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Biosmart Materials: Pioneering Innovation in Dental field

Rasha M. Abdelraouf [1*]

[1] ***Biomaterials Department, Faculty of Dentistry, Cairo University, Cairo 11553, Egypt***

* Corresponding author e-mail: rasha.abdelraouf@dentistry.cu.edu.eg

Abstract: The majority of dental materials are made to live rather "neutrally" in the mouth. They'll be more stable and durable if they're 'passive' and don't react to the oral environment. It is also anticipated that our materials would be favorably received and not be harmful or injurious. This is a wholly unfavorable approach to material tolerance and biocompatibility, and it obscures the prospect that employing materials that respond more dynamically to their surroundings may yield some benefits.

Keywords: smart material; passive; active; shape memory; dentistry.

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Introduction

The needs for materials have increased during the last few decades. The ongoing human drive to improve the efficiency of all kinds of structures is the cause of this. An extensive range of high-performance materials have been employed to satisfy these growing needs. It has long been believed that materials intended for prolonged usage in the body—more especially, the mouth—survive longer when they are "passive," meaning they don't interact with their surroundings. The understanding of the advantages of fluoride release from materials may have been the initial inkling that a "active" as opposed to a "passive" material could be appealing (1). A class of materials known as "smart materials" is highly responsive and possesses the innate ability to sense and respond to changes in their surroundings. They are frequently referred to as "responsive materials" as a result. The stimulation may come from the outside or the inside. From the use of passive materials to active materials and ultimately to intelligent materials with more sophisticated identification, discrimination, and reaction capabilities, materials science has clearly evolved since its inception (2).

Definition:

The term "smart materials" refers to materials whose characteristics can be modified by external factors such pH, temperature, moisture, stress, and electric or magnetic fields (1). Not only can "smart" materials sense changes in their surroundings, but they can also respond appropriately. Consequently, it may be claimed that they have actuator and sensor properties (3).

Nature of Smart Materials:

Piezoelectric materials, which generate a voltage in response to applied stress or vice versa, are examples of existing smart materials. When a voltage is applied, structures constructed with these items can be made to vary in size or shape. Similarly, a voltage that can be used for monitoring can be produced by a change in form. Because of their extraordinary and regulated structural changes, thermo-responsive materials, including shape memory alloys or shape memory polymers, adopt distinct shapes at different temperatures. pH-sensitive polymers are materials that expand or contract in reaction to changes in the media's pH, while magnetic shape memory alloys are materials that can change their shape in response to a change in magnetic field (1).

Smart Materials in Dentistry:

Tissue engineering and thermoresponsive polymers for the administration of therapeutic molecules are two examples of the biomedical uses of smart materials in the dental profession (4). Shape memory alloys for orthodontic wires, coils, and springs, as well as cercon smart ceramics, which provide a dental repair with remarkably natural looks, are a few examples of smart materials used in dentistry. Furthermore, amorphous calcium phosphate-containing smart composites promote the restoration of damaged teeth and smart glass ionomer. High-fluence laser radiation is delivered via smart fibers to remove dental enamel. With these advancements in material science, a new era of Bio-Smart Dentistry has begun—a stride into the future!

An ***example*** here is titanium, which is used for dental implants and in orthopedic devices. When fresh titanium is exposed to air it reacts rapidly with atmospheric oxygen to form a surface oxide which is typically a few nanometers thick. The oxide stoichiometry is approximately TiO_2. The surface is never perfectly clean TiO_2, for the TiO_2 terminated surface tends to bind molecules or atoms from the surroundings as a mono-molecular layer (1).

Thermoresponsive Polymers

Since polymers can be more easily customized and are less expensive than metals or ceramics, they form the basis of one of the main categories of "smart" materials. These "smart" polymeric materials react to a variety of stimuli, including temperature, pH, and chemical and biological stimuli. Temperature-responsive polymers find use in tissue engineering, medication delivery, and gene delivery, among other biological applications. Based on their three-dimensional structure, thermoresponsive polymers can be classified as hydrogels, films, micelles, crosslinked micelles, and interpenetrating networks (4).

Drug Delivery

As the name implies, drug delivery is the process or method of giving a pharmaceutical molecule (drug) to an animal or human in order to generate a therapeutic effect. Getting the medication to the correct place at the right time in the right concentration are crucial. Nevertheless, there are numerous barriers in the way of effective medication administration. These challenges include, but are not limited to, the medicines' low solubility, rapid body clearance rates, enzymatic or environmental degradation, non-specific toxicity, and failure to pass biological barriers (5,6). Drug delivery vehicles, the majority of which are based on polymers, are being used to get around these problems (5-7).

