası eğitim eksikliklerini tespit etmek açısından büyük önem taşımaktadır.

Yöntem: Klinik protez eğitimi alan 201 diş hekimliği lisans öğrencisi (99 dördüncü sınıf ve 102 beşinci sınıf) arasında kesitsel, anket temelli bir araştırma gerçekleştirilmiştir. Veriler, çevrimiçi olarak dağıtılan 24 maddelik yapılandırılmış bir anket kullanılarak toplanmıştır. Bilgi ve tutumlar, 12 maddelik Likert tipi bir ölçek kullanılarak değerlendirilmiştir. Tanımlayıcı istatistikler hesaplanmış ve gruplar arası karşılaştırmalar, uygun olduğu durumlarda Mann–Whitney U testi ve Ki-kare testi kullanılarak yapılmıştır (α=0,05).

Bulgular: Dördüncü sınıf öğrencileri, beşinci sınıf öğrencilerine kıyasla toplam bilgi ve tutum puanlarında istatistiksel olarak anlamlı derecede daha yüksek değerler sergilemiştir (p=0,012). Ayrıca, çene-yüz vakalarına daha fazla klinik maruz kalma ve kalıp alma işlemlerine daha fazla katılım bildirdiler (p=0,018 ve p=0,036). Buna karşılık, beşinci sınıf öğrencileri dijital tarayıcıların çalışma prensipleri konusunda kendileri tarafından bildirilen bilgi düzeyinde istatistiksel olarak anlamlı derecede daha yüksek sonuçlar sergilemiştir (p=0,002). Dördüncü sınıf öğrencileri ise dijital teknolojilerin doğruluğuna ve zaman tasarrufu sağlayan avantajlarına daha fazla güven duyduklarını ifade etmiştir (p<0,001 ve p=0,001). Dijitalleşmeye yönelik olumlu tutumlara rağmen, kraniyofasiyal CAD ve dijital görüntüleme platformları gibi özel dijital yazılımlar konusundaki farkındalık her iki grupta da düşük kalmıştır.

Sonuçlar: Diş hekimliği öğrencileri, maksillofasiyal protez alanında dijital teknolojilere karşı olumlu tutumlar sergilese de, teorik farkındalık ile pratik bilgi arasında boşluklar devam etmektedir. Yapılandırılmış dijital iş akışı eğitimini lisans düzeyindeki diş hekimliği müfredatına entegre etmek, klinik yeterliliği artırmaya ve gelecekteki klinisyenleri dijital odaklı maksillofasiyal rehabilitasyona daha iyi hazırlamaya yardımcı olabilir.

Anahtar Kelimeler: Maksillofasiyal protez, Dijital diş hekimliği, Diş hekimliği eğitimi, Diş hekimliği öğrencileri, Dijital iş akışı

INTRODUCTION

Maxillofacial prosthetics, a specialized field within prosthodontics, focuses on the functional and esthetic rehabilitation of individuals affected by congenital or acquired defects of the craniofacial and stomatognathic regions. These defects may arise from developmental anomalies, oncologic resections, traumatic injuries, or infectious diseases.[1,2] Rehabilitation following surgical loss of craniofacial tissues plays a critical role not only in restoring functional abilities but also in improving patients' psychological well-being and overall quality of life.[3] Successful outcomes in maxillofacial rehabilitation typically require a multidisciplinary approach that integrates the expertise of dental professionals, speech and language therapists, and mental health specialists working collaboratively throughout the treatment process.[1,4]

Conventionally, the fabrication of maxillofacial prostheses has relied on impressions obtained using conventional dental impression materials. However, conventional impression methods may not accurately capture soft-tissue morphology, as material weight, undercut engagement, and removal forces can influence tissue position, leading to discomfort and reduced precision, particularly in large or retentive facial defects.[5,6] In contrast, modern digital data acquisition techniques such as structured-light scanning, stereophotogrammetry, laser scanning, intraoral scanning, computed tomography/cone-beam computed tomography (CT/CBCT), and

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smartphone-based photogrammetry allow non-contact recording of facial structures, minimizing soft-tissue distortion while providing more consistent surface reproduction and improved patient comfort.[7,8]

