INVENTOPIA 2025

FBM-SEREMBAN INTERNATIONAL INNOVATION COMPETITION (FBM-SIIC)

INNOVATION IN ACTION: TURNING IDEAS INTO REALITY

Chapter 65
Boosting Performance through Quick Align Solutions

Noorharliana Mohamed Zohdi[1], Aida Adriana Abdul Halim[3], Mazli Bonit[2] & Afzan Adilah Ayoub[1*],

[1]*Centre of Comprehensive Care Studies, Faculty of Dentistry, Universiti Teknologi MARA Sungai Buloh Campus, Jalan Hospital, 47000 Sungai Buloh, Selangor, Malaysia.*
[2]*Faculty of Dentistry, Universiti Teknologi MARA Sungai Buloh Campus, Jalan Hospital, 47000 Sungai Buloh, Selangor, Malaysia.*
[3]*Kementerian Kesihatan Malaysia*

[*]*afzan_adilah@uitm.edu.my*

ABSTRACT
Dental simulation training has become a fundamental part of undergraduate dental education. Traditional mounting systems, particularly those using Plaster of Paris (POP), have long been the gold standard. However, POP presents various limitations, such as brittleness, poor retention, difficulty in alignment, time-consuming procedures, and lack of reusability. This paper introduces Quick Align, an innovative simulation model that uses epoxy resin with a magnetic metal attachment to overcome these challenges. This model allows efficient mounting and realignment of extracted human teeth while ensuring strong retention in the phantom head simulator. It also incorporates features for radiograph-taking and improved compatibility with operative protocols like rubber dam application. Survey results revealed significant improvements in stability, efficiency, and user satisfaction, making Quick Align a sustainable, cost-effective, and educationally valuable solution.

Keywords: dental simulation training, preclinical dentistry, epoxy resin, phantom head, reusable model

1. INTRODUCTION

Operative dentistry is a branch within dentistry concentrated on the functional and aesthetic rehabilitation of hard tissues. It is also recognised as the cornerstone of dentistry. A fundamental aspect of the undergraduate curriculum in Operative Dentistry and Endodontics is preclinical laboratory or simulation training, which is crucial for developing clinical skills.

This includes the ability to identify carious lesions prior to removal, comprehend the significance of cavity preparation according to the selected restorative material, and restore the tooth to its functional state. In dentistry, the irreversible nature of most operating procedures necessitates that students possess the competencies required for safe execution of patient treatment and care (Perry et al,2015). Simulation enables trainees to practise procedures with pertinent skills and assessed competence without jeopardising an actual patient. Consequently, most psychomotor abilities are acquired through simulation prior to students engaging in direct patient care (Gottlieb et al,2013).

The simulation training has progressed from tabletop simulators utilising typodonts, plastic, or extracted human teeth in a phantom head to contemporary advancements in virtual reality technologies, haptics, and robotics. Nonetheless, dental simulation offers a more authentic clinical educational setting. The phantom head simulator has served as the primary simulation apparatus for preclinical training since its inception in 1894 (Perry et al,2015). The phantom head is attached to a dental operating unit with a torso, enabling positional adjustments for students to work in a sitting and ergonomically suitable manner, akin to a clinical environment. It facilitates the proficient manipulation of both the dental mirror and handpiece, wherein the foundational principles must be mastered prior to advancing to more intricate skills. Contemporary phantom heads feature a water spray mechanism, and genuine teeth may be affixed. The utilisation of "resin-based" or synthetic teeth became increasingly prevalent in preclinical dental education during the 20th century. Nonetheless, replicating real teeth with synthetic alternatives would pose a significant difficulty. The predominant critique was the erroneous resin hardness relative to dentine, leading to modified tactility, which resulted in the lack of a 'drop' into pulp chambers during access cavity preparation, difficulties in locating canal orifices, and complications in root canal instrumentation. The benefits of utilising excised real teeth, encompassing their inherent tissue hardness, shape, colour, texture, and radiodensity, provide them the optimal material for acquiring the fine motor skills essential in restorative dentistry (Decurcio et al,2019). The phantom head simulator was favoured, since students taught on the bench top encountered challenges in transferring abilities to the phantom head, although the reverse was not true (Clancy et al, 2002). In addition to operational dentistry and endodontics, phantom heads are utilised for instructing prosthodontics, periodontics, and paediatric dentistry.