However, it is challenging to achieve the desired regulated release rate even when employing a carrier to administer the medication. In particular, drug delivery is frequently troublesome because the released drug's concentration in the target area is either too high or too low, and it is not supplied for the desired duration of time. Therefore, it is difficult to achieve the desired, regulated medication release that is frequently associated with a zero-order kinetic rate. Consequently, medication delivery uses "smart" polymeric carriers. Because these carriers release the drug only in reaction to an external stimulation, medication can be delivered at the appropriate timing and concentration. For instance, when the temperature rises, a carrier's polymer chains may expand, allowing the medication to diffuse out and be freed from the carrier (8).

Gene Delivery

As a method of fixing faulty genes that cause various genetic diseases, gene therapy attempts to treat a wide range of hereditary illnesses. of particular, a crucial stage of gene therapy is introducing the right therapeutic gene (DNA) into the cells to replace, repair, or regulate the damaged gene responsible for the illness. However, because DNA is a negatively charged, hydrophilic molecule, it is not possible to carry it into the cell's nucleus through the similarly negatively charged, hydrophobic cell membrane.(4)

As a result, carriers for gene delivery—also referred to as vectors or vehicles—have been created (9, 10). Since polymers are less expensive, safer, and easier to work with than alternative gene delivery vehicles like liposomes, a large number of these are based on polymers (8–12). Utilizing a polymeric carrier, also known as transfection, entails the following steps: (1) complexation of DNA and polymer; (2) addition of DNA/polymer complex (also known as polyplex) onto cells for a duration of time commonly referred to as the transfection time; (3) complex removal from the cells; and (4) incubation time, during which the cells are left to incubate until outcomes are observed. While the incubation and transfection phases are held at 37 °C (the body temperature that the cells require to live), complexation is often carried out at room temperature (4).

Tissue Engineering

The multidisciplinary discipline of tissue engineering uses concepts from biology and engineering to create biological replacements that enhance or restore tissue function (13). In tissue engineering, a scaffold or other substance is used to seed cells, which cause the tissue to mature as a result. This necessitates the employment of a biocompatible scaffold or substance, typically made of synthetic polymers or natural materials like proteins, with the right 3D shape to give encapsulated cells enough mechanical support and the ability to transfer growth hormones and nutrients (14). In tissue engineering, thermoresponsive polymers are frequently utilized in two ways: as injectable gels for in situ scaffolding and as substrates that support cell growth and proliferation. In the first application, the polymers' capacity to respond to heat is employed to control how tightly or loosely cells adhere to a surface. In the second use, cells are enclosed within a three-dimensional bodily structure. By adopting minimally invasive approaches, defects of any shape can be treated with encapsulated cells, nutrients, and growth factors thanks to the in situ construction of the scaffold, which differs from the construct's in vitro formation. In particular, the cells and thermoresponsive polymer are combined at room temperature before being injected into the body. The temperature rises to 37 °C during injection, causing the polymer to physically gel. The gel's three-dimensional structure contains the cells (4).

Shape Memory Alloys

In the 1930s, the form memory effect in materials was first noticed. Working with an alloy of gold (Au) and cadmium (Cd), Swedish physicist Arne Olander (1932) discovered an intriguing occurrence. The Au-Cd alloy underwent plastic deformation when cooled, and it reverted to its initial or "memorized" dimensional shape when heated. The alloys that displayed this behavior were referred to as Shape Memory Alloys (SMA), and the phenomenon was named the Shape Memory Effect (SME). Greninger and Mooradian (1938) used temperature c hangs to examine the emergence and disappearance of a martensitic phase in a Cu-Zn alloy. Additional investigation turned up more materials that proved this phenomenon as well. At the US Naval Ordnance Laboratories, the shape memory capabilities of nickel titanium alloys were unintentionally found in 1962. Nitinol (Nickel Titanium Naval Ordnance Laboratory) was patented (15).

The ability of shape memory alloys (SMAs) to go through a solid-to-solid phase transition distinguishes them from other metals. Because of this property, they can adopt two distinct crystalline lattice structures (austenite and martensite), which vary according to temperature and applied stress (15).

The crystallographic term for a SMA's low temperature phase, which begins to develop during cooling, is martensite. This is because, below a specific transition temperature, the martensitic crystalline structure is more thermodynamically stable. Depending on the local stress field, martensite can have a wide variety of lattice patterns when it emerges from austenite crystals in different directions. The structure may also seem de-twinned or twinned. Because the molecular arrangement can readily shift to a lattice layout that is more favorably aligned with the local stress field, this phase is when a SMA is most easily deformed. The twinned borders' movement is mostly to blame for this (15). A phase transition is usually brought about by a temperature shift. The martensite-start temperature (Ms) is the temperature at which the SMA begins to transition into the martensite phase. When the temperature drops below the martensite-finish temperature (Mf), this transition is finished (15).

