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Conventional vs. Digital Dental Impression:
Practitioner and Patient Perspectives

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ABSTRACT

Dental impressions are an important part of routine diagnostic and therapeutic dental procedures. Using conventional impression materials, the dentist captures intraoral details, and the dental technician uses impression for dental casts pouring. Intraoral scanners (IOS) are fast, accurate, and more pleasant for a patient than conventional impression techniques and became a valid alternative to those procedures. Thirty-four dental students performed alginate and digital impressions on each other and filled two 2-part questionnaires to reveal their preferences and expectations from both techniques. The results showed a statistically significant difference in time needed for digital and conventional impressions, with digital being faster. From the patient's perspective, the digital scan was more pleasant than the conventional impression. The majority of participants thought digital techniques would completely replace conventional techniques during their lifetime and find it necessary to implement new technologies in dental schools' curricula.

KEYWORDS

Clinical Workflow, Conventional Impression, Dental Education, Digital Impression, Intraoral Optical Scan, Medical Imaging, Operator Preferences, Patient Preferences

INTRODUCTION

Dental impressions are used for capturing details of oral and dental tissues using standard impression techniques and materials (Rudolph et al., 2015). They are essential and widely used for plaster study models manufacturing, used for diagnostic and treatment planning purposes. However, technical innovations in the dental field gave rise to new, faster and more pleasant solutions for both patient and doctor.

The concept of intraoral digital impressions was introduced in dentistry in the early 1980s and had been continuously evolving ever since. Digital workflow allows omitting a few procedural phases, making the process faster and more accurate. A standard digital procedure includes digital intraoral scan, appliance design, 3D printing, and appliance delivery. Virtual systems have changed both

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the everyday dental practice and dental education. Its constant and rapid development and endless possibilities for its elegant application and work optimization in all dental fields cannot be ignored, and there is a great need for its implementation in Dental Schools' curricula which requires a prior assessment of students' attitudes and preferences as well as the state of the knowledge regarding the impression techniques.

Several problems are connected with the use of conventional impression techniques that could be eliminated by digital scanning, including 'pull', tears, bubbles, voids and material shrinkage. Moreover, because models are cast in plaster or stone, they have some drawbacks in storage and retrieval, diagnostic versatility, transferability and durability (Joffe, 2004). The legal aspects of dental records are also fundamental since federal laws mandate the practitioner to keep and retain records, usually for ten years from the date of the last service to the patient, so there is a great need for rational space management since conventional dental casts require a substantial amount of storage space.

With digital models, data storage is made more efficient, eliminating the need for physical storage space, while also avoiding storage issues of plaster chipping or breakage (Martin et al., 2015).

Orthodontists and other dental medicine specialists are rapidly accepting digital technology and new materials in everyday work. Facial and dental scanners, cone-beam computed tomography, 3D printing, and other modern technologies allow professionals more accurate patient assessment, virtual model storing, treatment planning and appliance manufacturing. Procedural mistakes during conventional impression taking, casting and measuring are minimized using digital impressions, and virtual treatment planning allows fast and straightforward communication between lab and orthodontist's practice and quick and straightforward appliance production (Fleming et al., 2011; Flugge et al., 2013; Grunheid et al., 2014; Hayashi et al., 2013; Wiranto et al., 2013).

The article aimed to assess 4th, 5th and 6th-year students' perception of contemporary impression techniques and preferences towards conventional or digital impression technique and the need for implementation in Dental Schools' curricula. This paper is an extension of a pilot study presented initially in the 4th International Conference on Smart and Sustainable Technologies (SpliTech), Bol, Croatia, 2019, which resulted in impressive yet expected results and the need for new research with more participants included (Kalibovic Govorko et al., 2019).

The paper is organized in following sections: in Introduction, we will review the current work on digital and conventional impressions and comparison between them, in Materials and Methods, we will present our study design, in Results, we will show the results of our study, in Discussion, we will discuss our results and compare our data with current work and present conclusions in the Conclusions section.

BACKGROUND

The recent systematic review of Bohner et al. showed that the current digital technologies are accurate for specific applications. However, the scanning of edentulous arches still represents a challenge (Bohner et al., 2019).