Beyond data acquisition, the fabrication phase of maxillofacial prostheses has also undergone considerable technological transformation.[9] Conventional prosthesis production traditionally relies on manual sculpting, wax modeling, flasking procedures, and multiple clinical adjustments, which are highly operator-dependent and time-consuming. In contrast, digital workflows incorporating computer-aided design and computer-aided manufacturing (CAD/CAM) technologies enable virtual prosthesis design, standardized reproduction, and improved communication between clinicians and dental laboratories.[10,11] Additive manufacturing techniques, including three-dimensional printing, have further expanded the possibilities for personalized prosthetic rehabilitation by enhancing reproducibility, reducing fabrication time, and facilitating digital archiving of patient data. These developments reflect a gradual transition from conventional manual fabrication methods toward digitally guided maxillofacial prosthetic rehabilitation.[12-15] Consequently, facial scanning systems and digital design platforms for maxillofacial prosthesis fabrication have increasingly been introduced into clinical dental practice.[16,17]

Despite these technological advancements and their growing integration into clinical practice, the extent to which undergraduate dental education has adapted to these developments remains uncertain. Recent research has highlighted that although students in their clinical years may demonstrate a foundational understanding of digital systems, their actual clinical exposure and active involvement in advanced procedures often remain limited, frequently due to constraints in equipment availability, funding, or curriculum time.[18,19] Furthermore, professional surveys suggest that a majority of practitioners believe current training programs do not yet provide adequate education in these evolving technologies.[20,21] Evaluating the awareness and attitudes of students throughout different stages of their training is therefore crucial for identifying educational gaps and ensuring that future dental professionals are adequately prepared for the inevitable digital future of multidisciplinary head and neck care.[19,21,22]

Therefore, the aim of this study was to evaluate and compare the knowledge and attitudes of fourth- and fifth-year undergraduate dental students regarding conventional and digital workflows in maxillofacial prosthetics. The null hypothesis was that there would be no statistically significant difference in the total knowledge and attitude scores between fourth- and fifth-year students.

MATERIALS AND METHODS

The study protocol was reviewed and approved by the Hacettepe University Research Ethics Committee (Decision No: SBA 25/1042). All procedures were conducted in accordance with the principles of the Declaration of Helsinki. Participation was entirely voluntary, and electronic informed consent was obtained from all participants prior to data collection. No financial, academic, or other incentives were provided.

The study population comprised fourth- and fifth-year undergraduate dental students who were receiving advanced theoretical and clinical education in prosthodontics. A total of 201 students participated in the study, including 99 fourth-year students and 102 fifth-year students. The sample consisted of 131 females and 70 males. All participants were actively enrolled during the study period and met the inclusion criteria.

Data Collection

Data were collected using a self-administered, anonymous online questionnaire consisting of 24 structured items, developed and distributed via Google Forms. The questionnaire was developed based on a review of the relevant literature.[21,23,24]

The survey consisted of the following sections:

1. Demographic characteristics (gender and academic year)
2. Clinical exposure to maxillofacial prosthetic cases
3. Knowledge and attitudes toward digital workflows
4. Knowledge and attitudes toward conventional workflows
5. Professional awareness and clinical decision-making
6. Awareness of digital software and imaging technologies

Knowledge and attitudes were assessed using a 12-item Likert-type scale, based on participants' level of agreement with declarative statements, rated on a 5-point scale (1 = strongly disagree to 5 = strongly agree). The total score ranged from 12 to 60, with higher scores indicating greater knowledge and more positive attitudes toward maxillofacial prosthetics and digital workflows. Except for three questions that allowed multiple responses, all remaining items were designed as single-response multiple-choice questions.

Statistical Analysis

All statistical analyses were performed using IBM SPSS Statistics for Windows, Version 21.0 (IBM Corp., Armonk, NY, USA). The internal consistency of the Likert-scale items was evaluated using Cronbach's alpha coefficient (α=0.72), indicating acceptable reliability for the 12-item scale assessing knowledge and attitudes toward maxillofacial prosthetics. Descriptive statistics were presented as frequencies and percentages for categorical variables. For ordinal data, including individual Likert-scale items and total knowledge and attitude scores, results were summarized using median (minimum–maximum) as well as mean ± standard deviation.

Given the ordinal nature of the Likert-scale data and the non-normal distribution of scores, the Mann–Whitney U test was used to compare knowledge and attitude scores between fourth- and fifth-year students. Where applicable, the Kruskal–Wallis test was employed for comparisons involving more than two groups. Associations between categorical variables, such as demographic characteristics and clinical exposure, were analyzed using Pearson's Chi-square test or Fisher's Exact test, as appropriate.

