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# Blended learning compared to traditional learning for the acquisition of competencies in oral surgery by dental students: A randomized controlled trial

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## Abstract

**Objective:** To determine whether blended learning results in better educational outcomes compared to traditional learning in the acquisition of oral surgery technical skills for 4th-year undergraduate dental students.

**Materials and Methods:** Seventy-three students participated in this two-arm parallel randomized controlled trial. Only students in the blended learning group had access to the online preparation platform for oral surgery practical work (PW) on a pig's jaw and to the debriefing. Kirkpatrick's four-level model was used to assess the educational outcomes directly after (levels 1 and 2) and 6 months later, after the start of the students' clinical activity (levels 3 and 4).

**Results:** For level 1, higher global satisfaction scores were found for students in the blended learning compared to the traditional learning group ( $p = .002$ ). For level 2, blended learning resulted in an increase in knowledge score ( $p < .01$ ), comparable to that observed in the traditional learning group. For level 3, students in the blended group made more progress in 6 months than those in the traditional group in terms of feeling able to assess and perform anaesthesia ( $p = .040$ ) and surgical tooth extraction ( $p = .043$ ). No difference in level 4 was found for the 6-month clinical surgical activity between groups, but students in the blended group felt more able to assess and perform the surgical management of a failed extraction requiring bone removal ( $p = .044$ ).

**Conclusion:** Blended learning for oral surgery PW had a positive impact on three of the four Kirkpatrick levels (level 1, 3 and 4). Efforts should focus on the procedures that are perceived as the most difficult.

## KEYWORDS

computer-assisted instruction/methods, dental, dental education, oral surgery, students, tooth extraction

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## 1 | INTRODUCTION

Teaching oral surgery has an important role in the training of dentistry students for their future clinical practice. According to the Association for Dental Education in Europe (ADEE), a graduating dentist must be able to perform extractions of erupted teeth including surgery for the straightforward removal of fractured or retained roots and partially erupted teeth.<sup>1</sup>

The teaching of oral surgery differs widely across dental schools around the world.<sup>2-4</sup> In France, students follow a 6-year teaching curriculum, beginning their clinical training in the fourth year. In the French Dental School of Nantes, at the beginning of the fourth year, dental students take part in a practical work (PW) session to perform the main oral surgery procedures on a preclinical training model (pig's jaw) at least once before performing them on a patient. This preclinical model was considered as useful preparation by 100% of students according to a European survey, thus underlining its relevance.<sup>2</sup> Nevertheless, the teaching team of the Nantes dental school estimated that students had not mastered the theoretical foundations required for this PW, resulting in a loss of efficiency. It therefore seemed appropriate to improve this preclinical teaching, which could potentially improve the students' future clinical practice.<sup>5</sup>

Blended learning can be defined as a coherent and fertile combination of several registers of teaching and learning practices.<sup>6</sup> It aims to support the engagement and perseverance of learners and to contribute to students' success. It can bring together face-to-face and distance learning to combine the benefits of these two methods: the synchronous student-student and student-teacher interactions as well as the asynchronous flexibility. In recent years, blended learning has developed rapidly.<sup>7,8</sup> A recent meta-analysis has shown that it led to better knowledge acquisition than traditional learning in health-care education.<sup>7</sup> Moreover, it can foster student engagement.<sup>9</sup> Few studies have been conducted in the field of dentistry,<sup>8,10-12</sup> and none used specialized models to evaluate blended learning and its potential impact on clinical practice in oral surgery.

Evaluation is an essential part of curriculum development in education. The Kirkpatrick model is commonly used today to evaluate medical education.<sup>13</sup> This is a pyramidal model with four successive levels.<sup>14</sup> The first level is 'reaction' and evaluates satisfaction with training, the second level 'learning' investigates the increase in knowledge made possible by training, the third level 'behaviour' refers to changes in attitudes induced by training, and the fourth level 'results' observes the results of the training such as improved patient outcomes. Despite some limitations, in particular to be an outcome-based model, its success can be explained by the clarity of its taxonomy for evaluating training, and its simple structure.<sup>15</sup>

Therefore, the aim of this study was to determine, on the basis of the Kirkpatrick training evaluation model, whether blended learning results in better educational outcomes compared to traditional learning in the acquisition of oral surgical skills for 4th-year undergraduate dental students of the Dental School of Nantes (France).

## 2 | MATERIALS AND METHODS

### 2.1 | Trial design

This two-arm parallel randomized controlled trial (RCT) was conducted in the French Dental School of Nantes between September 2022 and March 2023. The allocation ratio of students was 1:1. The study received ethical approval from the ethics committee for noninterventional studies (CERNI) of Nantes University (IRB: IORG0011023, reference number 16032022).

### 2.2 | Participants

Eligible participants were all non-repeating 4th-year dental students of Nantes University. Following consent to take part in this study, each participant completed a pre-test questionnaire to score their knowledge of oral surgery. The questionnaire consisted of 10 questions, each with three response options (*yes, no, don't know*). Participants were then allocated to the traditional learning group or to the blended learning group. Randomization was stratified by gender and pre-test knowledge scores. Stratification by gender is justified because self-confidence in oral surgery is gender-dependent.<sup>3,16-18</sup> The randomization sequence was generated by Microsoft Excel 2019 (Microsoft Corporation, Issy les Moulineaux, France). A.C. implemented the randomization.

### 2.3 | Design of blended learning model

A qualitative survey was carried out among 11 5th-year dental students to gather their opinions on the PW delivered in the previous year. The strengths of this previous PW were chronology adapted to the curriculum, simulation of surgical procedures, fun, working in pairs. Its weaknesses were time-consuming theoretical reminders at the beginning, no inter-species comparison between the preclinical model (pig's jaw) and the human model, non-exhaustiveness of the surgical procedures covered (absence of anaesthesia and simple tooth extraction procedures from the PW program), difficulty in conveying the concepts of tactile perception/force to be applied.