Another review indicates that while all the intraoral scanner (IOS) systems can generate virtual models of acceptable accuracy in specific applications, they share similar limitations. However, different studies have reported variable outcomes from other IOS systems (Abduo & Elseyoufi, 2018). Current evidence suggests that patients are more likely to prefer digital workflow than conventional techniques (Gallardo et al., 2018). Digital impressions compared to traditional methods in young orthodontic patients were rated more comfortable, but data showed no difference in anxiety and stress; however, patients preferred digital impression systems instead of conventional impression techniques. Alginate impressions resulted as fast as digital impressions (Mangano et al., 2018).

Burhardt showed that young orthodontic patients preferred the digital impression techniques over the alginate method, although alginate impressions required the shortest chairside time (Burhardt et al., 2016).

The conventional impression was more time-effective than digital impressions. In terms of patient comfort, no differences were found between traditional and digital techniques. From the clinician's point of view, the conventional impression and the digital impression with iTero IOS was less demanding than the digital impression with Lava IOS (Benic et al., 2016).

The quadrant-like intraoral scanning was more time-efficient for single-implant sites than the conventional full-arch impression technique in a phantom head simulating standardized optimal conditions. A high acceptance of IOS was observed among students and dentists (Joda et al., 2017).

Zitzmann studied dental students' perceptions of digital and conventional impression techniques. Fifty undergraduate dental students took digital impressions in a standardized phantom model and then traditional impressions and completed a VAS questionnaire on the level of difficulty and applicability (user/patient-friendliness) of both techniques and found that most students perceived IOS as more straightforward than the conventional process. Most (72%) preferred the digital approach using IOS to take the implant impression to the traditional method (12%) or had no preference (12%). In this study, dental students with no clinical experience could acquire digital tools, indicating that digital impression techniques can be included early in the dental curriculum to help them catch up with the ongoing development in computer-assisted technologies used in oral rehabilitation (Zitzmann et al., 2017).

Another paper investigated the perspective of thirty-one 4th-year students on the user-friendliness of intraoral scanners compared to a conventional impression technique through four questionnaires. Participants took digital and traditional alginate impressions of both jaws on each other, and results showed that the majority of students (77%) were overall "very" or "rather" satisfied with the handling of the intraoral scanning method, and 58% preferred digital to alginate impressions from the practitioner's perspective. From the patient's perspective, the students did not report any significant differences between the two methods. However, the impression tray in conventional impressions reduced patient comfort significantly more than the camera in digital impressions (Schott et al., 2019).

Final-year dental students with no prior experience of intraoral scanning participated in a study to assess the average full-arch scanning time, perception and likelihood of future technology adoption using three different Computer-Aided Design/Computer-Aided Manufacturing (CAD/CAM) intraoral scanning systems on mannequin head-mounted model under supervision. Their scanning performance varied significantly and was dependent on the scanning system used. The overall IOS experience was positive, and the perception of time-saving, when using IOS versus conventional impression methods, determined the likelihood of future adoption of the technology (Ahmed et al., 2019).

Marti et al. compared the time differences between instructing dental students on digital scanning and a conventional impression technique on mannequin and typodont with a full-coverage metal crown preparation and compared students' attitudes and beliefs towards both methods. The time spent teaching students was more significant for scan than the conventional impression. Before the instruction and practice, students considered themselves more familiar with traditional than with digital impression. After education and training, the conventional technique proved significantly easier than expected. 96% of participants stated that the digital scan would become their predominant impression technique during their careers (Marti et al., 2017).

Sabalic conducted an anonymous paper-based and online survey to assess knowledge, attitude and practice on virtual reality-based technology (VRBT) among dental students and dentists. The results showed that subjects had positive attitudes towards VRBT but very few used VRBT in education and practice. Teaching about VRBT as part of undergraduate and continuing education programs could affect future dental practitioners' willingness to implement new technologies in practice and enhance critical assessment of the recent dentistry trends (Sabalic & Schoener, 2017).