Therefore, preclinical simulation provides a crucial bridge between theory and clinical practice in dental education. It allows dental students to develop essential motor skills, improve hand-eye coordination, and build confidence before treating real patients. The current standard—using POP for mounting extracted teeth (Figure 1)—presents multiple drawbacks: it's fragile, often misaligned, mouldy (Figure 2) and time-consuming to work with. In response to these issues, the Quick Align simulation model was developed to streamline training, enhance model durability, and reduce costs and time wastage.

2. LITERATURE REVIEW

Simulation-based learning has shown a significant positive impact on students' readiness and clinical performance. According to Perry et al. (2015), hands-on practice enhances students' dexterity and judgement. However, Decurcio et al. (2019) emphasize that artificial teeth fail to

replicate the tactile feedback provided by extracted teeth. Gottlieb et al. (2013) note that realistic materials are essential in preclinical endodontic training. Furthermore, Clancy et al. (2002) demonstrated that students trained in simulation environments perform better than those trained in conventional labs. Still, many of these benefits are lost when using outdated POP models, highlighting the need for a reliable, adaptable, and modern system like Quick Align.

Simulation-based education has become integral to dental training, providing students with a controlled environment to develop essential clinical skills before patient interaction. Perry, Bridges, and Burrow (2015) highlighted that simulation enhances psychomotor abilities and decision-making, leading to improved clinical performance. The evolution from traditional models to advanced simulation technologies reflects the ongoing efforts to optimise dental education.

Despite the advent of virtual reality (VR) and haptic technologies, physical phantom head models remain a cornerstone in preclinical dental education. Gottlieb et al. (2013) emphasised that these models offer tactile feedback crucial for procedures like cavity preparation and endodontic access. The realism provided by physical models aids in bridging the gap between theoretical knowledge and clinical application.

Traditional mounting methods, such as using Plaster of Paris (POP), present several challenges, including fragility, susceptibility to mould, and time-consuming preparation. Clancy et al. (2002) noted that these limitations could hinder the learning process and reduce the efficiency of simulation exercises. The need for more durable and user-friendly alternatives has become increasingly apparent.

Innovations in simulation materials and design aim to address these challenges. The development of models like Quick Align, utilising epoxy resin and magnetic attachments, offers improved stability and reusability. Such advancements align with the goals of enhancing educational outcomes while promoting sustainability and cost-effectiveness in dental training programmes. Thune et al (2025) highly recommended the advantages of using extracted teeth in learning dental anatomy and offers better educational results.

3. METHODOLOGY

The Quick Align model was produced from epoxy resin, offering enhanced strength and water resistance compared to POP. A hollow, arch-shaped groove (Figure 3) was integrated for mounting extracted teeth, with optional colours added for identification. Undercuts or grooves were added to the design to retain the mounting compound securely.

The key components include i) Thermoplastic compound: easily mouldable with warm water, allowing quick repositioning of teeth (Figure 4). ii) Radiograph sensor slot: integrated to allow intraoral radiographs to be taken without removing teeth (Figure 5), and iii) Magnetised base: replacing the brittle POP base with a secure metal attachment that holds firmly in the phantom jaw (Figure 6), facilitating stability during procedures like rubber dam placement. Students have the customisable options of full-arch or quadrant-based gutters for varied training needs.

4. RESULT & DISCUSSION

Pre- and post-evaluation among preclinical students was distributed. Based on the result, highly positive feedback was received. 88% of the users found the alignment process much easier than POP models. While 100% agreed the Quick Align model was more stable in the phantom head. 63% said it saved significant preparation time. More than 2/3 of the participants (75%) indicated the model was user-friendly in tooth mounting.

The model's reusability makes it cost-effective and environmentally sustainable. Unlike traditional POP models, which are disposed of after use or become mouldy over time, Quick Align can be cleaned, reused, and passed down to future cohorts. This significantly reduces material waste and long-term operational costs. The integrated radiograph slot is especially beneficial for endodontic training and minimises procedural interruptions.

5. RECOMMENDATION

The Quick Align simulation model addresses the inefficiencies of conventional mounting systems in dental education. By improving stability, simplifying alignment, and supporting radiographic procedures, it enhances both student learning and institutional resource management. Its sustainability and adaptability make it a highly promising innovation. We recommend its adoption in all dental faculties, along with future improvements such as smart feedback integration or haptic-enabled learning systems.