Six competencies were defined for this oral surgery PW: (1) set up and maintain an organized and safe working environment with four hands (pair); (2) implement different techniques of dental anaesthesia; (3) carry out the procedures that are mandatory for simple tooth extraction and tactilely perceive an empty tooth socket that has been correctly revised; (4) perform the necessary procedures for a surgical tooth extraction (mucoperiosteal flap, bone removal, root separation) and tactilely perceive the consistency of soft tissues and calcified tissues (teeth and bone); (5) identify a wisdom tooth germ in its socket and tactilely locate it in its bone crypt and; (6) implement the most common suture techniques in oral surgery. The new PW program (anaesthesia, simple and surgical tooth extraction, approach

for germectomy of wisdom tooth) on the preclinical training model of the pig's jaw covered each of these six targeted competencies.

The online preparation platform for the blended learning consisted of seven parts:

1. Introductions
2. Installation of the surgical table, hygiene and asepsis, ergonomics, end of operation and disinfection
3. Anaesthesia
4. Scenario 1: simple tooth extraction
5. Scenario 2: surgical tooth extraction
6. Scenario 3: germectomy of a wisdom tooth
7. Conclusion

For the introduction and conclusion, a video overlay tool (Rapidmooc Inwicast, Lyon, France) was used to integrate the teacher into the side of the slideshow in order to make the presentation more engaging for the students.<sup>19</sup> It was possible to move easily from one stage to another or from one species to another using an interactive summary. Each scenario referred to a presentation of a clinical-based procedure so that the students could project themselves as a future practitioner. The video capsules, edited using Adobe Premiere Pro (Adobe System 2022, San José, USA), were subtitled and accompanied by corollary text and diagrams (Adobe Illustrator, Adobe System 2022, San José, USA) or close-up images illustrating each procedure. Multiple-choice questions were used to stimulate the students' motivation. Animated diagrams were created with Adobe After Effect (Adobe System 2022, San José, USA) to summarize at the end of the section the actions the students had to carry out during the PW. An interactive presentation tool, Genially (Genially Web, S.L, Cordoba, Spain), was used to bring together the different digital content.

Students were able to access it by clicking on a link on the Moodle platform of Nantes University.

## 2.4 | Interventions

The intervention evaluated by this RCT was blended learning. Blended learning is not limited to consulting online resources, but involves a close combination of face-to-face and distance learning time. Increased support for students, and an additional debriefing, was therefore part of the intervention tested.

During the briefing, the expected competencies and learning outcomes as well as the pedagogical scenarios of the PW were presented face-to-face to the whole class with visual aids (slides, diagrams) (Figure 1).

In the traditional learning group (Figure 1A), 10 days after the briefing, the students attended a 3.5h PW involving various surgical procedures to be performed on a pig's jaw. Working in pairs, one student carried out a procedure assisted by the other student; the roles were then reversed before moving on to the next procedure included in the PW. Slides and videos with commentary describing the procedures to be performed were shown. The student-supervisor ratio for the PW was 4.4. A 30min guided debriefing took place 5 days later. The students' feelings (relevance of the PW, satisfaction, commitment), their analysis of how the activity had gone (what they had missed, what they had liked), and what they had gained from it (what they had learned, what they thought they could perform in the future, etc.) were collected in order to facilitate the transfer of knowledge and skills acquired to the clinic. In the week following the PW, the students began their clinical course. All the surgical procedures they performed over a 6-month period were evaluated on the basis of the number