To facilitate interpretation and visualization of response patterns, the original 5-point Likert-scale responses were recoded into a 3-point scale (Disagree, Neutral, Agree) and presented using frequency percentage bar charts. A p-value < 0.05 was considered statistically significant for all analyses.

A post-hoc power analysis was conducted using G*Power software (version 3.1) based on the final sample sizes (4th year: n = 99; 5th year: n = 102). The analysis demonstrated a statistical power of 96.4% to detect a medium effect size (Cohen's d = 0.5) at a significance level of $\alpha = 0.05$, confirming that the sample size was sufficient to identify statistically significant differences between the groups.

RESULTS

Comparison of descriptive characteristics, clinical experiences, and technical awareness regarding maxillofacial prosthetics by academic year are presented in **Table 1**. No statistically significant differences were found between fourth- and fifth-year students in terms of gender distribution ($p = 0.137$) or prior attendance at maxillofacial prosthetics courses ($p = 0.136$), with approximately 45% of students reporting no prior supplementary training.

Table 1. Comparison of descriptive characteristics, clinical experiences, and technical awareness regarding maxillofacial prosthetics by academic year.

Variable	Response	4th Year n (%)	5th Year n (%)	p-value*
Gender	Female	59 (59.6%)	72 (70.6%)	0.137
	Male	40 (40.4%)	30 (29.4%)	
Q3. Have you taken a course/seminar on maxillofacial prosthetics?	No	49 (49.5%)	42 (41.2%)	0.136
	Partially	26 (26.3%)	22 (21.6%)	
	Yes	24 (24.2%)	38 (37.3%)	
Q4. Have you observed a real maxillofacial case in the clinic?	No	73 (73.7%)	91 (89.2%)	**0.018**
	Yes	19 (19.2%)	8 (7.8%)	
	Unsure	7 (7.1%)	3 (2.9%)	
Q5. Have you been involved in the impression process?	No, never involved	71 (72.4%)	88 (87.1%)	**0.036**
	Yes, conventional	15 (15.3%)	4 (4.0%)	
	Both	8 (8.2%)	6 (5.9%)	
	Yes, digital	4 (4.1%)	3 (3.0%)	
Q7. Self-reported knowledge of digital scanner working principles	Very Low / None	20 (20.2%)	6 (5.9%)	**0.002**
	Low	51 (51.5%)	44 (43.1%)	
	Moderate	22 (22.2%)	40 (39.2%)	
	High / Very High	6 (6.1%)	12 (11.7%)	
Q16. Do you have knowledge about maxillofacial prosthetic materials?	No	53 (53.5%)	56 (54.9%)	0.193
	Partially	33 (33.3%)	40 (39.2%)	
	Yes	13 (13.1%)	6 (5.9%)	
Q20. Approach to patient management if a case presents	Referral Only	47 (47.5%)	62 (60.8%)	0.080
	Active Management	52 (52.5%)	40 (39.2%)	
Q21. Awareness of craniofacial CAD software	None	67 (67.7%)	68 (66.7%)	0.998
	At least one	32 (32.3%)	34 (33.3%)	
Q22. Which technique provides more accurate/detailed impressions?	Digital Face Scan	42 (42.4%)	34 (33.3%)	0.193
	Conventional Impression	3 (3.0%)	10 (9.8%)	
	Both	37 (37.4%)	39 (38.2%)	
	Unsure	17 (17.2%)	19 (18.6%)	
Q23. Is silicone 3D printing feasible?	Unsure	56 (57.1%)	50 (49.0%)	0.278
	Yes	41 (41.8%)	52 (51.0%)	
	No	1 (1.0%)	0 (0.0%)	
Q24. Awareness of digital imaging software	None	76 (76.8%)	70 (68.6%)	0.256
	At least one	23 (23.2%)	32 (31.4%)	

** Data were analyzed using the Chi-square test or Fisher's Exact test, where appropriate. Statistically significant values (p < 0.05) are indicated in bold.*