A shape memory alloy's strong, high-temperature austenite phase makes up the second crystalline lattice structure. The alloy exhibits a high modulus of elasticity due to the symmetrical structure of its cubic molecular arrangement in the austenite structure. Compared to the martensitic structure, this austenitic structure is far stronger.

Once more, temperature changes cause the phase transition to occur. At the austenite-start-temperature (As), the austenite phase begins to develop from the martensite phase. When the temperature rises above the austenite-finish-temperature (Af), this process is finished. Nonetheless, an applied stress has the ability to cause the change of austenite to martensite above the Af temperature. We refer to this as SIM, or strain-induced martensite. This SIM is the superelastic Effect's operating theory. The precise chemical makeup of the SMA can cause a large range in the transition temperatures (15).

In summary, temperature and stress can both cause transformation between the martensite and austenite forms. The low-temperature, high-stress form is called martensite, whereas the high-temperature, low-stress form is called austenite (16). Three unique qualities are displayed by SMAs as a result of this solid-to-solid phase transition: the Shape Memory Effect, Martensitic Deformability, and Superelastic Effect (15).

Shape Memory Effect

The ability of SMA, which has been "plastically" distorted, to restore a "memorized" shape by heating it sufficiently to finish the solid-to-solid phase transition is known as the Shape Memory Effect (SME). An SMA element can provide a significant amount of effort during this form recovery (15, 17).Thus, by heating the element over a specific temperature, SMA elements are able to regain a "memorized" or preset shape. The element is given the predefined shape during high-temperature manufacturing, which results in the SMA being in its austenitic state. This effect is based on the SMAs' solid-to-solid phase transition, which occurs within a particular temperature range. (15, 17). A SMA element will be fully in the martensite phase, where it is easily deformable, if its temperature is lowered below the Mf temperature. The element will stay distorted following a clear "plastic" deformation as long as the temperature remains below the transition point, which keeps the SMA in the martensitic phase.

The structure of the SMA will, however, revert to its austenite state, which is set up in the wire's initial shape, if the element is heated over the Af-temperature. The element will so revert to its initial "memorized" shape (15, 17). Furthermore, a SMA element might produce a lot of work and very high forces during the phase transformation if an external mechanical component prevents this shape recovery. For this reason, SMA components have a range of applications where they can be effectively used as actuators (15, 17). The one-way and two-way effects can now be separated into two groups inside the SME:

One-Way Effect

The differently aligned martensite structure will de-twine if a SMA member is deformed while it is in the martensitic state. When the load is released, the SMA element will maintain its distorted shape, much like regular plastic deformation. Nevertheless, the material will change from its martensite to its austenite condition and revert to its initial, "memorized" shape when heated. The SMA element can produce a substantial amount of work during this form change. As long as there is no external stress during this transition from austenite to martensite, the element usually does not undergo a reverse shape change if it is subsequently cooled to its martensitic phase (15, 17).

Two-Way Effect

The term "two-way effect" refers to a unique type of SME in which a shape change is caused by both the heating and cooling of a SMA element. This two-way phenomenon allows SMA components to "remember" both a low-temperature, martensitic structure and a high-temperature, austenitic shape. A SMA element can alternate between these two shapes based on temperature because to its property. Such an impact might be caused by a certain thermomechanical treatment (15, 17).

Martensite Deformability

In the martensitic phase, a SMA member is extremely malleable. This implies that it has a far lower risk of fracture than traditional materials since it may be bent repeatedly without strain hardening. The martensite structure's twinned structure is the cause of this. The twin borders are freely movable and do not create dislocations, which are thought to be the first signs of fracture. Martensite Deformability is the term for this characteristic. Moreover, following deformation, the element can regain its original shape when heated. The Shape Memory Effect helps achieve this (15, 17).

Superelastic Effect

When a load is applied to typical materials that exhibit elastic deformation, the deformation will eventually dissipate when the force is removed. This normal elastic deformation differs from the superelastic deformation that takes place in SMAs in that the former can be elastically stretched or compressed five to ten times more than that of conventional materials. This phenomenon is known as the superelastic effect (in engineering material science, pseudoelasticity). At temperatures higher than those required to convert the SMA from martensite to austenite (Af), this effect can be seen. The alloy's chemical composition should be changed to match the transformation temperature to the outside temperature where the SMA is meant to be used in order to exhibit the PE (15, 17).

The superelastic Effect happens without a temperature shift, in contrast to the Shape Memory Effect. This is due to the fact that the application of a load has the ability to produce the solid-to-solid phase change that gives rise to the unique features of SMAs. An SMA element exhibits elastic initial behavior when it is loaded during the austenitic phase. Simply because of the loading, the austenite structure changes into martensite when the load is increased to a particular point. The term "stress induced martensite (SIM) transformation" refers to this procedure. Since the martensite phase is far less stiff than the austenite phase, if this transformation is complete, the material will begin to deform elastically once more (15, 17).

