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Use of Manual Dexterity Tests in Dental Education

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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Review Article

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ABSTRACT

Background: Manual dexterity is a skill that dental students must develop to help overcome the initial difficulties they face in their training. For this reason, screening individuals to determine the extent of their manual dexterity prior to their pre-clinical training seems to be an important way to establish which strategies may facilitate this learning process. Dexterity tests and assessments specific to the field can be very useful in this respect.
Objectives: The purpose of this study was to perform a literature review to determine which manual dexterity assessment methods have been used in dental education programs.
Methods: The review was performed using the terms "manual dexterity", "dentistry", "dexterity tests", and "dental students".
Results: A total of 38 articles were collected, being the majority English-language articles on the topic of manual dexterity assessment were considered (n=22 articles). Of these 22 articles, 17 addressed the topic of manual dexterity tests in the field of dentistry.
Conclusion: The studies used manual dexterity tests as part of the dentistry program admissions process, to predict student performance in practical courses and/or to aid in the practical learning process; however, most of the tests applied had not been created specifically for dentistry.

Keywords: Manual dexterity; occupational health; ergonomics; dental students.

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1. INTRODUCTION

As part of their professional education, dental students must develop cognitive and practical skills and competences [1-3] that will enable them to independently maintain a safe and effective practice [3-4].

To reach this point in their education, students must receive complementary theoretical and practical training. In this context, manual dexterity represents an important factor in the transition from theory to practice [1,4-5]. Fine motor skills [4,6] and spatial intelligence [7] are competences that are often developed in pre-clinical training labs. However, because this training takes place in the initial phases of dentistry programs, some students still fail to possess sufficient experience and continue to face difficulty with respect to these skills.

For this reason, screening individuals to determine the extent of their manual dexterity prior to their pre-clinical training seems to be important. Through this screening process, individual difficulties may be revealed, and strategies may be established to allow students to make the most of their practical training.

Manual dexterity is understood as the ability to synchronise muscle movement and vision; it is a skill that is considered unique to each individual [8]. Small object manipulation is defined as dexterity of the fingers, dexterity with objects such as tweezers and fine motor dexterity [1,9], all of which play important roles in the dentistry profession.

The most commonly used tests to assess manual dexterity are the Purdue Pegboard Test, the Minnesota Manual Dexterity Test, the Box and Block Test, the O'Connor Dexterity Tests and the Functional Dexterity Test [8]. Though all of these tests measure dexterity, each one is unique, and they are therefore recommended for different purposes [8-9].

Given the importance of improving manual dexterity in dental training programs, it is recommended that a series of tests specific to the field be selected to aid in the learning process. Thus, this literature review sought to determine the manual dexterity assessment methods currently used in dental education.

2. METHODOLOGY

This literature review was performed using the Science Direct, Scientific Electronic Library Online (SCIELO) and National Library of Medicine (MEDLINE) databases, which were searched to find articles published between 1985 and 2018.

The search was focused on manual dexterity assessment in the dentistry profession. The main keywords were "manual dexterity," "dentistry," "dexterity tests," and "dental students." A total of 38 articles were collected. Articles were included in the review being the majority complete articles published in English and if they addressed manual dexterity assessment. A total of 22 articles were included.

3. RESULTS AND DISCUSSION

The articles are presented in Table 1. This literature review revealed that a majority of the articles considered (n=17) addressed manual dexterity tests in the context of dentistry [1,3,4,5,7,10,11,12,13,14,15,16,17,18,19,20,21].

Manual dexterity is extremely important in the pre-clinical phase of dental education [7;4]. The search of the literature produced studies that have evaluated dexterity, though the studies' ultimate recommendations for the use of dexterity tests varied: while some studies support the use of dexterity tests in admissions programs or to predict student performance in practical courses [13,1,19], others argue that dexterity assessments can aid in the practical learning process and in the development of motor skills [18,7,5,3,4].