In a pilot study by Kalibović Govorko et al., eighteen dental students and recent graduates performed a scan and polyvinyl siloxane impression on each other. They filled two two-part questionnaires to reveal their preferences and expectations from both techniques. The results showed a statistically significant difference in time needed for digital and conventional impression, with digital

being faster. After the scanning, all participants answered that the digital impression technique would spare more time in their office. The majority of participants thought digital strategies would completely replace conventional methods during their lifetime, and that attitude hasn't changed afterwards. This pilot study showed participants' inclination towards new impression techniques and the need for their implementation in Dental School's curriculum (Kalibovic Govorko et al., 2019).

MATERIALS AND METHODS

Thirty-four participants included in the study were randomly selected among 4th, 5th and 6th year's Dental Medicine students from the University of Split School of Medicine, 14 from 4th and 5th and six from 6th year. Participants from each study year were then randomly grouped in pairs. Each pair member was assigned to perform upper jaw digital and conventional impressions on each other. The participant's opinion was evaluated with two two-part questionnaires; from the patient's and doctor's perspective, before and after impression taking, addressing several domains. We used questionnaires from the paper written by Marti et al., which were adapted to suit our research (Marti et al., 2017) [REMOVED HYPERLINK FIELD]. After filling the first part of both questionnaires, participants first watched an investigator-led demonstration on digital and alginate full-arch impression technique and then performed both impressions on each other, digital scan and then conventional impression. Sirona Primescan intraoral scanner (Dentsply Sirona, Sirona Dental Systems Bensheim, Germany) was used for digital impression acquisition. Metal stock trays and Orthotrace alginate mixed in Hurricane mixer (all Zhermack SpA, Badia Polesine, Italy) were used for alginate impression. The digital scan was timed twice, and alginate impression once and performed until a clinically acceptable result was achieved. After both impressions were taken, participants filled the second part of both questionnaires.

The collected data were analyzed using GraphPad Prism software version 7.00 for Windows (GraphPad Software, La Jolla California USA, www.graphpad.com).

RESULTS

In this study, 34 participants were included; fourteen 4th, fourteen 5th and six 6th year students of Dental Medicine, with an average age of 22.9 ± 1.1 years (range 21 to 26 years).

Impression Execution Time

Students performed digital impression twice, and after that, performed alginate impression once. The analysis showed a significant difference in the 4th-year students' group only, between first scan and second scan compared to conventional impression time (s, $p^{scan1} = 0.0031$, $p^{scan2} < 0.0001$, uncorrected Fisher's LSD test, Fig.1.).

There was no statistically significant difference between the duration of a first and second digital impression among 4th, 5th or 6th-year students (ns, p= 0.1811, p= 0.4908, p= 0.8436, paired t-test). Still, there was a significant difference between the duration of the first scan between 4th and 5th (mean diff.=-1.282, 95% CI, unpaired t with Welch's correction) as well as between 4th and 6th-year students (mean diff.=-0.8024, 95% CI, unpaired t with Welch's correction, Fig.2.).

There was also a significant difference between the duration of the second scan between 4th and 5th (mean diff.=-1.361, 95% CI, unpaired t with Welch's correction) as well as between 4th and 6th-year students (mean diff.=-0.9876, 95% CI, unpaired t with Welch's correction, Fig.3.).

Alginate impression time decreased significantly with a higher year of study (s, p=0.0109, 95% CI, test for linear trend, Fig.4.).

Practitioner's Perspective

When asked whether they have acquired enough knowledge about the usage of software and/or other digital/electronic devices during their education, 24 students (70.6%) disagreed.

Figure 1. Scan 1, scan 2 and conventional impression time (*statistically significant)