The material will unload elastically until the stress is low enough to initiate the transition back into the parent austenite phase if the loading is removed before the material plastically yields. This is made possible by the element's constant temperature above the transition temperature Af. The material will finish transforming back into its austenite phase and will unload elastically until the zero stress point is reached if the stress is decreased even further. The SMA element can regain all of its generated strain and its original, undeformed shape at zero stress during this unloading process (15). The phase transitions from austenite to martensite and vice versa include energy loss (hysteresis). For both full and partial transformations, the amount of energy wasted is proportionate to the degree of transformation finished during the loading cycle. Minor loop hysteresis cycles are another name for these partial transformations, which cause the SMA to simultaneously consist of the austenite and martensite phases (15, 17).

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Type of the Paper (Editorial)

Nitinol in dentistry

Rasha M. Abdelraouf [1*]

[1] ***Biomaterials Department, Faculty of Dentistry, Cairo University, Cairo 11553, Egypt***

* Corresponding author e-mail: rasha.abdelraouf@dentistry.cu.edu.eg

Abstract: An alloy of nickel and titanium In recent years, endodontic instruments have been made using nitinol. A lower modulus of elasticity and better strength are found in nitinol alloys when compared to stainless steel alloys. Because of their extremely elastic nature, Nitinol wires regain their original shape after deformation upon unloading. These qualities are interesting to endodontists because they make it possible to build root canal tools that take advantage of these advantageous traits to give them an advantage while creating curved canals. In order to fully understand the special qualities of nitinol alloys utilized in dentistry, this review attempts to give an overview of them.

Keywords: nitinol; nickel; titanium; dentistry.

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The nickel-titanium alloys that are utilized in dentistry have a temperature transition range and are composed of 55% nickel and 45% titanium. To reduce the temperature transition range, cobalt is used. The martinitic NiTi phase has a monoclinic, triclinic, or hexagonal structure, while the austenitic NiTi phase has a body-centered cubic structure. Furthermore, as the transformation progresses, a third form known as the R phase (rhombohedral) emerges as an intermediary phase. Changes in composition result in modifications to the mechanical characteristics and start and completion temperatures of martensitic and austenitic materials. As a result, several Ni-Ti alloy variants have been created for use in dentistry (1). The mechanical characteristics of an orthodontic nickel titanium alloy are contrasted with those of a beta-titanium alloy and stainless steel. The biggest spring back, or maximal elastic deflection, is found in nickel titanium alloys, which is significant when substantial deflections are required, like in cases with misaligned teeth. Between the three alloys used to make orthodontic wires, nickel-titanium has the lowest spring rate and the highest resilience. Clinically, a greater working range and lower, more constant stresses can be applied with activations due to the low elastic modulus and strong resilience (2). Shape memory effect may be seen in NiTi wire constructed of martensitic alloy that changes to an austenitic structure at body temperature (37 °C). Shape memory wires are often utilized in orthodontics because they have a better springback than superelastic wires (1). Conversely, endodontic instrument alloys have an austenite-finish temperature of roughly 25 oC (16), because only wires with austenitic finish temperatures lower than 37 oC show superelasticity. Super-elastic files are advantageous because they preserve the canal's shape closely without posing a risk of file breakage (3). The equipment induces a transition from austenite to martensite within the canal. Keep in mind that martensite has a modulus of 50 GPa and Ni-Ti austenite has a modulus of 120 GPa. Springback without permanent deformation and a return to the austenitic phase happen when the tension lowers. Ni-Ti's exceptional elasticity allows for 8% strain deformations in endodontic files while still allowing for full recovery. When compared to stainless steel instruments, this value is less than 1%. Furthermore, Ni-Ti alloys are better at creating curved root canals than stainless steel because they have lower moduli of elasticity (3). Still, forming the nitinol wire is not without its challenges. The orthodontic nickel wire is better suited for use with pre-torqued, pre-angulated brackets since it requires certain bending techniques and cannot be twisted over a sharp edge or into a complete loop. Additionally, wires must be linked mechanically because the alloy cannot be soldered or welded. (16) Unlike stainless steel endodontic instruments, which require a special apparatus to twist the starting wire, nickel-titanium endodontic instruments must be made by machining the starting wire (3). Nickel-titanium alloy finds numerous uses in the biomedical field, including endovascular stents, distraction osteogenesis appliances, and devices for mending fractured bones (4).