The schools that include these tests in their dental program admissions processes also provide specific student selection processes in general [11,12,15,1,18,19]. Cognitive ability is also extensively evaluated through the use of theoretical exams or grades from higher school or other academic programs; when evaluating motor skills or predicting pre-clinical performance, different tests have been applied [13,1,19].

Kothe et al. [19] and Schwibbe et al. [20] argue that, although the wire bending test (part of the HAM-Man) was developed to measure motor skills in pre-clinical laboratory courses, it was found to be very useful in dental student admissions processes; it seems to be a greater predictor than grade point average (GPA), which is more useful for evaluating cognitive abilities. Lundergan et al. [1] evaluated the O'Connor Tweezer Dexterity Tests (Models #32022 and

Table 1. Manual dexterity assessment tests considered in different publications in the literature and their applicability in the field of dentistry

Author(s)	Ability test considered	Applicability / recommended use
Mathiowetz et al., [22]	The Box and Block Test	Useful when evaluating training programs designed to improve manual dexterity.
Kramer et al., [10]	The Perceptual Ability Test (PAT), which consists of 5 subtests: a) orthographic projections; b) angles; c) apertures; d) cubes; and e) form development.	Most useful for observing specific abilities.
Spratley et al., [12]	a) The Pins and Collars Test; b) the Right- and Left-Hand Screw Test; c) the Needle-Threading Test	Useful for predicting which dental students will be unqualified or inept.
Simon et al., [11]	Aptitude tests: structural visualisation, dexterity, personality, reasoning, language skills and memory; Dexterity tests: finger dexterity, tweezer dexterity	The combination of aptitude and dexterity tests is important in attempts to discern aptitude for the dentistry profession.
Luck et al., [13]	Fine motor skill tests: a) tremometer test; b) tremometer test with a mirror; c) two-hand sinusoid test; d) electronic archery (video game).	Not recommended as admissions tests for dental education programs. Useful for observing the development of motor skills over the course of pre-clinical training.
Wanzel et al., [23]	Six visual-spatial tests with different degrees of complexity: the pure image test (recognising simple shapes) and mental rotations and formula tests (ability to mentally spin two- and three-dimensional blocks).	Useful for identifying students' visual-spatial abilities in order to guide their training.
Wanzel et al., [14]	a) The Low-Level Visual-Spatial Ability Phase Discrimination Test; b) the Intermediate-Level Visual-Spatial Ability Gestalt Completion Test; c) the High-Level Visual-Spatial Ability Mental Rotations Test; d) the Surface Development Test; and e) the Fine Motor Manual Dexterity Crawford Small Parts Dexterity Test	Visual-spatial ability tests are more important during initial training in procedures that require motor skills; their importance diminishes as students gain experience in performing related procedures.
Gansky et al., [15]	The Manual Dexterity Test	Useful for identifying some of the individuals who will experience difficulty in pre-clinical training.
Lundergan et al., [16]	a) Structural visualisation tests; b) a visual memory test; c) a manual dexterity test; and d) admissions tests	Dexterity tests should be included in dental program admissions processes only after careful consideration, since some tests may not be predictive of student performance.
Lundergan et al., [1]	a) The O'Connor Tweezer Dexterity Test (Model #32022); b) the O'Connor Tweezer Dexterity Test (Model #18)	Useful for analysing pre-clinical performance in restorative dentistry, fixed prosthetics and endodontics. They offer little in terms of predictive value for use as admissions tests.
Berger et al., [9]	a) The Purdue Pegboard Test; b) the O'Connor Finger Dexterity Test	The Purdue Pegboard Test is useful for analysing motor coordination and both gross and fine motor skills; the O'Connor finger dexterity test may be used to predict rapid small object manipulation skills.
Yancosek et al., [24]	a) The Box and Block Test; b) the Crawford Small Parts Test; c) the Functional Dexterity Test; d) the Grooved Pegboard Test; e) the Jebsen Taylor Test of Hand Function; f) the Minnesota Manual Dexterity Test; g) the Minnesota Rate of Manipulation Test; h) the Moberg Pick-Up Test; i) the O'Connor Finger Dexterity Test; j) the Purdue Pegboard Test; k) the Sequential Occupation Therapy Dexterity Assessment; and l) the Wolf Motor Function Test	Tests (a), (c), (d) and (f) are recommended for evaluating overall manual dexterity; tests (j) and (f) are useful for fine manual dexterity assessment; test (b) can be used to test manual and finger dexterity; test (e) is useful for evaluating fine dexterity and finger dexterity; test (g) can be used to assess bilateral manual dexterity; test (h) is recommended for manual dexterity and fine motor skill assessment; test (k) is specifically for patients with rheumatoid arthritis; and test (l) can be administered to evaluate functional dexterity in acute or subacute stroke patients.
Urbankova et al., [18]	Individual Dental Education Assistant (IDEA) Simulator (IDEA Dental, Las Vegas, NV, USA) is a computer-assisted simulator that uses haptic technology (SenAble Technology, Woburn, MA, USA)	This device may be used in dental education programs to both predict and aid in the development of students' motor skills.
Dimitrijevic et al.,[17]	Depth Perception Task; Distance Estimation Task; Writing Task	Useful for assessing students' difficulty in applying the concepts of depth and distance to dentistry and for aiding in students' development of motor skills and the ability to understand instructions.
Gal et al., [7]	Individual Dental Education Assistant (IDEA) Simulator (IDEA Dental, Las Vegas, NV, USA)	May offer potential benefits in education, such as the development of self-perception and improved manual dexterity.

