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ABSTRACT

A logical, performer-based approach to teaching psychomotor skills is described. Four phases of surgical psychomotor skills training are identified, using an example from a dental preclinical training curriculum: (1) dental students are acquainted with the postural and positional parameters of balanced psychomotor performances; (2) students learn the basic psychomotor skills in a setting that stimulates an optimal operational setting regarding spatial dimensions, tissues, and perceptual features (e.g., sight, sound, smell); (3) students apply the basic skills in an optimal clinical setting that is consistent with their preclinical setting; and (4) students apply their knowledge of postural and positional parameters (performance logic) to nonideal operational settings so they can learn to adapt equipment to their needs as human operators. The example from dental training is the surgical cutting of dental hard tissues with a high speed aid turbine handpiece. The following steps are involved: specifying parameters in numerical terms for both task end product and process; confirming parameters plus performance practice, evaluating the targeted tooth, cutting simulated tissues in the simulation setting, evaluating the end product, and correlating process and product. Worksheets and diagrmas that illustrate these steps are included. (SW)

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Division I: Education in the Professions

Performance Simulation: The Method

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INTRODUCTION

Various presumptions will be made at the outset of the following discussion of the applications of performance logic and performance simulation to preclinical dental education.

We presume a human performer, operating in a setting in Earth's gravitational field. That is, we recognize the force of gravity. This seemingly unremarkable presumption is the all-important starting point for performance logic. We also assume that there is a requirement for fine motor (micromotor) skills in the clinical practice of dentistry.

With performance logic, we shall identify those basic skills critical to the psychomotor performances of dentistry in the context of frequency, timing, and duration of associated tasks in the optimal clinical operational setting. Then we can define the clinical operational processes related to these psychomotor skills according to numerical parameters which specify the posture and position of the human operator in free space, relative to the "ZYX 0", or focal point of operation.[1,2,3] Such free-space configurations for operator positioning are designated with the presumptions of 1) an oral field of operations in a human subject (patient), and 2) the associated limitations imposed thereby for the relative positioning of the operator and the operating site.

ABSTRACT

This paper describes a logical, performer-based approach to the teaching of psychomotor skills.

After identifying four basic phases of surgical psychomotor skills training, it is shown how students can be brought to any tasks in such a way that they will be able to derive adequate balance and control to minimize their dependence upon any ergonomic compromises of equipment which they may be called upon later in practise to use for such tasks.

An example taken from a dental preclinical training curriculum is used as an illustration of the practical utilization of this method, detailing how the performance simulation method can enhance the performer's conceptual and perceptual appraisal both of the postural aspects of psychomotor tasks, and of the precision of the end products as well.

The Phases of Performance Simulation Learning

Bearing the foregoing in mind, we are prepared to apply performance logic to a statement of our intentions for the psychomotor training aspects of dental education:

Phase 1. Dental students are to be acquainted with the postural and positional parameters of balanced psychomotor performances, with special emphasis on the effects of variation in each parameter on the performance of micromotor skills. Illustrations for this phase are best drawn from dental surgery, where tolerances are often less than 0.3 mm in all three spatial dimensions. The phase is initially cognitive, but there is a strong psychomotor correlation component as each parameter is examined and applied in "free space" (non-equipment-bound) exercises. The teaching of this phase involves introduction of the students to the numerically based reference language, which consists of nine sets.[1,2,3,4,5,6] Any part or all of these numerical sets may be employed in the cognitive and/or psychomotor teaching phases, depending upon the desired degree of detail in specification of either process or end products, and depending upon the linguistic makeup of the group of students.

The important message of this first phase of training is this: <u>the student performer's inate, keen sense of proprioceptive balance must be trusted and cultivated.</u> If this sense has been contaminated by either previous habit or setting, the problems must be illuminated and eliminated before the introduction of the simulation hardware of Phase 2 further complicates them.