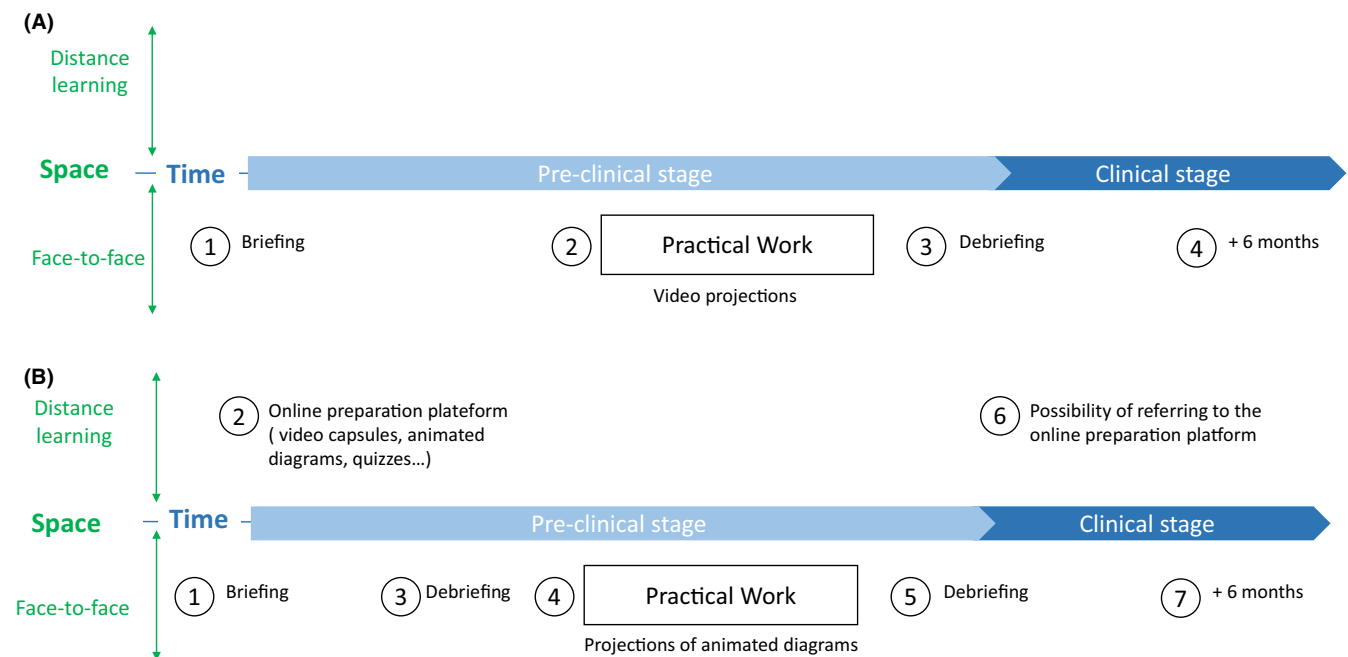


FIGURE 1 Pedagogical scenarios of oral surgery practical work for the traditional learning group (A) and the blended learning group (B).

of procedures performed and their level of autonomy using dental software (LOGOSw, Liffré, France). The students were reviewed at 6 months to complete the final questionnaire.

In the blended learning group (Figure 1B), the students accessed the online platform to prepare the PW on the day after the briefing. The videos available on the online platform of the blended learning group were the same as those used during the PW session of the traditional learning. Only the students of this group were able to access this tool for the duration of the study. A guided debriefing of the preparation platform took place 9 days later. The students' feelings as well as their analysis of how the activity had gone and what they had gained from it were recorded in order to facilitate the transfer of knowledge to the PW. The PW of the blended learning group was identical in every aspect to that of the traditional learning group, so that relevant comparisons could be made. The only difference was that the animated diagrams from the online platform were projected instead of the videos from the traditional teaching group, since the students had already been able to consult these videos online. The debriefing of the PW and the 6-month assessment were also similar to those of the traditional learning group. Importantly, after the start of the clinical course, the students of the blended learning group still had access to the online platform and, thus, were able to use the various videos of procedures performed on human models in order to better prepare for the procedures planned for their patients.

## 2.5 | Outcomes

Kirkpatrick's four-level model<sup>14</sup> was used to assess the effectiveness of the acquisition of oral surgical technical skills in the blended learning group and in the traditional learning group, allowing comparisons to be made between groups. Level 1 (reaction) was assessed through the satisfaction score at the preclinical stage directly after the PW. Level 2 (learning) was assessed using a pre- and post-test knowledge score at the preclinical stage before and directly after the PW. Level 3 (behaviour) was assessed through a score measuring the application of the learned knowledge in the clinical stage at 6 months. Level 4 (results) was also assessed in the clinical stage, at 6 months, via a combination of a score measuring the students' clinical surgical activity over 6 months and a score measuring self-confidence from a validated questionnaire originally developed by the Association of British Academic Oral Maxillofacial Surgeons (ABAOMS).<sup>16</sup> The questionnaire response options used a Likert scale.

## 2.6 | Statistical analysis

Data from the completed questionnaires were imported into Microsoft Excel 2019 (Microsoft Corporation, Issy les Moulineaux, France) for descriptive analysis. Likert scale responses were treated as continuous data because the sample size was greater than 5 per

group, enabling the use of robust parametric tests.<sup>20,21</sup> For each variable, numbers and percentages were calculated and given as mean  $\pm$  standard deviation (SEM). GraphPad Prism 5.0 software (GraphPad Software, USA) was used to perform Student's *t*-tests in order to compare data and generate graphics. Spearman's rho correlations were calculated between students' clinical scores at 6 months and their responses to the ABAOMS questions measuring self-confidence. The results were considered statistically significant at the level of  $p < .05$ .

## 3 | RESULTS

### 3.1 | Participants

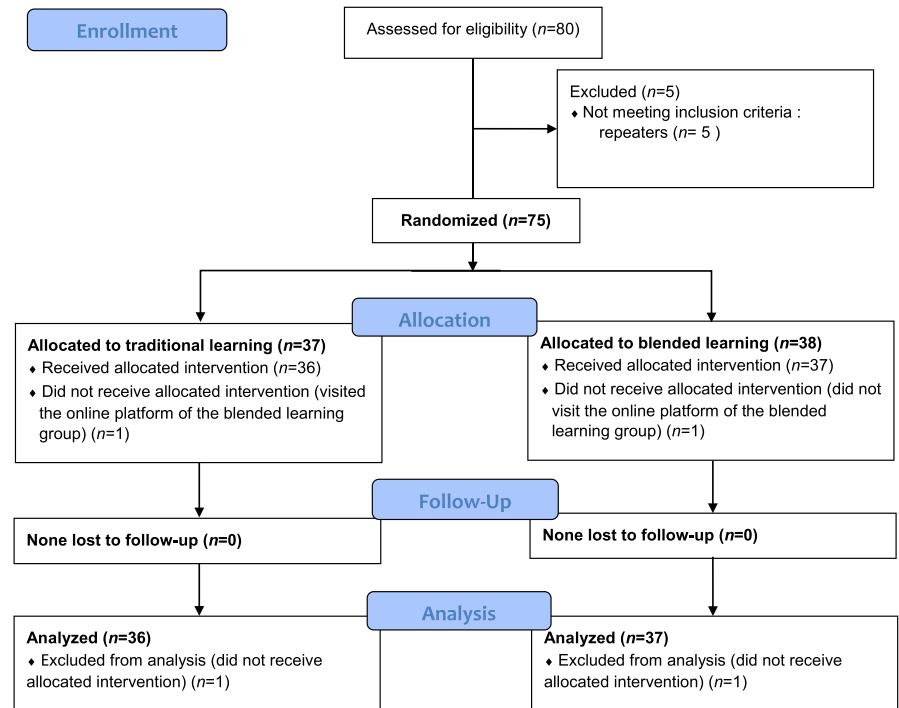
Of 80 4th-year dental students assessed for eligibility, 75 were included in the study (Figure 2). They were randomly assigned to the traditional learning group ( $n = 37$ ) or the blended learning group ( $n = 38$ ). After randomization, one student from each group was excluded because they did not receive the allocated intervention. No student was lost during the 6-month follow-up. For the final analysis, the traditional learning group included 36 students, 25 female (69.4%) and 11 male students (30.6%), with an average pre-test knowledge score of  $5.44/10 \pm 0.21$ ; the blended learning group included 37 students, 25 female (67.6%) and 12 male students (32.4%), with an average pre-test knowledge score of  $5.32/10 \pm 0.16$ . No statistical differences were observed between the groups regarding gender distribution or pre-test knowledge score.