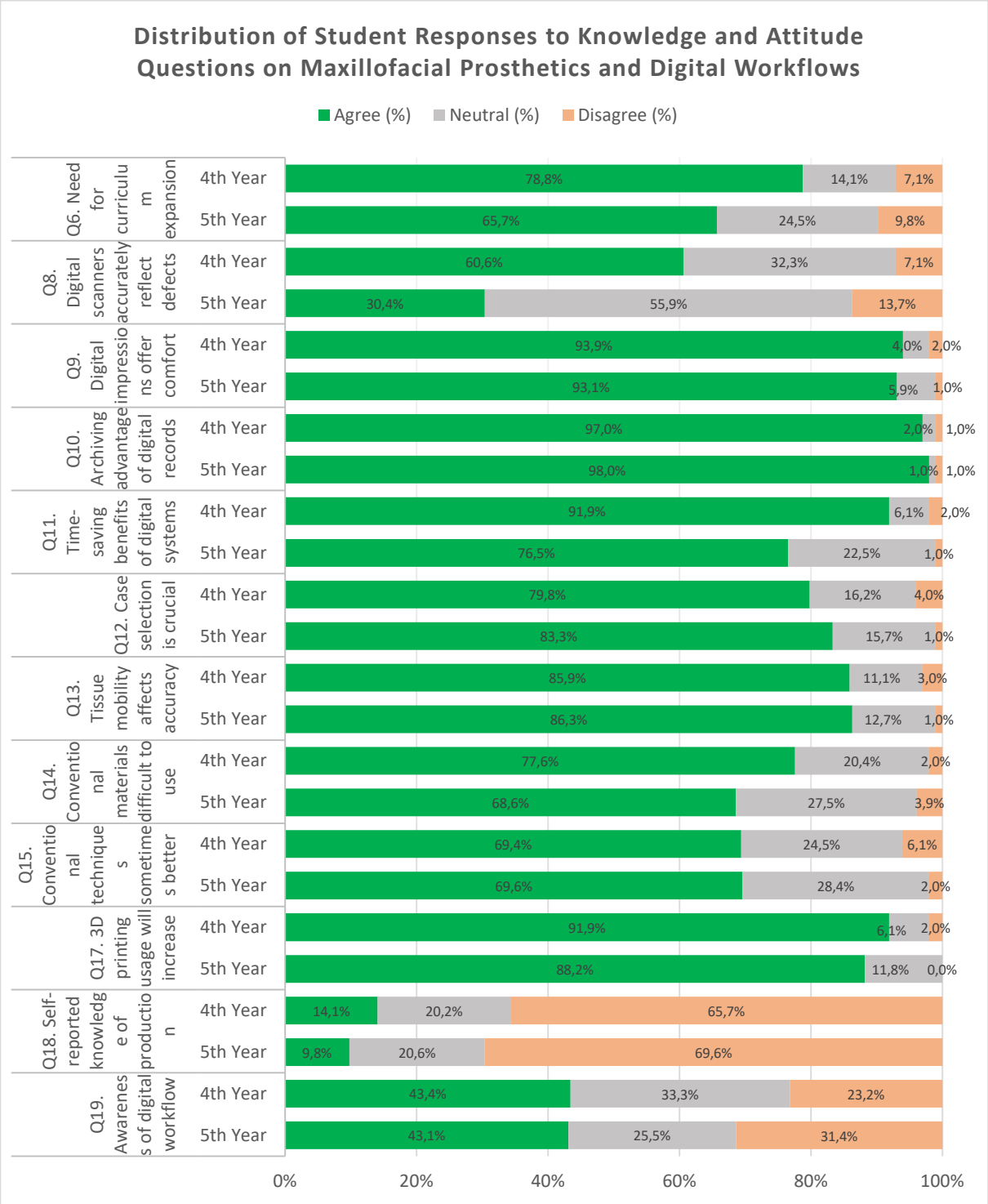
Fourth-year students reported significantly higher clinical exposure than fifth-year students; 19.2% had observed a real maxillofacial case compared to 7.8% of fifth-year students (p = 0.018). Similarly, participation in impression procedures was more common among fourth-year students (27.6%) than fifth-year students (12.9%) (p = 0.036).

In contrast, fifth-year students demonstrated significantly higher self-reported knowledge of digital scanner operating principles (p = 0.002), with 50.9% reporting moderate or higher knowledge compared to 28.3% of fourth-year students. However, awareness of specific digital workflows remained low in both groups, with most students reporting no familiarity with craniofacial CAD software (67.2%) (p = 0.998) or digital imaging software (72.6%) (p = 0.256). No significant difference was observed in knowledge of prosthetic materials (p = 0.193).

Regarding patient management approaches, no statistically significant difference was found (p = 0.080), although referral tendency was higher among fifth-year students (60.8%) compared to fourth-year students (47.5%).

Table 2 details the percentage distribution of participants' responses, highlighting the divergent perspectives between 4th and 5th-year dental students.

Table 2. Distribution of student responses to knowledge and attitude questions on maxillofacial prosthetics and digital workflows.