Phase 2. Students are given an opportunity to learn the basic psychomotor skills in a setting which simulates an optimal operational setting regarding spatial dimensions, tissues, and perceptual (sight, sound, smell, temperature, etc.) features, and which is logical and consistent with the performance balance learned on a theoretical basis earlier. The important messages of the teaching of this preclinical phase is this: <u>the software must precede the hardware, not vice versa.</u>

Ideally, the performance simulation setting should encourage the student's awareness of the learned postural/positional parameters. To this end, certain variables found in the optimal clinical setting may be limited or fixed (e.g., a back pole for the operator's spinal reference, a fixed position light, etc.), although the value of such limitations is currently under especially close scrutiny[7]. No hardware, no matter how perfectly ergonomically conceived or engineered, will accommodate all human users without some requirement for some adaptation of some individuals to it. This further emphasizes the need for each individual to have a solid free-space reference for balance prior to beginning work in any hardware setting, whether in the Simulation Laboratory or in the clinic.

Phase 3. Once these basic skills have been learned in the preclinical setting, it is important to give students the opportunity to apply them in an optimal clinical setting, and in one which is consistent with their preclinical setting. The monitoring of the process and end products in this clinical setting must be as identical to that of the preclinical setting as is consistent with the requirements of good patient care.

As the student establishes full postural/positional and/or end product self-monitoring skills, training may expand to more complex diagnosis and treatment challenges. Any new psychomotor skills which are introduced at any point in training should be related in specific terms to the reference base upon which fine motor skills have been built already for the student. This sort of consistency, in practical dental educational terms, requires a high degree of performance logic literacy amongst course coordinators involved in the teaching of both preclinical and clinical psychomotor courses. However, even in the absence of such consistent instructor orientation to performance logic, it has been our observation that there is considerable positive pressure from knowledgeable students on instructors to account for any illogical or inadequate postural/positional demands of any new psychomotor challenge.

Phase 4. At some time during their monitored clinical education students should be given an opportunity to apply their knowledge of postural/positional parameters (performance logic) to a representative sampling of non-ideal operational settings of the sort they are likely to encounter (and in which they may be expected to perform their micromotor skills in the unmonitored clinical practice world) so that they can learn how best to adapt equipment to their needs as human operators.

A Preclinical Exercise

In order to review the unique characteristics of the performance simulation teaching method, and of the logic upon which it is based, we will select and analyze a single preclinical simulation exercise (from Phase 2, above), the surgical cutting of dental hard tissues with a high speed air turbine handpiece.

This exercise will be accomplished in two different settings: the performance simulation setting (in which all simulated clinical portions will be performed) and the nearby Measurement Laboratory setting (in which will occur the precise measurements of the planned and actual end product of the performance, and in which most of the evaluation and discussion will take place immediately following the psychomotor performance). The two distinct settings, even if they be housed in the same room or laboratory, allow for clear separation of the artificial portions from the realistic clinical portions of the exercise, and promote higher quality monitoring of both performance process and end product. This separation of settings makes more obvious to both performer (operator) and monitor when any inefficiencies or deficiencies in preparation are compromising the simulated surgical performance. It also helps clarify whether a particular problem is conceptual, psychomotor, or both.

Step 1. Parameters specified in numerical terms for both task end product and process. It is important that the critical control points (usually the tooth landmarks and the extremal points of the proposed tooth cavity preparation outline - Figure 1) be clinically valid. If they cannot be so, then they should be clearly identified for their arbitrary nature. Inappropriate physical (e.g., visual and proprioceptive) references can be highly detrimental to early psychomotor learning.

Process parameters (Figure 2) can be practiced productively in free-space as well as in the performance simulation setting.

The degree of detail of the evaluation parameters must be appropriate to the level of psychomotor skill development and to the specific exercise at hand.