### 3.2 | Level 1 of Kirkpatrick's evaluation model: Reaction

Overall, regarding all of the items of the satisfaction questionnaire, the vast majority of students were satisfied with the teaching, both in the traditional learning group (93.0%) and in the blended learning group (97.6%) (Table 1). Students in the blended learning group exhibited higher global satisfaction scores with the educational program than students in the traditional learning group ( $p = .002$ ). Furthermore, they were more likely to agree that the duration and the pace of the course were satisfactory (91.9% vs. 61.1%,  $p = .006$ ) and that the theoretical input was sufficient to participate in the PW (94.5% vs. 77.8%,  $p = .016$ ), while those in the traditional group found the exchanges most rewarding (100% vs. 97.3%,  $p = .014$ ).

The feedback from the students during the structured debriefings was overwhelmingly positive in both groups, with 18 positive and four negative comments, as shown Table 2. The blended group's online platform was seen as being reassuring, motivating, and pleasant. Regarding the appreciation of the PW, only the students in the traditional group reported that the time of the PW was insufficient, and only the students in the blended group emphasized the contribution of tactile perception (hardness of bone, soft tissue flexibility).

**FIGURE 2** CONSORT 2010 flow diagram showing participant enrollment, allocation, follow-up, and analysis for the randomized controlled trial.



### 3.3 | Level 2 of Kirkpatrick's evaluation model: Learning

Blended learning and traditional learning resulted in an increase in the knowledge score (pre-test vs. post-test knowledge score,  $p < .001$ ), in a relatively similar proportion (Figure 3). However, the pre-test and post-test scores were not significantly different between the two groups (Figure 3).

### 3.4 | Level 3 of Kirkpatrick's evaluation model: Behaviour

The results regarding the application of learned knowledge at 6 months are presented in Table 3. At 6 months, students in the blended group made more progress than those in the traditional group in terms of feeling able to implement different techniques of dental anaesthesia (2.22/7 vs. 1.67,  $p = .040$ ) and to perform the necessary procedures for surgical tooth extraction and tactilely perceive the consistency of soft tissues and calcified tissues (1.81/7 vs. 1.25,  $p = .043$ ).

### 3.5 | Level 4 of Kirkpatrick's evaluation model: Results

At 6 months, no significant difference between the clinical scores of students in the two groups was recorded, but the box plot was shorter for the blended group (see Figure 4). More than 70% of the students stated that the teaching in oral surgery had given them sufficient knowledge to undertake independent clinical practice

(Table 4). A slight correlation was found between this statement and the clinical score ( $r = .29$ ,  $p = .007$ ). Overall, 100% of the students felt confident to perform simple exodontia of a single-rooted tooth, whatever their learning group, whereas they were less confident in the skills related to other types of tooth extraction. Students in the blended group felt more able than those in the traditional group to assess and perform the surgical management of a failed extraction (e.g. a lower second molar) requiring bone removal (62.2% vs. 44.4%,  $p = .044$ ). No student disagreed that oral surgery is an enjoyable and rewarding discipline.

## 4 | DISCUSSION

This RCT provided for the first time an assessment, based on the four levels of Kirkpatrick's training evaluation model, of blended learning versus traditional learning in oral surgery. Only the blended learning group benefited from access to the online preparation platform, as well as an additional debriefing, in line with the intervention tested. Since the PW and the educational videos were similar for the two groups, it was then possible to determine the impact of blended learning on student training. Such assessment is crucial in the healthcare profession for educators and learners alike.<sup>8</sup> We showed that blended learning had a positive impact on three of the four Kirkpatrick levels (levels 1, 3 and 4). It should be noted that the difference observed for level 4 concerns the subjective self-confidence and not the objective clinical score.

Our blended learning was based on a qualitative student survey aimed at evaluating the PW in its pre-existing form. Areas of strength were maintained and areas of weakness were reworked for improvement. Student feedback is essential for evaluating academic

TABLE 1 Dental students' satisfaction regarding oral surgery practical work in the traditional learning group and in the blended learning group. Kirkpatrick level 1 (reaction).