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Relevance of vertical dimension of occlusion with anthropological measures of face and fingers. A cross-sectional study amongst Libyan population

Hana E. Mahjoub[1]*, Najat A. Mohamed[2], Warida A. Elnaihoum[3], Isaeida Abdulla Ali Mohamed[4], Ahmed Farkash[5]

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[1] Lecturer, Department of Removable Prosthodontics, Faculty of Dentistry, University of Benghazi, Benghazi, Libya
[2] Assistant lecturer at department of prosthodontics, faculty of dentistry. University of Benghazi, Libya
[3] Lecturer at department of prosthodontics, Faculty of dentistry, University of Benghazi, Libya
[4] Lecturer at department of prosthodontics, Faculty of dentistry, University of Benghazi, Libya
[5] demenstrator at Faculty of dentistry, University of Benghazi, Libya

* Corresponding author e-mail: Lady.dent@yahoo.com

Abstract: Restoring physiological vertical dimension of occlusion (VDO) is a critical step during complete mouth rehabilitation. An improper VDO compromises the aesthetics, phonetics and functional efficiency of a prosthesis. Universally, there are no precise and consistent methods to record VDO. Many facial and body landmarks have been proposed in the literatures correlating to the VDO, many dentists face difficulties in determining correct VDO due to the subjectivity involved in decision- making, especially when rehabilitating fully edentulous patients or patients who no longer have stable tooth contact. These methods do not require a great amount of time and experience to master. Aim: Investigate the relation between anthropological measurements of face and fingers with VDO. Material and method: A total of 117 subjects of either sex within age group (18 to 60 years) participated in this study, all participants have Class I occlusion with no history of orthodontic treatment. Exclusion criteria included: supra eruptions, physiologic or pathologic migrations, deep bite, open bite, severe attrition, and extensive extra-coronal restorations, such as crowns and bridge work. Facial and hand deformities and subjects with a history of oral and maxillofacial trauma were also excluded because the study involves facial and finger measurements. All the participants in this research were informed about the study and the nature of measurements that would be taken. Ethical statement: this work was carried out under the approval of the institutional ethical committee at University of Benghazi, Libya (approval no.0153). Conclusion: Facial measurements can be used initially to approximate the measurements of VDO and then using the other methods to test the suitability of the dimensions, initially established VDO could be correlated to the index finger and little finger measurements in Libyan females and could be correlated to measurements of inner canthus of left eye to left corner of mouth (Rima Oris) in both males and females.

Keywords: *Anthropological, Index finger, Little finger, Vertical dimension of occlusion, inner canthous, rima-oris, corner of mouth*

I. Introduction

Restoring physiological vertical dimension of occlusion VDO is a critical step during complete mouth rehabilitation. The generalization of correlation between the facial measurements to VDO is disapproved due to racial differences and it is practical to correlate lower third of the face to the remaining craniofacial measurements in different ethnic groups. Anthropometric measurements are stable landmarks and do not change over the natural aging cycle. These readings are specific to the patient and are easily repeated[1]. Several methods were used in determination of the correct occlusal vertical dimension like anterior teeth measurements, closest speaking space, swallowing method, patient's neuromuscular perception, cephalometric radiographs, intraoral and extra-oral anatomic landmarks[2]. Multiple researchers have attempted to find the correlation between VDO and other craniofacial measurements in various ethnic groups. Since there is a noticeable genotypic and phenotypic variation between ethnic groups, it is sensible to analyze the hypothesis in the different ethnic groups[3]. There is no precise and consistent method to record VDO. Many facial and body landmarks have been proposed in the literatures correlating to the VDO, many dentists face difficulties in determining correct VDO due to subjectivity involved in decision making, especially when rehabilitating fully edentulous patients or patients who no longer have stable tooth contact. An anthropometric method to determine VDO is attractive and practical because it is simple, economic, non-invasive, and reliable[4,5]. Anthropometric measurements like finger lengths and other facial measurements can offer significant prosthetic advantages in estimating the VDO by eliminating the guesswork involved in subjective methods to determine

VDO such as resting jaw position or swallowing method. They do not require radiographs nor special or complicated measuring devices and provide reproducible values for future reference. These methods do not require a great amount of time and experience to master[4,5].

II. Aim:

To investigate the relation between anthropological measurements in the face and fingers with VDO.

III. Material and method:

A total of 117 subjects (58 male and 59 female) within an age group of (18 to 60 years) participated in this study, all participants have Class I occlusion with no history of orthodontic treatment. Exclusion criteria include: supra eruptions, physiologic or pathologic migrations, deep bite, open bite, severe attrition, and extensive extra-coronal restorations, such as crowns and bridge work. Facial and hand deformities and subjects with history of oral and maxillofacial trauma were also excluded because this study involves facial and finger measuring. All the participants in the research were informed about the study and the nature of measurements that would be taken. The following anthropological readings from the face and hands were selected:

1.Base of the nose to inferior of the chin reading was considered as vertical dimension of occlusion (VDO) reading (fig.1).