Step 2. Confirmation of parameters plus performance practice -- "targetting". Using the Handpiece Pen* (a simulation of the high speed handpiece which makes a 0.1 mm wide ink mark --- Photo 1), the student will mark the specified tooth landmarks and extremal points for the planned tooth cutting (Photo 2). This is an excellent control exercise on its own and gives the student a strong proprioceptive awareness of the three dimensional surface morphology of the tooth to be cut. If the student makes any errors, the marks can be wiped off with solvent and the step repeated until this level of control is accomplished. Hence, there is no tissue destruction associated with any early errors of control: even with simulated tissues, destructive results can still be psychologically depressing for the student just beginning micromotor control exercises.

The colour-collar on the Handpiece Pen increases student awareness of appropriate mirror (view) angles -- if the operator sees the collar, the mirror is located so that the working surface will be obscured by the required water spray coolant during use of the highspeed handpiece itself. (This is an example of the artificial manipulation of a variable during simulation, as described in Phase 3 above).

As the students practice drawing the prescribed dots and lines in the Performance Simulation setting, under the watchful eyes of monitors who can give immediate feedback on the performance process (Figure 3), the students are practicing three-dimensional perception and control of an instrument with absolute spatial fidelity to the final cutting instrument.

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* Manufactured by J. Morita Corporation.

Step 3. Evaluation of "targetted" tooth. This is first done in the Performance Simulation setting, using the instruments and techniques consistent with clinical evaluation of such a psychomotor task, i.e., dental mirror, explorer, and periodontal probe. Then the evaluation is done in the Measurements Laboratory setting using a 10x scope (Photo 3) to confirm the correct completion of Step 2 and the student's perceptual and conceptual accuracy in the performance simulation setting.

Step 4. Performance of the surgical cutting of the simulated dental hard tissues in the performance simulation setting. This must be accompanied by immediate feedback by an external monitor in order to correlate kinesthetic perceptions by the student with the observed control and balance.

Step 5. Evaluation of the end product. As for Step 3, this will occur first in the performance simulation setting, using clinical instruments, and then immediately thereafter in the Measurements Laboratory setting. Any errors in the end product are quantified and specified by the student according to the prescribed tolerances, and this self-evaluation can be easily confirmed by an instructor.

Step 6. Correlation of process and product. After these results are correlated (this can occur in either, or both, settings) the student will be able to assess the degree of success and to identify sources of error. Comparisons with the student's past evaluations for this task (or for related tasks) is useful for diagnosis of errors of process and/or product. The numerical gridded format for evaluating psychomotor performances lends itself particularly well to pattern recognition for troubleshooting specific errors or types of errors.

Summary

The performance simulation method is a logical, performer-based approach to the teaching of psychomotor skills. It is basically software-oriented, although undeniably it can be well supported with appropriate hardware, for greater ease of monitoring and learning. Ultimately, of course, any hardware should be logically conceived and engineered to accommodate to the human performer's needs in such a way as to enhance the performance, not to compromise it. However, the application of the performance simulation method in psychomotor teaching has great value even when utilized with the most dismally compromising of hardware, provided that it is the performer which is the reference starting point, not the equipment.

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FIGURES

LR/mc
File Ref: RD/FACULTY;LR/PS/METHOD

PERFORMANCE SIMULATION DIMENSIONAL EVALUATION WORKSHEET

14 O SLOT — BUR# 331

/ /
YY MM DD

Student : ____

SimLab Wing#: ____

Ma	1	4	Ta	5	2	1	1	Me

PLANNED DIMENSIONS — ACTUAL DIMENSIONS — ERRORS

Te	Me	To	Mi	Mu	Te	Ma	No 0	1	2	3	4	5	6	7	8	9	Z	Y	X	T	Z	Y	X	T	Z ±	Y ±	X ±	T	ZY ±	ZX ±	YX
	[illegible]	[illegible]	1 4	→2		1 4				1			0																		
	[illegible]	[illegible]		→		1 4				1			4		1			0	0												
						1 4				1			3		1				0												
						1 4				1					2	0															
						1 4				1			2		1																
						1 4			1	1			3		1		1 7														
						1 4			1	1			4		1		1 7														
						1 4			1	1			5		5		1 7														
						1 4			1	1			6		6		1 7														
HIGH SPEED →																				2 C											