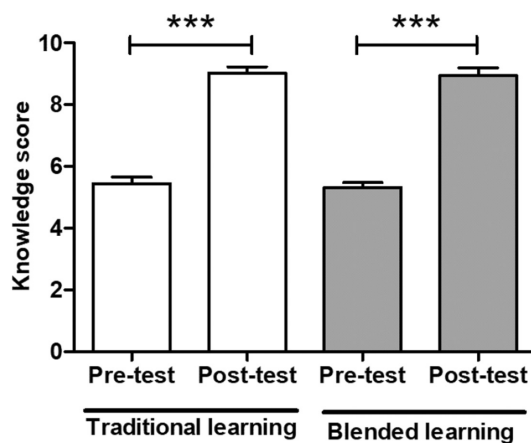
Questions	Group	Score n (%)					Mean score ± SEM	p-Value
		1	2	3	4	5		
1. The teaching objectives were clearly presented	Traditional	0 (0)	0 (0)	0 (0)	11 (30.6)	25 (69.4)	4.69 ± 0.08	ns
	Blended	0 (0)	0 (0)	0 (0)	7 (18.9)	30 (81.1)	4.81 ± 0.07	
2. The structure of the teaching was satisfactory	Traditional	0 (0)	0 (0)	0 (0)	12 (33.3)	24 (66.7)	4.67 ± 0.08	ns
	Blended	0 (0)	0 (0)	0 (0)	7 (18.9)	30 (81.1)	4.81 ± 0.07	
3. The duration and pace of the course was satisfactory	Traditional	0 (0)	7 (19.4)	7 (19.4)	12 (33.3)	10 (27.8)	3.69 ± 0.18	.006
	Blended	0 (0)	2 (5.4)	1 (2.7)	19 (51.4)	15 (40.5)	4.27 ± 0.13	
4. The training materials and aids were satisfactory	Traditional	0 (0)	0 (0)	2 (5.9)	12 (35.3)	20 (58.8)	4.53 ± 0.11	ns
	Blended	0 (0)	2 (5.4)	1 (2.7)	9 (24.3)	25 (67.6)	4.54 ± 0.13	
5. The content of the course was satisfactory	Traditional	0 (0)	0 (0)	0 (0)	12 (33.3)	24 (66.7)	4.67 ± 0.08	ns
	Blended	0 (0)	0 (0)	0 (0)	8 (21.6)	29 (78.4)	4.78 ± 0.07	
6. Theoretical input was sufficient to participate in the practical work	Traditional	0 (0)	3 (8.3)	5 (13.9)	11 (30.6)	17 (47.2)	4.17 ± 0.16	.016
	Blended	0 (0)	0 (0)	2 (5.6)	11 (30.6)	23 (63.9)	4.58 ± 0.10	
7. I felt generally comfortable to participate in the practical training	Traditional	0 (0)	0 (0)	0 (0)	15 (41.7)	21 (58.3)	4.58 ± 0.08	ns
	Blended	0 (0)	0 (0)	0 (0)	13 (36.1)	23 (63.9)	4.64 ± 0.08	
8. The exchanges with the supervisors and between the students were rewarding	Traditional	0 (0)	0 (0)	0 (0)	4 (11.4)	31 (88.6)	4.89 ± 0.05	.014
	Blended	0 (0)	0 (0)	1 (2.7)	11 (29.7)	25 (67.6)	4.65 ± 0.09	
9. This teaching seems useful for my future clinical practice	Traditional	0 (0)	0 (0)	0 (0)	3 (8.3)	33 (91.7)	4.92 ± 0.05	ns
	Blended	0 (0)	0 (0)	0 (0)	2 (5.4)	35 (94.6)	4.95 ± 0.04	
10. I felt engaged in this course	Traditional	0 (0)	0 (0)	1 (2.9)	4 (11.4)	30 (85.7)	4.83 ± 0.08	ns
	Blended	0 (0)	0 (0)	0 (0)	2 (5.4)	35 (94.6)	4.95 ± 0.04	
Total	Traditional	0 (0)	10 (2.8)	15 (4.2)	96 (27.0)	235 (66.0)	4.56 ± 0.04	.002
	Blended	0 (0)	4 (1.1)	5 (1.4)	89 (24.2)	270 (73.4)	4.70 ± 0.03	

Abbreviation: ns, non-significant.



**TABLE 2** Summary of discussions with dental students during structured debriefings of oral surgery practical work in the traditional learning group and in the blended learning group. Kirkpatrick level 1 (Reaction). Items in bold were not expressed by students in the other experimental group.

Group	Tool	Positive points	Negative points
Traditional learning	Online platform		
	Practical work	<ul style="list-style-type: none"> <li>• Reassuring</li> <li>• Motivating</li> <li>• Diversity of surgical procedures covered</li> <li>• Presence of many supervisors</li> <li>• <b>Theoretical reminders from last year</b></li> </ul>	<ul style="list-style-type: none"> <li>• Wish to add an additional tooth extraction</li> <li>• <b>Insufficient time</b></li> </ul>
Blended learning	Online platform	<ul style="list-style-type: none"> <li>• Reassuring</li> <li>• Motivating</li> <li>• <b>Pleasant</b></li> <li>• Diversity of surgical procedures covered</li> <li>• <b>Made the link between the procedures to be performed on the pig's jaw and on humans</b></li> <li>• <b>Clear, concise, and precise videos led to a reminder of past lessons and a better understanding of the concepts</b></li> <li>• <b>Interactive quizzes to encourage high student involvement</b></li> <li>• <b>The animated diagrams at the end of the modules helped the students to understand the actions to be performed in a synthetic way</b></li> </ul>	<ul style="list-style-type: none"> <li>• <b>Absence of voice-over and commentary on the videos in the human model</b></li> </ul>
	Practical work	<ul style="list-style-type: none"> <li>• Reassuring</li> <li>• Motivating</li> <li>• Diversity of surgical procedures covered</li> <li>• Presence of many supervisors</li> <li>• Perception of real tactile sensations (hardness of bone, soft tissue flexibility)</li> </ul>	<ul style="list-style-type: none"> <li>• Wish to add additional tooth extraction</li> </ul>



**FIGURE 3** Pre- and post-test knowledge scores of dental students in the traditional learning group and in the blended learning group. Kirkpatrick level 2 (Learning). Data are shown as mean  $\pm$  SEM, \*\*\* $p < .001$ . (Student's *t*-test).

programs and improving teaching.<sup>2,4,16,22</sup> Interestingly, each of the four weaknesses identified in the former PW model through the qualitative survey among 5th-year dental students, were transformed into strengths in the blended version: (1) duration, blended learning had permit to eliminate the time-consuming theoretical reminders at the beginning of the PW, and students in the blended learning group were more satisfied with the duration and pace of

the course than students in the traditional learning group; (2) interspecies comparison between the preclinical model (pig's jaw) and the human model, only the students in the blended learning group stressed that the PW made the link between the procedures to be performed on the pig's jaw and on humans; (3) exhaustiveness of the surgical procedures covered, the students in the two experimental groups appreciated the diversity of surgical procedures covered by the new PW program; and (4) tactile perception, only the students in the blended group emphasized the perception of real tactile sensations during the PW.