2. Inner Canthus of the left eye to left Corner of Mouth (Rima Oris) (ICCM) reading (fig.2).

3. Inner Canthus of right eye to Outer Canthus of left eye reading (ICOC) (fig 3).

4. Right Index finger (IF) (fig.4).

5. Right Little Finger (LF) (fig.5).

6. Length of the Right Ear auricle was recorded from upper border of ear to lower border of the pinna of the ear (EL) (fig. 6).

Digital Vernier caliper was placed with the lower end touching the lower border of mandible in chin area at mid-symphysis region with the teeth in maximum intercuspation, the upper end lightly touched the skin at the base of the nose, this was considered as VDO reading. Other facial measurements, such as inner canthus of the right eye to outer canthus of the left eye and inner canthus of the left eye to rima oris were taken in similar manner, length of the right ear was recorded from upper border of ear to lower border of the pinna of the ear. Patient was asked to keep the right hand in a supine/palmer position, caliper readings were taken from the tip of the finger to the nearest finger crease. An average of 3 readings were taken in all the measurements. The data obtained was statistically analyzed and tabled[6].

Fig.1:VDO

Fig.2:ICCM

Fig.3:ICOC

Fig.4:IF

Fig.5:LF

Fig.6:RE

Results:

A screening process was conducted on a sample of 117 individuals, consisting of females 59 (50.4%) and 58 (49.6%) males. The age range of the participants spanned from 18 to 60 years. Table 1 displays the distribution of the Individuals involved in the study, categorized by gender and age group.

Table (1): The distribution of participants by age group and gender.

Age group	Male	Female	Total
18-27 years	23(38.3%)	37(61.7%)	60(51.3%)
28-37 years	14(58.3%)	10(41.7%)	24(20.5%)
>38	21(63.6%)	12(36.4%)	33(28.2%)
Mean age	34±١٢.4	28.37±8.4	31.٢±١٠.9

A study employed an independent-samples t-test to examine the disparities in readings across various parameters for male and female participants. Table (2) presents the relevant data. A statistically significant difference was seen in all parameters, with a p-value of < 0.001 except for Right Inner Canthus of eye to Left Outer Canthus of eye ($p = 0.048$). The findings of this study indicate that there is a notable impact of gender on the VDO measurements. The VDO levels of male subjects were found to be greater in comparison to those of female subjects.

The mean VDO dimension measurements in males was found to be 66.2 mm, with a standard deviation of 5.6 mm. The mean value of (VDO) measurements in females was found to be 60.07 mm, with a standard deviation of 3.8 mm. The t-test conducted to assess equality between measures of (VDO) for males and females yielded a statistically significant difference ($t = 6.804$, $p < 0.001$). A comparative analysis of male and female observations revealed a statistically significant distinction at a significance level of 5%. This finding suggests that males exhibited considerably higher values across all observed readings in comparison to females.

Table(2): Comparison of males and females with mean score of different parameters

Parameter	Male		Female		t value	P value
	Mean	SD	Mean	SD		
Vertical Dimension of Occlusion	66.2	5.6	60.07	3.8	6.804	<0.001
Right Index Finger	71.39	5.46	66.1358	4.62	5.6	<0.001
Right Little finger	60.61	4.82	55.64	4.9	5.5	<0.001
Left Inner Canthus of eye to Corner of Mouth	69.1	5.13	61.9	3.67	8.705	<0.001
Right Inner Canthus of eye To Left Outer Canthus of eye.	60.49	13.5	54.89	16.4	2.002	0.048
Right ear length	62.37	4.08	58.65	6.17	3.793	<0.001

A Pearson correlation coefficient was utilized to examine the association between VDO reading and other anthropological readings (Table 3). The results indicated a medium positive correlation, with "r" values ranging from 0.324 to 0.613, and a p-value of <0.001 for both male and female subjects. Among males, the measurements of the Left Inner Canthus of eye to Corner of Mouth showed a particularly close relationship with VDO dimension readings ($r = 0.380$, $p = 0.004$) compared to other anthropological parameters examined in the study. In females, also the measurements of the Left Inner Canthus of eye to Corner of Mouth were closely associated with VDO dimension readings ($r = 0.512$, $p \leq 0.001$).

Table (3): Correlations between bases of nose-lower border of chin (VDO) with other parameters

Parameter	Vertical Dimension of Occlusion correlation					
	Total n(117)		Male n(58)		Female n(59)	
	r value	P value	r value	P value	r value	P value
Right Index Finger	0.429*	<0.001	0.229	0.087	0.259*	0.047
Right Little finger	0.404*	<0.001	0.191	0.155	0.265*	0.042
Left Inner Canthus of eye to Corner of Mouth	0.613*	<0.001	0.380*	0.004	0.512*	<0.001
Right Inner Canthus of eye To Left Outer Canthus of eye	1	0.284	-0.188	0.162	0.226	0.085
Right ear length	0.324*	<0.001	0.186	0.171	0.202	0.125

* .Correlation is significant at the 0.01 level (2-tailed).