Author(s)	Ability test considered	Applicability / recommended use
Kothe et al., [19]	Hamburg Assessment Test for Medicine - Manual Dexterity (HAM-Man)	An instrument that assesses motor skills and which is used in dental program admissions processes.
Gonzales et al., [8]	The variable dexterity test is based on four subtests: precision, cylinder, spherical and extended spherical tests.	Useful for assessing overall functional dexterity of the hands in daily activities.
Koo et al., [5]	Individual Dental Education Assistant (IDEA) Simulator (IDEA Dental, Las Vegas, NV, USA) is a computer-assisted simulator that uses haptic technology (SenAble Technology, Woburn, MA, USA) with a manual dexterity module	Useful for manual dexterity analysis and training.
Al-Saud et al., [4]	Simodont VR Haptic Dental (MOOG, Nieuw Vennep, Netherlands) supported by bespoke 'Courseware' software (Academic Centre for Dentistry Amsterdam, Amsterdam, Netherlands) with a range of manual dexterity exercises.	Useful for the analysis and development of fine motor skills.
Schwibbe et al., [20]	a) Hamburg Assessment Test for Medicine – Natural Sciences (HAM-Nat) b) Technical Aptitude of the Leistungspruefsystem c) Hamburg Assessment Test for Medicine – Manual Dexterity (HAM-Man).	Test (a) is recommended for assessing cognitive ability; test (b) is recommended for assessing spatial ability; and test (c) is recommended for assessing motor skills.
Bakler et al., [3]	Simodont VR Haptic Dental Trainer supported by the "courseware" software with a range of manual dexterity exercises	Useful for developing the skill of self-assessment in the evaluation of manual dexterity.
Lugassy et al., [21]	Purdue Pegboard test and O'Connor Tweezer Dexterity test under different conditions of direct and indirect vision	1.The O'Connor test under indirect vision is the most appropriate way to monitor and predict the manual skills required of dental students. 2.Three parameters (the initial phantom course grade, the O'Connor test under indirect vision and the Purdue test using both hands) predict the success of dental students during the initial phases of phantom training.