** The categories "Strongly Disagree" and "Disagree" were merged into Disagree, while "Strongly Agree" and "Agree" were merged into Agree.*

As shown in **Table 3**, fourth-year students expressed a significantly greater need for increased theoretical and practical education in maxillofacial prosthetics (Q6, $p = 0.021$). They also reported higher confidence in the accuracy (Q8, $p < 0.001$) and time efficiency (Q11, $p = 0.001$) of digital systems. Additionally, fourth-year students perceived conventional impression procedures as more challenging (Q14, $p = 0.049$).

No significant differences were found between groups regarding patient comfort with digital impressions ($p = 0.386$), advantages of digital archiving ($p = 0.505$), limitations of digital techniques ($p = 0.594$), or the suitability of conventional methods in certain cases ($p = 0.805$). Both groups showed similar perspectives on future increases in 3D printing applications ($p = 0.418$).

Self-reported knowledge of production phases ($p = 0.340$) and CAD-3D printing workflows ($p = 0.410$) remained moderate to low in both groups. The total knowledge and attitude score was significantly higher among fourth-year students ($p = 0.012$).

Table 3. Comparison of self-reported knowledge and attitude scores regarding maxillofacial prosthetics and digital workflows between 4th and 5th year students.

Variable / Item	4th Year (n=99)		5th Year (n=102)		p-value*
	Mean ± SD	Median (Min-Max)	Mean ± SD	Median (Min-Max)	
Q6. Need for curriculum expansion	3.9 ± 1.0	4 (1-5)	3.7 ± 0.9	4 (1-5)	**0.021**
Q8. Digital scanners accurately reflect defects	3.6 ± 0.8	4 (1-5)	3.2 ± 0.7	3 (1-5)	**<0.001**
Q9. Digital impressions offer comfort	4.4 ± 0.7	4 (2-5)	4.3 ± 0.7	4 (1-5)	0.386
Q10. Archiving advantage of digital records	4.6 ± 0.6	5 (1-5)	4.6 ± 0.6	5 (1-5)	0.505
Q11. Time-saving benefits of digital systems	4.5 ± 0.7	5 (2-5)	4.1 ± 0.8	4 (2-5)	**0.001**
Q12. Case selection is crucial	4.0 ± 0.8	4 (1-5)	4.1 ± 0.7	4 (1-5)	0.594
Q13. Tissue mobility affects accuracy	4.2 ± 0.8	4 (1-5)	4.1 ± 0.7	4 (1-5)	0.788
Q14. Conventional materials difficult to use	4.1 ± 0.8	4 (2-5)	3.8 ± 0.8	4 (1-5)	**0.049**
Q15. Conventional techniques sometimes better	3.8 ± 0.8	4 (1-5)	3.8 ± 0.7	4 (2-5)	0.805
Q17. 3D printing usage will increase	4.2 ± 0.7	4 (1-5)	4.2 ± 0.6	4 (3-5)	0.418
Q18. Self-reported knowledge of production*	3.8 ± 1.0	4 (2-5)	3.8 ± 0.9	4 (2-5)	0.340
Q19. Awareness of digital workflow	3.2 ± 0.9	3 (1-5)	3.1 ± 1.0	3 (1-5)	0.410
TOTAL KNOWLEDGE & ATTITUDE SCORE	**48.3 ± 4.5**	**48 (29-57)**	**46.9 ± 4.3**	**47 (23-55)**	**0.012**

* Data were compared using the Mann-Whitney U test. Total score range is 12-60. Q18 was reverse-scored to ensure scale consistency. Statistically significant values ($p < 0.05$) are indicated in **bold.**

DISCUSSION

The present study aimed to evaluate and compare the knowledge levels and attitudes of fourth- and fifth-year dental students toward conventional and digital workflows in maxillofacial prosthetics. The null hypothesis was rejected, as fourth-year students demonstrated significantly higher total knowledge and attitude scores than fifth-year students. This finding suggests that early academic exposure may foster technological optimism, which appears to evolve into a more cautious and clinically grounded perspective in later years.