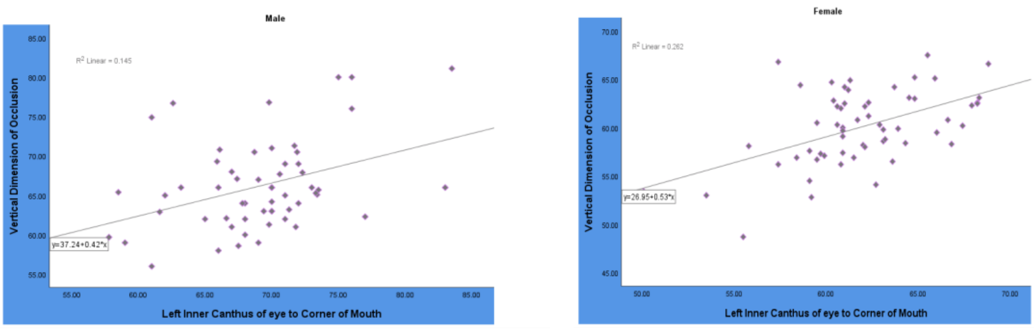

Fig.7: Scatter plot diagram showing the correlations between VDO and Left Inner Canthus of eye to Corner of Mouth in male and female subjects.

IV. Discussion:

Correct vertical dimension of occlusion VDO is important in the construction of complete dentures, as the patients are fully edentulous or no longer have stable tooth contact. Pre-extraction records play a major role in the assessing and establishing VDO. Anthropometric measurements are stable repeatable landmarks and specific to the patient[2]. Incorrect VDO can result in an unsuccessful denture. Where increased VDO can result in difficulty in mastication and speech. It can also lead to muscle spasm and temporomandibular joint disorders[7-9]. Similarly, a decreased VDO can cause early wrinkles, poor chewing, deepening of nasolabial groove and folds at the corner of the mouth that result in collection of saliva and hence angular cheilitis. When pre-extraction records are not available, there is no universally accepted method for determining VDO. Therefore, several methods have been used for recording the VDO and each method has its limitations to be absolutely accurate. Physiological methods such as swallowing, rest vertical position, phonetics have been used to record VDO. Mechanical methods such as ridge parallelism, pre-extraction records and cephalometric radiographs were also used[10_13]. The difficulty in taking facial measurements is the excessive soft tissue bulk under the chin. The vertical dimension of occlusion must be determined carefully by the dentist for a successful prosthesis VDO is the result of a musculoskeletal balance. The correct VDO can be better described as a range instead of a fixed point. Therefore, to evaluate the VDO, a varied method should be adopted at all the stages of rehabilitation to maximize the benefits and minimize damage to the stomatognathic system[14].This study was made amongst Libyan population in Benghazi city to determine the correlation between VDO and anthropometric craniofacial measurements to be used in the absence of pre-extraction records in male and female subjects to predict VDO before application of more confirming methods. The difference in correlation between male and female craniofacial measurements are due to the more prognathic mandibles and steeper mandibular angle in male in comparison to females, although the anterior lower face height is similar for both genders [15,16]. In our study both genders in the age range of (18_60 years) were involved in determining the correlation between VDO and anthropometric measures (facial and fingers). The left facial measurements were more reliable in predicting OVD than right side measurements. The variation could be due to right hemisphere dominance for emotional expressions. The mobility of facial expression also exhibits facial asymmetry, and studies indicated the left side of the face is most commonly dominant in both males and females[17]. The statistically significant correlation was observed between OVD and the dimension between pupils to the chelion in both genders, similar strong correlations observed between the OVD and the pupil-rima oris distance[18]. The measures used in our study amongst the Libyan population included mainly the right side as measures used from inner canthus of the right eye to outer canthus of left eye, and from inner canthus of left eye to left corner of mouth (rima oris). The right ear auricles length was used. Among males and females, the measurements of the Left Inner Canthus of eye to Corner of Mouth showed a particularly close relationship with VDO compared to other anthropological parameters examined in the study.

It was reported that known VDO of 95% of subjects with natural teeth corresponded with three facial measurements which are: the distance from the center of the pupil of the eye to a line projected laterally from the median line of the lips; the distance from the glabella to the subnasion; and the distance between the angles of the mouth with the lips in repose[19]. Anthropometric measurements of VDO amongst the Arab Saudi population were significantly and positively correlated with length of index finger, length of little finger, and distance from tip of thumb to tip of index finger of the right hand. In males, correlation of VDO was strongest for the length of the index finger, whereas in females, it was strongest for the length of the little finger[14]. A correlation between VDO and index finger was studied in 250 subjects (166 female and 84 male), significant correlation was revealed between VDO and index finger in both male and female subjects[20]. In this study a correlation was evaluated between VDO which was measured from Base of the nose to inferior of the chin and finger measurements, statistical analysis revealed that VDO was correlated positively with the index finger length and the little finger length in females but in males there was no correlation .