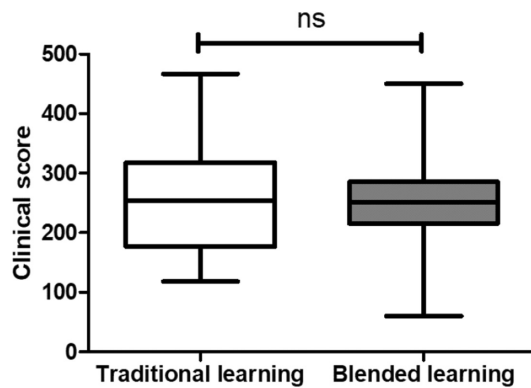
For the first level of the Kirkpatrick model, students' satisfaction scores were high for both kinds of PW. For example, satisfaction with the materials was higher than the highest data recorded in a European survey about the teaching of tooth extraction (4.5/5 vs. range from 2.9 to 4.1).<sup>2</sup> Students' satisfaction was globally higher in the blended learning group, which is consistent with the results of a systematic review in orthodontics education.<sup>11</sup> More generally, the results regarding the level 1 evaluation of blended learning in healthcare are mixed.<sup>7</sup> It should be noted that this is difficult to assess due to the absence of a standardized definition of satisfaction.<sup>7</sup> The responses to the satisfaction questionnaire and the debriefing were consistent and showed that the duration and pace of the training were more satisfactory. This could be explained by the fact that in blended learning, animated summary diagrams were projected during the PW instead of the more time-consuming



**TABLE 3** Responses from dental students on the impact of the oral surgery practical work on their clinical behaviour in the traditional learning group and in the blended learning group at 6 months. Kirkpatrick level 3 (Behaviour).

Questions	Group	Score n (%)					Mean score ± SEM	p-Value
		1	2	3	4	5		
1. The oral surgery PW work has contributed to the development of my skills in oral surgery	Traditional	0 (0)	0 (0)	0 (0)	14 (38.9)	22 (61.1)	4.61	ns
	Blended	0 (0)	0 (0)	1 (2.7)	14 (37.8)	22 (59.5)	4.57	
2. The knowledge acquired during the oral surgery PW has a positive impact on my behaviour/practice	Traditional	0 (0)	0 (0)	0 (0)	20 (57.1)	15 (42.9)	4.43	ns
	Blended	0 (0)	0 (0)	0 (0)	18 (50.0)	18 (50.0)	4.50	
3. I share my knowledge from the oral surgery PW with my colleagues	Traditional	1 (2.7)	0 (0)	6 (16.7)	19 (52.8)	10 (27.8)	4.00	ns
	Blended	2 (5.4)	2 (5.4)	8 (21.7)	18 (48.6)	7 (18.9)	3.70	
<b>Change in self-positioning of skills between directly after the PW and at 6 months</b>								
<b>For each of the following skills, on a scale from 0 (not at all capable) to 7 (fully able), I feel able to:</b>								
4.1 Set up and maintain an organized and safe working environment with four hands (pair)	Traditional						1.36 ± 0.2	ns
	Blended						1.68 ± 0.2	
4.2 Implement different techniques of dental anaesthesia	Traditional						1.67 ± 0.2	.040
	Blended						2.22 ± 0.2	
4.3 Carry out the procedures that are mandatory for simple tooth extraction and tactilely perceive an empty tooth socket that has been correctly revised	Traditional						1.86 ± 0.2	ns
	Blended						2.11 ± 0.2	
4.4 Perform the necessary procedures for a surgical tooth extraction (mucoperiosteal flap, bone removal, root separation) and tactilely perceive the consistency of soft tissues and calcified tissues (teeth and bone)	Traditional						1.25 ± 0.3	.043
	Blended						1.81 ± 0.2	
4.5 Identify a wisdom tooth germ in its socket and tactilely locate it in its bone crypt	Traditional						0.17 ± 0.2	ns
	Blended						0.57 ± 0.2	
4.6 Implement the most common suture techniques in oral surgery	Traditional						1.31 ± 0.3	ns
	Blended						1.32 ± 0.3	

Abbreviations: ns, non-significant; PW, practical work.



**FIGURE 4** Clinical score of students in the traditional learning group and in the blended learning group in the 6 months following the practical work. Kirkpatrick level 4 (Results). Data are shown as mean  $\pm$  SEM, ns  $p > .05$  (Student's *t*-test).

videos the students had previously consulted online and that the students were better prepared and more efficient in carrying out the surgical procedures. This second hypothesis is corroborated by the fact that more students in this group said the theoretical input was sufficient for participating in the PW. Unexpectedly, students in the traditional group found the exchanges most rewarding than those in the blended group did. This may be because the students in the blended group received all the information they needed for the PW via the online platform and did not progress to more advanced surgical skills by obtaining the information from their supervisors, or that the supervisors did not provide additional information to that supplied remotely.