A key finding was the discrepancy between clinical exposure and technical knowledge. Fourth-year students reported greater clinical exposure to maxillofacial prosthetic cases and higher involvement in impression procedures, whereas fifth-year students showed better understanding of digital scanner principles. This pattern may reflect differences in curriculum structure, where early exposure occurs during specific prosthodontic rotations, while final-year students prioritize general clinical requirements, limiting their involvement in specialized areas. Similar observations have been reported by Gad et al., who noted that broader clinical experience does not necessarily translate into proficiency in advanced digital workflows.[18]

Regarding technological perceptions, fourth-year students showed a substantially higher degree of trust in the accuracy of digital scanners and were more convinced of the time-saving benefits of digital systems compared to fifth-year students. While digital technologies such as CT scanning, intraoral scanners, and rapid prototyping are recognized in the literature for improving the reproduction of form and texture in prostheses, senior students in this study reported a higher level of comfort with conventional materials.[6,9,14] This cautious attitude among fifth-year students may stem from a burgeoning recognition of clinical limitations, such as the challenges posed by tissue mobility in conventional impressions and the necessity for careful case selection, a consensus shared by both cohorts in this study.

Despite the enthusiasm for digitalization, general awareness of specialized software remained alarmingly low across the entire cohort. The majority of students reported no familiarity with craniofacial CAD (67.2%) or digital imaging software (72.6%). This is consistent with global trends; for instance, Wolfaardt et al. highlighted that although advanced digital technologies (ADT) are central to the future of the field, formal education and clinical competency requirements remain underdeveloped.[20,21] These findings, together with the strong demand for curriculum expansion, highlight the need for enhanced digital training in undergraduate programs.[20]

Although the topic differs, similar educational gaps have been reported in studies evaluating dental students' awareness of oral cancer in Türkiye, highlighting the broader need for standardized curricula addressing emerging clinical competencies.[22] Furthermore, the interest in 3D printing was high in both groups, with a shared belief that its application will inevitably increase. This mirrors the work of Ketharinath et al., who concluded that adding digital dentistry to the curriculum is essential for the future development of prosthodontics, providing higher treatment accuracy and reduced patient discomfort.[19]

From an educational perspective, early and continuous exposure to digital workflows, including facial scanning, CAD design, and additive manufacturing, may help bridge the gap between theoretical awareness and clinical competence. In this context, dental curricula should be revised to position students not merely as passive end users of technology, but as professionals capable of managing digital workflows, material selection, and quality control processes.[20] Furthermore, a structured curriculum framework should be developed for maxillofacial prosthetics, aligned with international standards and incorporating competencies in advanced digital technologies.[22] Finally, the high proportion of students requesting additional training underscores the necessity of integrating digital dentistry not only as theoretical content but also as hands-on modules embedded within both preclinical and clinical training phases.[18]

However, this study has several limitations. The reliance on a cross-sectional survey at a single institution may limit the generalizability of the findings.[19,25] Future multicenter studies are required to provide a broader perspective on the impact of digital workflows on student education.[23] Additionally, the subjective nature of self-reported knowledge points toward the need for objective clinical assessments in future research.[9] Expanding digital training opportunities within dental curricula may play a key role in preparing future clinicians for the rapidly evolving digital landscape of maxillofacial prosthetic rehabilitation.

CONCLUSION

Within the limitations of this study, it was concluded that fourth-year dental students demonstrated higher overall knowledge and attitude scores toward digital and conventional workflows in maxillofacial prosthetics compared with fifth-year students. Despite generally positive attitudes toward digital technologies, awareness of specialized digital software and production workflows remained limited among both groups. While undergraduate students possess a visionary outlook on digital maxillofacial prosthetics, there is a clear need to support this interest with structured hands-on training to facilitate their transition into modern clinical practice.

Değerlendirme / Peer-Review

İki Dış Hakem / Çift Taraflı Körleme

Etik Beyan / Ethical statement

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It is declared that during the preparation process of this study, scientific and ethical principles were followed and all the studies benefited are stated in the bibliography.

Benzerlik Taraması / Similarity scan

Yapıldı - ithenticate

Etik Bildirim / Ethical statement

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Çıkar Çatışması / Conflict of Interest

Yazarlar çıkar çatışması bildirmemiştir. | The authors have no conflict of interest to declare.

Yazar Katkıları / Author Contributions

Çalışmanın Tasarlanması | Design of Study: İSY (%30), AÖ (%20), ABKG (%20), DŞH (%30)
Veri Toplanması | Data Acquisition: İSY (%40), AÖ (%30), AD (%30)
Veri Analizi | Data Analysis: İSY (%50), DŞH (%50)
Makalenin Yazımı | Writing up: İSY (%50), AÖ (%20), ABKG (%15), DŞH (%15)
Makale Gönderimi ve Revizyonu | Submission and Revision: İSY (%50), AÖ (%20), ABKG (%15), DŞH (%15)

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