In the VDO measurement taken from the base of the nose to lower border of chin was least correlated to outer canthus of eye to the rima oris measurement. When the VDO measurements were taken from the tip of the nose to the base of the chin, there was strong correlation between the VDO measurement and the outer canthus of eye to the rima oris measurement[21]. Some studies proposed a correlation between the eye – ear distance, but recently it was reported that there is a non -significant correlation between the clinical OVD and eye-ear distances in males[22]. In our study the measurements of VDO was made between base of the nose and the inferior of the chin but the correlation with eye-ear distance was not evaluated, on another hand , right ear auricles lengths were evaluated and no correlation was reported .

Conclusion:

Facial measurements can be used initially to approximate the measurements of VDO and then using the other methods to test the suitability of the dimensions initially established.VDO could be correlated to the index finger and the little finger measurements in Libyan females and could be correlated to the measurements of inner canthus of left eye to left corner of mouth (rima oris) in both males and females .

Ethical statement: this work was carried out under the approval of institutional ethical committee in university of Benghazi, Libya (approval no.0153).

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Teledentistry applications

Tamer M. Hamdy [1,*]

[1] Restorative and Dental Materials Department, Oral and Dental Research Institute, National Research Centre (NRC), Giza, Dokki, 12622, Egypt
* Corresponding author e-mail: dr_tamer_hamdy@yahoo.com

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Abstract: In order to provide dental consultations and treatment planning, teledentistry combines the fields of telecommunications and dentistry. Clinical data and images are exchanged over long distances. Teledentistry has the potential to enhance oral healthcare delivery, increase accessibility, and reduce costs. Additionally, it might end the differences in oral health care that exist between urban and rural areas. The present evidence that is available in the literature is reviewed in this article, together with the history, justification, scope, foundation, and prerequisites of teledentistry. The future of this cutting-edge and alternative approach to providing dental treatment is also covered in this article, along with the ethical and legal concerns surrounding the practice of teledentistry.

Keywords: Teledentistry; Clinical data; telecommunications.

The practice of providing healthcare over long distances using information-based technology and communications networks is known as "telemedicine [1]. When participants are separated by distance, it uses electronic information and communication technology to provide and assist healthcare [2]. Telemedicine is a link in a longer chain of healthcare. It has the potential to strengthen this chain, raising the standard and effectiveness of medical care [3]. In addition to being utilised domestically to connect healthcare providers in underdeveloped nations with hospitals in rich nations, telemedicine is currently employed globally in university medical centres, community hospitals, managed-care organisations, and rural hospitals. Technological developments in digital communication, telecommunication, and the Internet present a hitherto unseen chance for remote access to healthcare [4].

For the management of dental caries, nanotechnology, which deals with nanostructures at the nanometer scale (0.1–100 nm), offers novel methods. The biggest development in the therapeutic management of the missing enamel surface may come from remineralization. Nanotechnology was used to mimic the biomineralization process that naturally forms and repairs dental enamel. The main inorganic component of hard dental tissues is hydroxyapatite. The use of nano-hydroxyapatite as a preventive and therapeutic measure against tooth caries has significant potential. Dental materials' characteristics at the nanoscale are very different from those at the microscale. Newly developed nanoparticles can be employed to regulate the development of cariogenic biofilms and new tooth restorative materials [6]. Some key applications of teledentistry could be summarized in the following points:

- Remote Screenings and Evaluations

Teledentistry allows dental professionals to conduct screenings, examinations, and assessments of patients remotely using images and video. This expands access to care and allows early detection and evaluations.

- Remote Consultations

Dentists can have virtual consults with colleagues to discuss patient cases, treatment plans, and get second opinions. This facilitates collaboration and knowledge sharing.

- Remote Patient Monitoring

Clinicians can remotely monitor patients to supervise their treatment progress for things like oral appliances and orthodontics. This improves continuity of care.

- Dental and Oral Health Education

Teledentistry facilitates providing education and teaching good oral care habits to patients, students, and underserved communities through virtual channels.

- Reducing Wait Times and Travel Burdens

With remote options, patients have reduced wait times for consultations and evaluations and decreased travel burdens for those in rural areas far from clinics.

In summary, by bridging geographical barriers and enabling remote point-of-care, teledentistry improves access, reduces costs, facilitates collaboration among dental practitioners, and enhances overall oral health outcomes and quality of life for patients. The capabilities continue advancing alongside telehealth tech innovations.

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