Figure 16: Traditional POP foundation

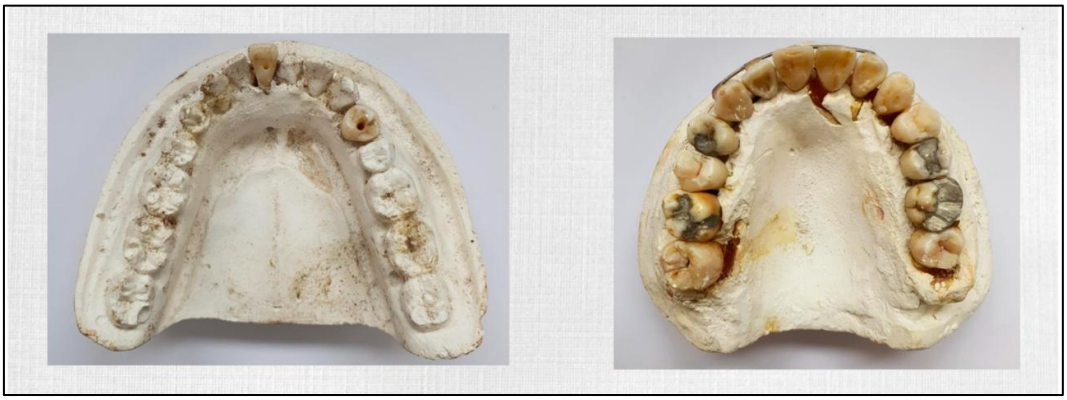

Figure 2: Mouldy foundation

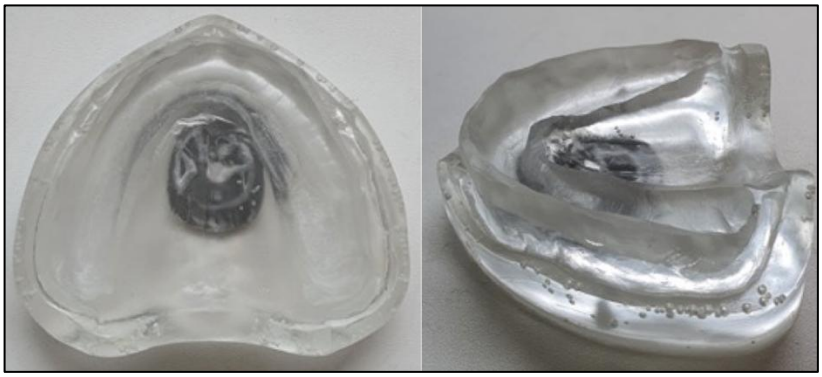

Figure 3: Quick Align dental simulation model

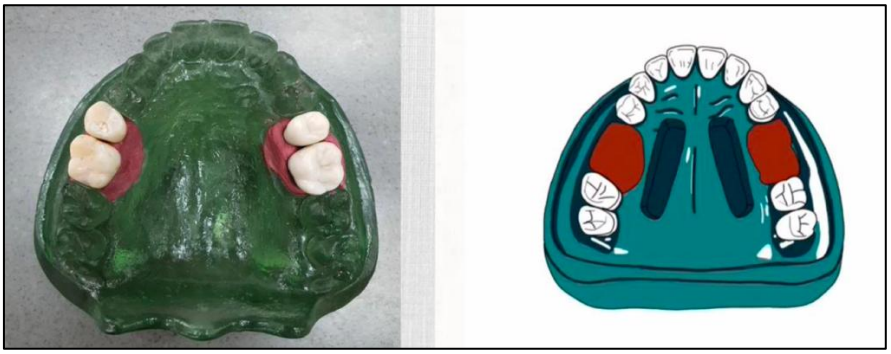

Figure 4: Compound material is utilised to secure the extracted tooth in position.

Figure 5: Retention-enhancing features, such as undercuts or grooves, can be incorporated into the hollow segment to augment retention. A radiographic sensor slot has been incorporated in the centre of the model to facilitate radiograph acquisition for endodontic procedures.

Figure 6: Metal attached on the epoxy substrate to substitute the non-retentive plastic fastener

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