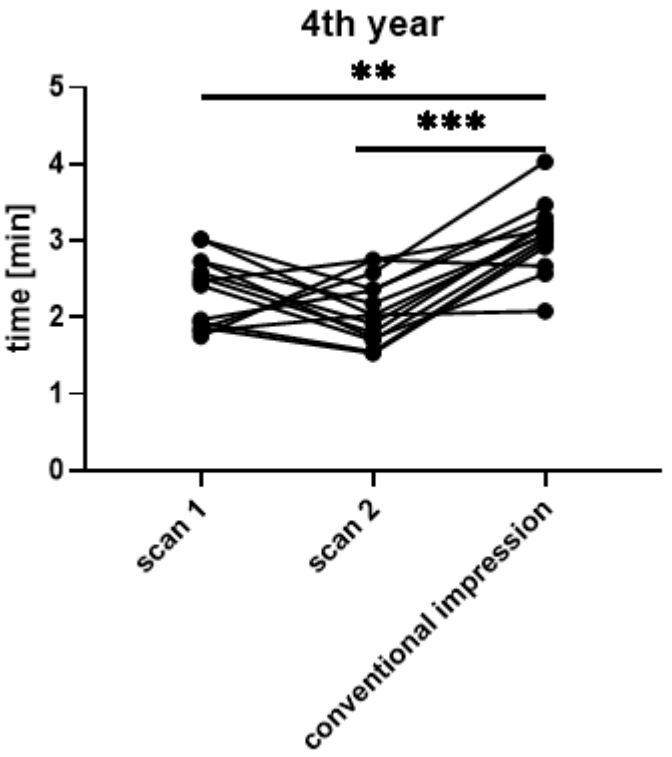


Figure 2. Scan 1-time comparison (*statistically significant)

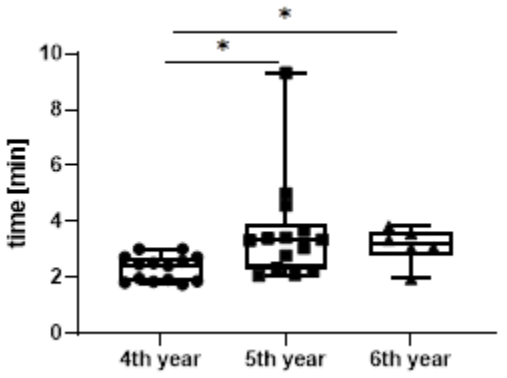


Figure 3. Scan 2-time comparison (*statistically significant)

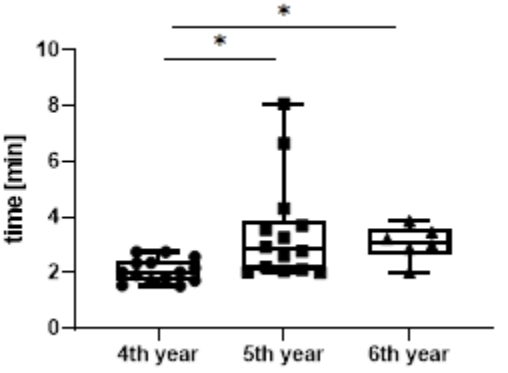
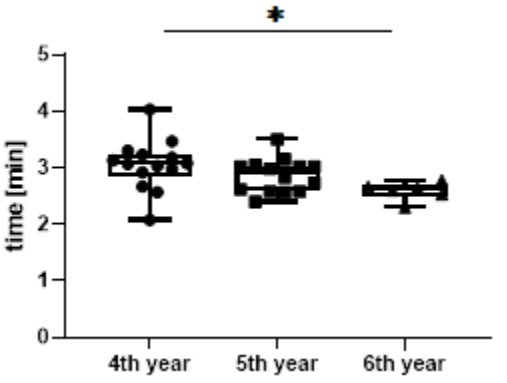


Figure 4. Alginate impression time comparison (#statistically significant)



Only nine students (26.5%) answered that they are entirely or partially familiar with independent use of software and different digital/electronic devices, and 18 students (53%) are wholly or partially unfamiliar with independent use of software and other digital/electronic devices.

When asked whether it is necessary to implement new technologies in dental schools' curricula, 32 students (94.1%) thought it was ultimately (67.6%) or partially true.

The majority of participants were thoroughly familiar with the conventional technique (62%), but only 12% were thoroughly familiar with the digital impression technique.

Before impression taking, most (70.6%) thought that the digital impression technique would be easier to perform. Afterwards, it significantly changed to 41.2% of participants (s, p =0.0145, Chi-square test).