All students, with the exception of one in the traditional group, stated they felt engaged in the course. Student engagement represents the investment and energy that students devote to learning.<sup>9</sup> This concept is made up of three interdependent dimensions: behavioural, emotional, and cognitive.<sup>23</sup> Heilporn et al. described three classes of teaching strategies to foster student engagement in blended learning environments,<sup>9</sup> which were found here. First, the course structure and pace: in our study all the students found that the teaching objectives were clearly presented and the teaching structure was satisfactory, which promote behavioural engagement. Second, the selection of teaching and learning activities: all of the students found that the teaching seemed useful for their future clinical practice, and that the content of the course was satisfactory, which may have promoted their engagement in all three dimensions. The use of a preclinical training model is generally considered by European students to be useful for subsequent tooth extractions in a patient, but there are exceptions.<sup>2</sup> The type of preclinical model used, the practice time, the supervision, and the time elapsed between training with the model and the transition toward the clinic can affect the student' perception of the usefulness of the training model. Moreover, PW is a type of active learning that encourages behavioural engagement. Finally, the teacher's role and course relationships: All the students felt generally comfortable to participate in the PW that also promote behavioural engagement. There are

many factors that encouraged student engagement in this course, which means that it may be difficult to demonstrate the added value of blended learning.

At the second level of the Kirkpatrick model, blended learning resulted in an increase in the knowledge score, comparable to the increase observed in the traditional group. This finding is in line with the two systematic reviews based on RCTs in the field of dentistry.<sup>10,11</sup> However, it is contrast to the results of a study on dental anaesthesia, a procedure that was part of our PW program.<sup>12</sup> According to a meta-analysis in healthcare education, blended learning had a more positive effect on knowledge acquisition than traditional learning (standard mean difference 0.768, 95% CI [0.595; 0.941]), but the studies were heterogeneous.<sup>7</sup> Kirkpatrick level 2 is the most widely studied in the literature, given the objectivity of its assessment, while levels 3 and 4 are not sufficiently well documented to allow a valid conclusion to be drawn.<sup>7</sup>

The third level of the Kirkpatrick model was assessed 6 months after the students started their clinical practice. Students in the blended group made more progress than those in the traditional group regarding feeling able to implement dental anaesthesia and surgical tooth extraction. One explanation is that the online platform could be consulted whenever students in this group wanted to and it included useful resources for carrying out this procedure on humans. Videos help students to understand the surgical techniques in oral and maxillofacial surgery.<sup>24</sup> Anatomical diagrams on the platform could be of particular importance, as understanding the anatomy necessary to perform a procedure has been described to be an important factor engendering confidence.<sup>4,16</sup>

According to some authors, clinical competency and self-confidence are the main objectives of the professional health care programs.<sup>25</sup> This is why the combination of these two elements was defined as the outcome of our education program (level 4 of Kirkpatrick). While competency-based outcomes are the standard for evaluating educational interventions, student perceptions can be useful as a complement to these data.<sup>25</sup> Although subjective by nature, surveys assessing students' self-confidence in performing oral surgery procedures are reported to be useful to improve quality of teaching.<sup>5,16,26</sup> To assess it we used questions from the ABAOMS questionnaire.<sup>3,16,18,22</sup> In our study, the clinical competence was a global score, comprising all procedures, while the ABAOMS questionnaire was used as complement to assess only some particular dental procedures. Dental students' level of confidence in oral surgery after only 6 months of clinical practice appeared to be high, as more than 70% of the 4th-year students stated that the teaching in oral surgery was good preparation for independent practice. This rate is among the highest when compared with those reported in survey from the United Kingdom, Turkey, or Kuwait,<sup>3,4,16,18</sup> ranging from 45% to 79%. In addition to the training course, many factors can affect confidence such as gender<sup>3,16-18</sup> and the number of years of study.<sup>3,4</sup> In accordance with the literature, we showed that students felt more confident performing a simple exodontia of a single-rooted tooth than for other types of tooth extraction.<sup>3-5,16,18,26</sup> The surgical management of a failed extraction requiring bone removal

TABLE 4 Responses from dental students on their confidence in oral surgery procedures in the traditional learning group and in the blended learning group at 6 months (ABAOMS questionnaire), Kirkpatrick level 4 (Results).

Questions	Group	Score n (%)					Mean score $\pm$ SEM	p-Value
		1	2	3	4	5		
1. The teaching that I have received in oral surgery has given me sufficient knowledge to undertake independent practice	Traditional	0 (0)	0 (0)	9 (25)	22 (61.1)	5 (13.9)	3.89 $\pm$ 0.10	ns
	Blended	0 (0)	2 (5.4)	9 (24.3)	25 (67.6)	1 (2.7)	3.68 $\pm$ 0.10	
2. I feel confident that I could extract an upper single-rooted tooth with an intact crown, in an otherwise intact dentition	Traditional	0 (0)	0 (0)	0 (0)	14 (38.9)	22 (61.1)	4.61 $\pm$ 0.08	ns
	Blended	0 (0)	0 (0)	0 (0)	18 (48.6)	19 (51.4)	4.51 $\pm$ 0.08	
3. I feel confident that I could remove visible retained roots of an upper left first molar with elevators or forceps	Traditional	0 (0)	0 (0)	5 (13.9)	21 (58.3)	10 (27.8)	4.14 $\pm$ 0.11	ns
	Blended	0 (0)	0 (0)	5 (13.5)	22 (59.5)	10 (27.0)	4.14 $\pm$ 0.10	
4. I feel confident to assess and perform the surgical management of a failed extraction (e.g. a lower second molar) necessitating:	Traditional	3 (8.3)	6 (16.7)	13 (36.1)	11 (30.6)	3 (8.3)	3.14 $\pm$ 0.18	ns
	Blended	1 (2.7)	6 (16.2)	15 (40.5)	12 (32.4)	3 (8.1)	3.27 $\pm$ 0.15	
4.2 Bone removal	Traditional	2 (5.6)	8 (22.2)	10 (27.8)	12 (33.3)	4 (11.1)	3.22 $\pm$ 0.18	.044
	Blended	1 (2.7)	2 (5.4)	11 (29.7)	19 (51.4)	3 (10.8)	3.62 $\pm$ 0.14	
4.3 Sectioning the tooth to facilitate elevation of the roots	Traditional	0 (0)	3 (8.3)	5 (13.9)	21 (58.3)	7 (19.4)	3.89 $\pm$ 0.14	ns
	Blended	1 (2.7)	0 (0)	5 (13.5)	19 (51.4)	12 (32.4)	4.10 $\pm$ 0.13	
4.4 Wound closure using appropriate suture materials	Traditional	0 (0)	1 (2.8)	6 (16.7)	18 (50.0)	11 (30.6)	4.08 $\pm$ 0.13	ns
	Blended	0 (0)	1 (2.7)	2 (5.4)	26 (70.3)	8 (21.6)	4.10 $\pm$ 0.10	
5. Oral surgery is an enjoyable and rewarding discipline.	Traditional	0 (0)	0 (0)	7 (19.4)	8 (22.2)	21 (58.3)	4.39 $\pm$ 0.13	ns
	Blended	0 (0)	0 (0)	4 (10.8)	14 (37.8)	19 (51.4)	4.40 $\pm$ 0.11	
Total	Traditional	5 (1.7)	18 (6.3)	55 (19.1)	127 (44.1)	83 (28.8)	3.92 $\pm$ 0.06	ns
	Blended	3 (1.0)	11 (3.7)	52 (17.6)	155 (52.4)	75 (25.3)	3.97 $\pm$ 0.05	