FIGURE 1

Te	Step Name
01	Highspeed Set (mo31 8292)
02	
03	
04	
05	
06	
07	
08	
09	

COURSE RD 410

PERFORMANCE SIMULATION SET SPECIFICATIONS

PROCEDURE: m 25 0 slot

Ne	Instrument Name
21	High Volume Evacuator
51	331 Bur

Ma | Ra

Ce | Ne | Co | Mi | Mu | Te | Ma | No 0 1 2 3 4 5 6 7 8 9

FIGURE 2

Performance Simulation Laboratory Monitor Form

Assessment of Process and Human Contact - Oral Care

Draft # 840717 U.B.C.

Date: __/__/__
YY MM DD

ma ____ ta ____ me ______________

Setting 1 - Monitored by ____________

Setting 2 - Monitored by ____________

Muscle Memory Sets																									# of ma-mo Errors								Note
STUDENT station #1 Name	mi									mi															Z		Y		X				
	01	02	03	04	05	06	07	08	09	1+	2+	3+	4+	5+	9	me me	mi mo	mi ma	mi mu	mu mo	mi Z YX	mi to	te T	me	+	-	+	-	+	-	ZYX Sum	YX ZX ZY	
WILLETTS, Sally																																	
FLETCHER, Jack																																	
CIAMMAICHEL[illegible] Tony																																	
YAN, Tim																																	
MARANDI, S[illegible]																																	
ZARIKOFF, Dean																																	
BARLOW, Chris																																	
OGASAWARA, Dwayne																																	
SUN, Alice																																	
KWONG, Wilson																																	

Performance Simulation Setting

- 0 = Muscle Memory Sets Within 0 Range (OK)
- 1 = Aware of Adaptation To Setting Outside 0 Range of Muscle Memory Sets
- 2 = Evident Lack of Awareness of Reference Muscle Memory Sets

Measurement Laboratory Setting

Z,Y,X + : Error of Excess of Dimension
- : Error of Shortage of Dimension

YX, ZX, ZY: Angle Error (Tooth Positioning, e.g.)

me-me: Instrument Layout
mi-mo: Finger Rest
mi-ma: Human (Performer-Patient) Contact (lip Retraction, etc.)
mi-mu: Performer-Instrument Contacts (mi-mu-ma & mi-mu-me)
mu-mo: Instrument-Task Object Contacts
miZYX: Peformer's Paths of Motion Relative to Reference
mi-to: Force Application
te-T : Time (Frequency, Duration), Steps & Start-En Route-Stop
me: Finishing Status - Cleanliness, - Organizations

File Ref: RD/Faculty; LR/PERF/SIM.5

FIGURE 3

PHOTO 1

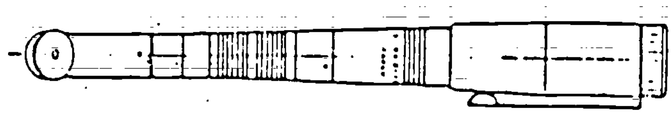
DENTAL HIGHSPEED HANDPIECE TRAINING PEN

Features

* Lines for preparation and reference points may be made on the dental model inside the manikin head in a manner simulating actual clinical conditions.

* Using the grip marks on the Training Pen, correct handpiece grips can be practiced.