Participants expected conventional impression to be comfortable before, and the same answer prevailed afterwards (ns, p=0.5313, Wilcoxon matched-pairs signed-rank test). As for digital scan, before and after, the majority (54%) answered it would be easy (ns, 4th year p= 0.0736, 5th year p=0.4797, 6th year p=0.0726, uncorrected Fisher's LSD test).

The number of scans they thought to be necessary to take before they could perform it competently hadn't changed before and after for 4th and 6th-year students, but it was significant for 5th-year students (s, p=0.0357, uncorrected Fisher's LSD test).

When asked about a technique that would save more time in their office, there was a significant difference between before and after answers among 4th-year students: before, 92.9% of students thought it would be a digital impression and none of them that it would be a conventional impression, and afterwards, it changed to 57.1% and 35.7% respectively (s, p= 0.0452, Chi-square test).

When asked which technique would save more money, before, all answers were equally distributed, but after, the most frequent response was the conventional technique. Still, it was not significantly different (ns, p= 0.3859, Chi-square test).

The majority of participants thought they would use digital techniques as a leading impression technique at some point in their career and completely replace conventional methods during their lifetime. That attitude hasn't changed afterwards (88.2% before, 91.1% after).

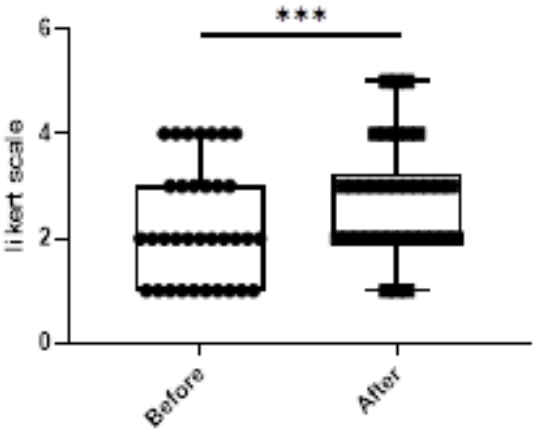
When asked whether getting familiar with dental scanners changed their opinion on the usefulness of scanning technology, 56% said their opinion improved, remained unchanged in 38% and worsened in 6% of the participants.

Patient's Perspective

All answers in this questionnaire, before and after, were analyzed using Wilcoxon matched-pairs signed-rank test.

The majority of participants thought that the conventional impression wasn't pleasant (61,7%), but that changed afterwards to 44,1% (s, p=0.0007, Fig. 5.). After they experienced it, students thought it was more pleasant than before.

Figure 5. Before and after opinion on the statement that conventional impression is pleasant. (*statistically significant)



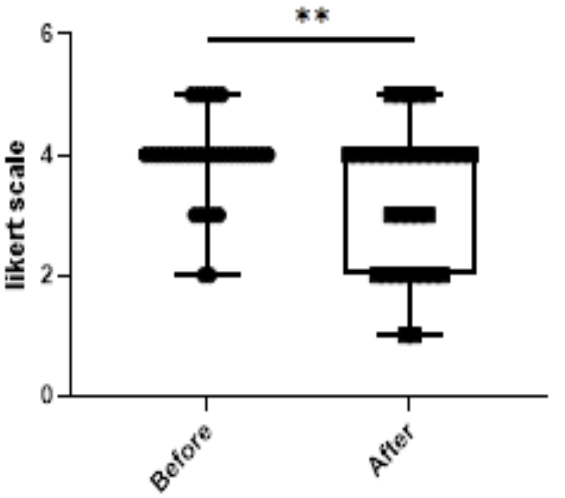
There was a significant difference between before and after answers regarding conventional impression execution speed (s, p=0.0001). Participants thought that traditional was quicker to perform afterwards.

The majority thought that it was true and partially true that conventional impression causes gag reflex before (76,4%), but the percentage of participants with that opinion afterwards significantly changed to 55,8% (s, p=0.0329).

When asked if a conventional impression was comfortable for the practitioner to perform, the most frequent answer was that it was partially true and after it significantly improved (s, p=0.0061).

When asked if scanning was pleasant, most (79%) thought it was entirely and partially true before, and that opinion worsened significantly (s, p=0.0034, Fig. 6.).