#18) to determine whether they could be used as dental program admissions tests; the authors compared these tests to the Perceptual Ability Test (PAT), which is commonly used as part of the admissions process. They found that the O'Connor Tweezer Dexterity Test did not exhibit sufficient reliability to be used as a replacement for the PAT, which is useful for observing specific skills [10]. Some fine motor assessment tests, such as the tremometer test, the tremometer test with a mirror, the two-hand sinusoid test and tests involving archery video games have been used on dental students and students in medical school to assess motor skills. They were found to be ineffective as admissions tests but practical when used to predict performance [13].

Meanwhile, Gansky et al. [15] considered the Manual Dexterity Test and its ability to predict performance in pre-clinical courses. Scores on this test, which requires students to carve a two-sided geometric shape similar to that of a class II cavity preparation into a chalk block, were found to be predictive of students' difficulties in their courses. However, most of the students who failed the Manual Dexterity Test were nevertheless able to develop the motor skills necessary to graduate from the program.

The Virtual reality simulators (VRSs) have also been used to predict performance [24]. VRS technology has been cited by various authors [7,18,5,3,4] as a tool that can contribute to the development of motor skills. Gal et al. [7] and Al-Saud et al. [4] highlight the possibility of this technology to provide simultaneous feedback with standardised assessments. VRSs have been proposed to enable more training hours for students without the need for a professor or instructor [7,5,4,3]. Bakler et al. [3] suggest that the use of VRSs promotes student independence in choosing how and when to practice and develop their skills and ultimately allows students to choose times in which they will be most receptive to assessment. However, Al-Saud et al. [4] emphasise that multi-modal feedback (the use of VRSs combined with an in-person professor or instructor) is still the most effective option in the learning process. The exercises offered by VRSs are typically simple and non-specific and the use of tools that are more consistent with professional experience, such as cavity preparation activities, may better assist in the development of students' motor skills [5].

This literature review revealed that most of the tests used to assess manual dexterity were not created specifically for evaluating or training dental students. The most commonly cited tests were the Purdue Pegboard Test [9,24,25], the O'Connor Finger Dexterity Test [1,9,24,25,26] and the Minnesota Rate of Manipulation Test [24,25,27]. The Purdue Pegboard Test is used to assess fine finger dexterity skills [9,25] and is considered the test of choice for this specific type of dexterity [25]. The O'Connor Finger Dexterity Test is used to assess rapid small object manipulation [9,26] and the results of the different versions of this subtests have been correlated with performance in pre-clinical dentistry courses [1]. Nevertheless, authors have reported the need to apply these tests with caution, since few studies have evaluated their validity or reliability [25]. The Minnesota Rate of Manipulation Test is the test of choice for assessing gross motor skills [27].

In order to effectively develop manual dexterity, the visual and perceptual skills must be considered [17]. Wanzel et al. concluded that the ability to mentally plan the sequence of a procedure is very important in determining the final performance of this procedure [14].

According to Lundergan, dexterity tests are not predictors of performance in dentistry courses and the fine hand-eye coordination can be trained by dental students during the preclinical course [16]. Lugassy et al. mentioned that the main difficulty that students met during the preclinical course is to deal with indirect vision. This ability significantly improves with training and the use of tests that develop manual dexterity with indirect vision may be beneficial for students who are experiencing greater difficulties [21].

For a test to be considered adequate or appropriate, it must provide important information, such as the quality and speed of manual performance [8] and it must provide precise and valid data. Therefore, more studies must be performed in this field to confidently establish which tests can aid in the teaching and assessment processes involved in dental education [18].

4. CONCLUSION

The studies considered in this literature review used manual dexterity tests as part of the dentistry program admissions process, to predict student performance in practical courses and/or to aid in the practical learning process. The tests

used specifically for dentistry were HAM-Man, Perceptual Ability Test (PAT) and Manual Dexterity Test (MDT). However, because most of the tests applied were not developed specifically for dentistry, further research is encouraged to ultimately improve the quality of dental student admissions, assessment and education.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

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COMPETING INTERESTS

All authors have declared that no competing interests exist.

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