* The color of the ink can be changed easily by changing the cartridge. (Red, Green, Black and Blue ink cartridges are provided)



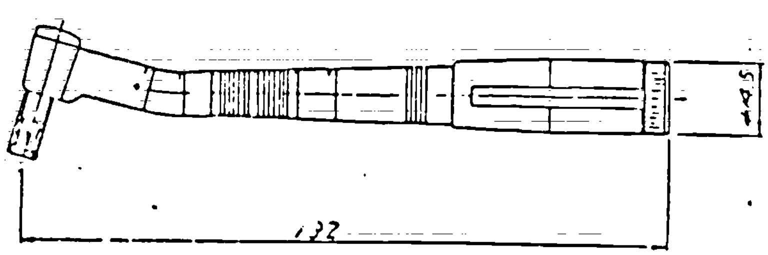
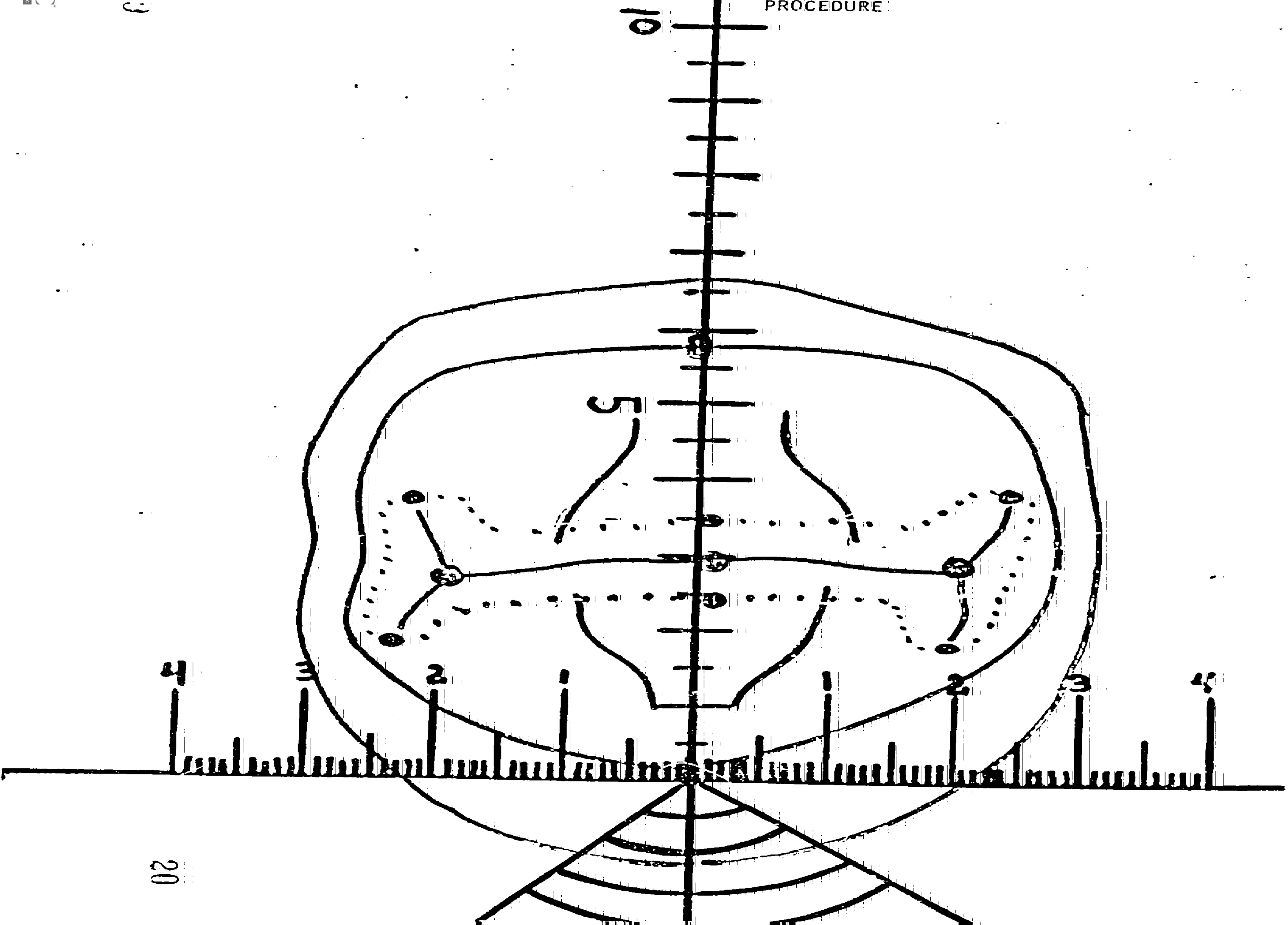
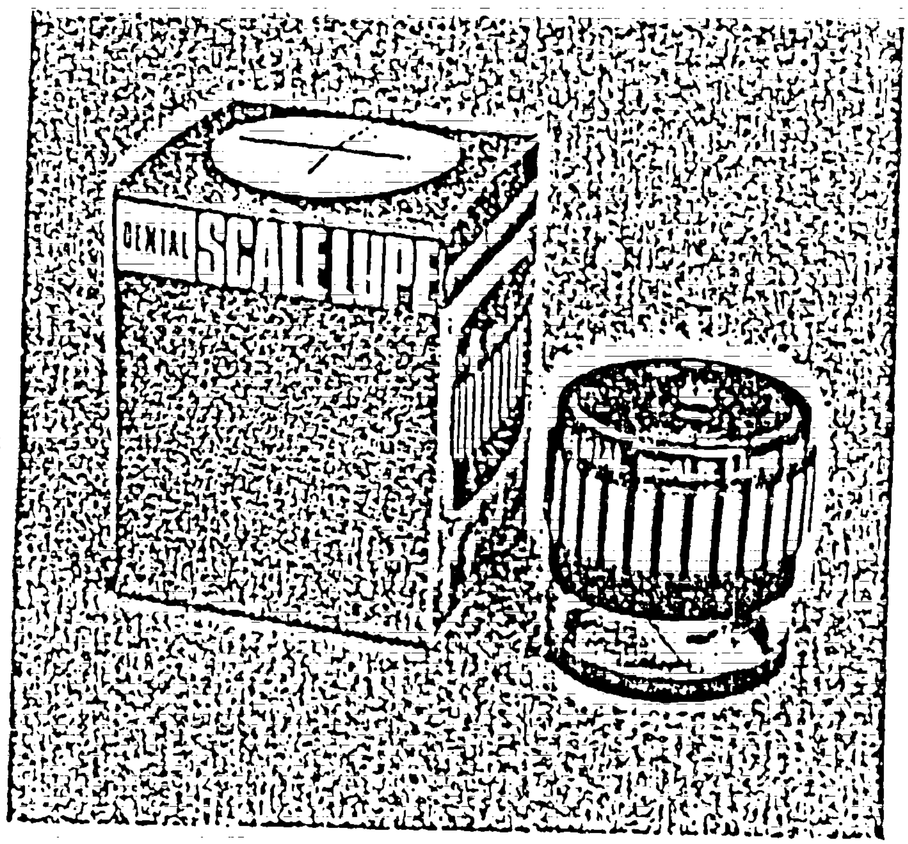


PHOTO 2

"TARGETTING" FOR TOOTH SURGICAL PROCEDURE



10X DENTAL MAGNIFYING LUPE



SCALE LUPE

10X (Magnifying Power)

28 m/m (Effective Diameter)

φ43 m/m × H50 m/m (Measurement)

82 g (Weight)

ABSTRACT

This paper describes a logical, performer-based approach to the teaching of psychomotor skills.

After identifying four basic phases of surgical psychomotor skills training, it is shown how students can be brought to any tasks in such a way that they will be able to derive adequate balance and control to minimize their dependence upon any ergonomic compromises of equipment which they may be called upon later in practise to use for such tasks.

An example taken from a dental preclinical training curriculum is used as an illustration of the practical utilization of this method, detailing how the performance simulation method can enhance the performer's conceptual and perceptual appraisal both of the postural aspects of psychomotor tasks, and of the precision of the end products as well.