Figure 6. Before and after opinion on the statement that digital impression is pleasant. (*statistically significant)



Opinion about scanning speed significantly worsened afterwards (s, p=0.0047). The majority of the participants thought it was relatively quick before (82,3%), but later, only 47% of participants felt that.

Students thought that scanning caused neither gag reflex nor breathing difficulties, and that opinion stayed the same after.

When asked whether scanning was easy for the practitioner, the majority thought it was wholly and partially true (70,5%), and afterwards, it worsened to 56%, but it was not significant (ns, p=0.1743).

DISCUSSION

Digitization of medicine and dental medicine is influencing practitioners' workflow daily. It has started forty years ago and is rapidly and continuously improving. The development of computer technology and accompanying equipment results in significant clinical work changes. There is a great need for their implementation in dental schools' curricula and the development of new training methods.

This study is an extension of a pilot study (Kalibovic Govorko et al., 2019) which assessed 5th and 6th-year students and young dentists' perception of contemporary impression techniques and preferences towards conventional or digital impression technique. This research engaged bigger groups of students than the original pilot study, which included younger students with no impression experience. Also, we used different impression material, alginate, instead of polyvinyl siloxane. The reason for using different material was the improved quality and stability of alginate, its lower price compared to polyvinyl siloxane and more simple impression technique and handling.

The analysis of the time needed for two consecutive digital and one alginate impression showed that the first digital impression time was lowest in the 4th-year group, followed by 6th and 5th-year students. The 4th-year students were also the fastest with the second scan, followed by 6th and 5th-year students.

The analysis showed a significant difference between the first scan and second scan compared to conventional impression time in the 4th-year students' group only, with the digital impression being faster. Since there are no objective reasons for better results in younger students, the simple explanation of better scanning results could be a greater physical dexterity of that group of students. Another research showed that the conventional impression was more time-effective than digital impression. They used a different scanner, different impression material and a single crown scan instead of a full-mouth scan (Benic et al., 2016)[. Alginate impressions in orthodontic patients in another study resulted as fast as digital impressions (Mangano et al., 2018).

As for the conventional impression, the higher the study year, the shorter the impression time, which could be attributed to the fact that younger students are less experienced in conventional impression technique and older students have been practicing it for the past few years.

When asked whether they have acquired enough knowledge of the usage of software and/or other digital/electronic devices during their education, almost two-thirds of them disagreed. That information is valuable since it points out that regional universities are inert when implementing the new technologies in the undergraduate curriculum.

It surprises that only 26.5% of participants answered that they are entirely or partially familiar with independent use of software and different digital/electronic devices, and 53% are wholly or partially unfamiliar with independent use of software and other digital/electronic devices. These generations of students grew up with digital technologies, but their usage is limited and orientated mainly to mobile phone-based applications.

The results showed that students are aware of the lack of their competencies; when asked whether it is necessary to implement new technologies in dental schools' curricula, 32 students (94.1%) thought it was entirely or partially true.

It is encouraging that most participants were completely familiar with the conventional technique, so it is evident that the traditional curriculum serves its purpose, which is in concordance with Marti et al. (Marti et al., 2017).

Understandably, only 12% of participants were completely familiar with the digital impression technique. The conventional technique is being taught in dental schools, and digital techniques are left out and usually available only on paid courses or in our study programme as an elective 3-day course for 5th-year students since 2018.

Before impression taking, the majority (70.6%) thought that the digital impression technique would be easier to perform than conventional, and afterwards, results significantly changed, decreasing to 41.2% of participants. Students' expectations were high, and the digital scanning technique is still demanding, especially when scanning the entire arch. Our results differ from Zitzmann's (Zitzmann et al., 2017). They performed implant impressions on a customized maxillary model situation with a bone-level type implant, and our participants took both impressions on patients.

Participants expected both conventional and digital impressions to be easy before, and the same answer prevailed afterwards.

The number of scans they thought to be necessary to take before they could perform it competently hasn't changed before and after for 4th and 6th-year students. Still, it was significant for 5th-year students, they thought that they would need, on average, seven attempts less than they estimated earlier.