Abbreviations: ns, non-significant.

had the highest response of not feeling confident in the traditional group, in line with previous studies.<sup>3,16,18</sup> This is probably due to the fact that this procedure requires more experience and coordination<sup>3</sup> and is intimidating for students, since it is one of the most invasive, even when students are competent to perform it.<sup>27</sup> Interestingly, the blended learning approach had a positive impact on confidence to assess and perform the surgical management of a failed extraction necessitating bone removal. This could be because students are conditioned to be more receptive to the tactile perceptions of this procedure, thanks to the recommendations of the online platform. Indeed, during the debriefings, only the students in the blended group emphasized the contribution of tactile perception (hardness of bone, teeth, and soft tissue flexibility). Another explanatory factor is access to the online platform containing anatomical diagrams. The superior progress made by the blended group regarding Kirkpatrick level 3 corroborates this hypothesis.

Self-assessment of confidence is a subjective indicator, and does not equate to clinical competence.<sup>3,5,16,22</sup> In our study, a positive correlation was found between self-assessment and the clinical score recorded. This finding supports previous studies showing positive correlations between the students' confidence level and the number of teeth they extracted.<sup>3,5</sup> The more tooth extractions the students performed, the more confidence they reported. By broadening the assessment to dental education in general, a systematic review evidenced that the predictive value of self-assessment on student performance is poorly studied. However, there is a tendency for the best-performing students to under-assess themselves, for the worst-performing students to over-assess themselves, and for students on the whole to rate themselves better than the teachers do.<sup>28</sup>

After 6 months, there was no significant difference between the clinical scores of students in both groups. The clinical score considered the students' autonomy in performing the surgical procedures as well as the difficulty. Nevertheless, it is possible that this score could not highlight a potential clinical impact of blended learning if this effect focused on some sub-categories of procedures such as surgical avulsions requiring bone removal, since these procedures are not the most frequent clinical conditions encountered. Another explanatory hypothesis is that the students in the blended learning group did not have superior technical skills for surgical avulsions requiring bone removal and that this could potentially lead to a safety problem for patients due to overconfidence. It should be noted that the size of the box plot was smaller for the blended group with a similar median, which suggests that blended learning could make it possible to reduce the variability of results between the students and thus create greater equity between them.

Our study has several unavoidable limitations. It is difficult to separate the participants in the two experimental groups of this RCT since they are all students of the same year of study. To reduce this bias, we digitally restricted access to the online platform to the blended group only, for the duration of the study. In addition, we asked through the final questionnaire whether the students of the traditional group accessed the online platform, which led to the

exclusion of one student in this group. Thus, the two experimental groups may not be strictly homogeneous, which could influence the results. However, randomization was stratified by gender and pre-test knowledge scores to prevent this bias. Then, students in the blended learning group benefited from more teaching hours than those in the traditional learning group, since they could spend as much time as they wished on the online preparation platform, and they benefited from an additional debriefing, that was, therefore, part of the intervention tested. This could be responsible for the higher levels of confidence observed in the blended learning group. Finally, we had nine blank answers, which represents only 0.4% of non-responses for the questionnaire.

## 5 | CONCLUSION

Teaching practical skills is an important part of the training course for future dentists. Oral surgery PW in its blended version combined face-to-face and distance learning with an online platform containing a variety of digital media (videos, animated and non-animated diagrams, interactive questions). Compared with traditional learning, our study showed that blended learning could have a positive impact on three of the four Kirkpatrick levels (levels 1, 3 and 4). It should be noted that the difference observed for level 4 concerns the subjective self-confidence and not the objective clinical score. Blended learning could be a promising prospect for oral surgery teaching, and efforts should be focused on the procedures that are perceived as the most difficult. Further high-quality comparative studies are needed to evaluate blended learning and its potential impact on clinical practice in order to improve healthcare education in undergraduate teaching.

### AUTHOR CONTRIBUTIONS

N.B. and A.C. contributed to the conception or design of the work. N.B., A.G.C., E.H., P.L. and A.C. contributed to the investigation. N.B. and A.C. drafted the manuscript. N.B., A.G.C., E.H., P.L. and A.C. critically revised the manuscript. All authors gave final approval and agreed to be accountable for all aspects of the work ensuring integrity and accuracy.

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### CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

## DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

## CONSENT

Informed consent was obtained from all subjects involved in the study.

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