When asked about a technique that would save more time in their office, there was a significant difference between before and after answers among 4th-year students: before, 92.9% of students thought it would be a digital impression and none of them that it would be a conventional impression, and afterwards, it changed to 57.1% and 35.7% respectively. The older students thought it would be a digital impression, and that hasn't changed significantly. A study with final-year dental students on full-arch scanning revealed that the overall IOS experience was positive with a perception of time-saving and showed a likelihood of future technology adoption (Marti et al., 2017)

When asked which technique would save more money, before, all answers were equally distributed, but after, the most frequent response was the conventional technique, but it was not significantly

different. High-quality digital scanners are still quite expensive. Maybe a mere contact with the sophisticated device during the research and the simplicity of the alginate impression stress the apparent price difference between them.

The majority of participants thought they would use digital techniques as a leading impression technique at some point in their career and completely replace conventional methods during their lifetime. That attitude hasn't changed afterwards, which is in concordance with Marti et al. (Marti et al., 2017)

The majority of participants thought that the conventional impression wasn't pleasant, but after they experienced it, it changed. Afterwards, students thought it was more pleasant than they expected. We used vanilla scented alginate with fast setting time which all attributed to a better impression experience. It shows the importance of the patient's perspective and experience in assessing the rationale for implementing new technologies.

There was a significant difference between before and after answers regarding the speed of conventional impression execution. Participants thought that the traditional impression was quicker to perform afterwards.

The majority thought that it was partially true that conventional impression causes gag reflex before, but that opinion significantly changed afterwards. After experiencing the conventional technique, a smaller number of participants thought it would cause a gag reflex.

When asked if a conventional impression was comfortable for the practitioner to perform, the most frequent answer was that it was partially true and after, it was significantly different. It seemed easier to perform after experiencing it.

When asked if scanning was pleasant, most (79%) thought it was entirely and partially true before, and that opinion worsened significantly to 55%. Compared to the conventional impression, a digital impression was more pleasant, but Benic (Benic et al., 2016) found no patient comfort differences.

Opinion about scanning speed significantly worsened afterwards. The majority of the participants thought it was rather quick before (82,3%), but later, it changed to 47%.

The reason for the change in opinion is that for a full-arch scan, the practitioner needed to smoothly guide a rather massive scanning head across the three sides of the tooth-arch. That is much easier done on a model than in a patients' mouth and usually requires repeated scanning of the dental arch's hard-to-reach parts.

Students thought that scanning caused neither gag reflex nor breathing difficulties, and that opinion stayed the same after.

When asked whether scanning was easy for the practitioner, the majority (54%) thought it was partially and wholly true, and afterwards, it worsened slightly but not significantly. We believe that the reason for that is the scanner head's size, which requires some handling exercises. The study conducted by Schott et al. showed that the majority of students were overall "very" or "rather" satisfied with the handling of the intraoral scanning method (Schott et al., 2019). Although our study differs in methodology, we could say that results are in concordance.

All these post-exposure changes in attitudes result from direct experience with digital and conventional impressions in patient's and practitioner's roles. IOSs are great tools for everyday practice, but their use requires training and changing the usual workflows. The results of this research remind us of the importance of clinical exercises for dental students' education, the necessity of constant contact with new technologies, and the opportunity to learn through the change of the perspective, from practitioners to patients.

STUDY LIMITATIONS

To achieve higher significance, multicenter studies on the higher number of participants are needed. A twice-yearly assessment of students' progress in terms of conventional and digital impression timing from first clinical study-year until graduation would yield valuable information for further curriculum development.

CONCLUSION

Within the limitations of this study, the following conclusions were drawn:

- Alginate impression time decreased significantly with a higher year of study.
- Almost two-thirds of the students think they have not acquired enough knowledge about the usage of software and/or other digital/electronic devices during their education.
- After the digital impression experience, the majority thought it was less pleasant and less quick than before.
- After the conventional impression experience, the majority thought it was more pleasant and quicker to perform than before.
- From a patient's perspective, the digital scan was more pleasant than the conventional impression.
- The majority of students find it necessary to implement new technologies in dental schools' curricula.

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CONFLICTS OF INTERESTS

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