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Local modeling of the human humerus, its challenges and possibilities

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Abstract

Words ordinarily has been found not been to be enough in effective teaching and as such instructional materials is the conduit, through which message, information, ideas and knowledge can be passed effortlessly, instructional technology enables the development of both certain learning as well as abilities of the students as well as the mental skill, intellectual and motor skill of the students. The production of the model involved four stages. The first stage was modelling stage which involved sourcing and making a clay mould of same features, the second stage was the first casting stage which was done using silicon to get a trapped image out of the clay mould, the third stage is the charging which is done using a mixture of resin, accelerator, catalyst, and fibre matt to get a stronger jacket, the fourth stage is the second casting process which involved using the fibre glass jacket to produce the real mould using the mixture of accelerator, catalyst and marble dust. The fifth stage is finishing stage and involved filing the product to remove rough edges and painting it with an oil paint with colour similar to that of the real human bone. The result from this research showed that anatomical models can be produced using locally available materials around us, some of the challenges of producing a human model included; cost and durability of materials. The techniques introduced in this article allow forming the bone surface model of the humerus, part-moulding of parametric geometrical models. The necessity of a model is to establish geometrical models of as a teaching resource to understand better what is taught. As medical personnel requires models for consultation and possible treatment to diseases, while teachers need them as teaching aids to foster learning by the students. Students should use materials in their communities to produce different anatomical models for learning and also that the art of modelling should be incorporated in the approved National University Commission (NUC) curriculum to widen the scope of anatomical studies.

Keywords: Humerus; Anatomical model; Bone; Moulding; Casting

1. Introduction

The motivation of any classroom teacher in a teaching learning environment is to help the students in understanding. Research has revealed that, several and varied instructional aids such as resource person, textbooks, charts, projectors etc. are at the disposal of teachers which can be used to achieve the said motive [1]. However, most teachers are of the view that, facilitating students' understanding in the teaching and learning situation can only be generated from the appropriate introduction of lesson and effective classroom management [2]. Most teachers succumb to this method of lesson delivery with little or no attention to how instructional aids like resource person, textbooks, charts, projectors etc. can be used to make lessons more encouraging so as to improve students' understanding and performance [1]. [3] indicated that there was a good correlation between teaching and use of instructional materials. He maintained that some teachers absolutely have been captivated by the offering of teaching and learning material. Instructional materials are some of the parts of teaching which are not only meant to supplement learning but are to complement its process.

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Even though the utilisation of instructional materials cannot be overemphasised, but nonetheless they cannot remedy all the problems surrounding the teaching - learning but can do so to a larger degree simply due to the fact that it is another tool that can impact the reality of teaching and learning learning endeavours [4].

Words or verbalisation, ordinarily, has been found to be insufficient in effective teaching and instructional materials is the conduit, through which message, information, ideas and knowledge can be disseminated (with less effort) through. They are thus manipulable, visible, audible, touchable or discussable, they enable things, anything or anyone the teacher uses to aid instruction process [5]. According to [6], the application of instructional technology, e.g. projecting teaching materials in the classroom, lengthens the communication between teachers and students. Instructional technology enables the development of both certain learning as well as abilities of the students as well as the mental skill, intellectual and motor skill of the students. The presence of charts, diagrams, projectors, multimedia and models allow the teacher to explain to her students the numerous problems and issues easily. According to [7], successful application of projected teaching aids enhance students educational performance and to achieve this goal, teachers must employ the instructional methods effectively to conceptualise and erase the ambiguity in minds of the students. Speedy learning and accuracy are some of the individual attributes of instructional materials. They simplify the tasks, and make them interesting, precise, cleaner and enhancing conforming to understanding of anatomy in concepts. To learn anatomy a learning experience in form of art is required. Human anatomy is so proximate to life that so many teaching instructors need never be devoid of instructional resources to teach of anatomy. An individual can acquire quite a lot when there is building up and not destroying, organising and not disorganizing, imitating the dead and not killing again something already dead [8]. Without instructional materials, teaching of anatomy in regard to its scope and nature, which are multidimensional, integrative and dynamic, cannot effectively occur. Teaching of anatomy should not just be done in a way that competencies of the teachers can be refined to effectively administer instructional materials; but at the same time they should also promote strategies, which facilitates the integration of instructional materials that can be useful in teaching and learning of anatomy goals and objectives.

Low supply of instructional materials is one of the largest issues in the utilisation of instructional materials. Another method used in learning is the study aid or skill or study strategies. It is believed to be necessary in school in obtaining grade and also plays a habitual role or learning in life. These involve mnemonics that facilitate the memory of information, proper reading and focusing as well as note taking. More generally, any capability that increases the capability of an individual in the study and passing of a test can be called study skills and this may also involve time management and motivational technique. The study aid may be anything, equipments, device, stimulation or any other article that can better extrovert the learning process with the usage of a diverse range of teaching and enables the learners to acquire knowledge at various levels. [9] defined study aid as those devices that can make study and learning easier. The term study aid was also explained as the adoption of any such facilities, materials and equipments applied by the teacher to explain, probe, and highlight something in the lesson to render the lesson more understandable to the learner as defined by [10]. The concept of making materials and equipment improve the process of studying is as ancient as humanity is.

The essence of teaching has to do with impartation of ideas, skill and attitude that a teacher has to a learner. Practise has demonstrated that oral messages alone in communication of ideas in Nigeria being gross and inefficient with regard to eliciting desired learning outcomes. The rate of failure of those students in the tertiary institutions at the conclusion of the semester exams also sends shivers. This might be explained with the purpose that there are areas in anatomy that very much are difficult areas of understanding to the local pupils. Without appropriate teaching materials that would make learning practical and interesting, these topics cannot be taught effectively. [11] have also highlighted the impact of using instructional materials on teaching and learning. Of what we hear we learn and remember only 10 per cent; of what we talk about with others and as much as 40 per cent; of what we see with our eyes directly, or what we practise [11] we learn and remember up to 80 per cent. Human anatomy poses a great challenge to both lecturers and students, it appears abstract and the volume is much and this makes it difficult for students in medical school to appreciate the human body. Also with rapid development of high technology, it is very essential for study aid to be used in almost every classroom. Also printed materials are becoming increasingly inadequate in the delivery of quality lectures and proper understanding of student, it is therefore pertinent that this study be carried out to provide a model of human humerus for effective, adequate and quality medical school to enable study of anatomy and other related courses in an effective, adequate and quality way.

An anatomical model describes every little detail of human structure and a medical student needs to grasp all of it as soon as possible. Knowing in details of the patient's body through these models reassures and allows them to be level headed. With the help of such models, teachers can not only elaborate the human body and the damaged area but can also explain the step by step process of the surgery they are going to do. The act of describing different structures of human body to patients and students becomes a lot easier when they are having anatomical models. Anatomical models provide a more realistic platform to the learning and teaching process of human anatomy, therefore, of significant benefits to the teacher and students. This information relayed to medical students at various levels through learning institutions must be adequately demonstrated and clearly brought using models to make it understandable and clear. Due to insufficient fund medically inclined institutions find it difficult to provide ample human bones in their museums to foster learning activities among students especially those who would want to borrow these bones for personal study at the comfort of their homes. Based on the aforementioned, there is need to produce human humerus using local materials such as fibre and plastic of Paris.

2. Methods

2.1. Procedures involved in model production

Production of the models was done using the methods involved in sculpting. Both the fabric and POP bones were produced in the same process. The process involved five (5) stages:

- Moulding
- Casting 1
- Charging
- Casting 2
- Finishing

2.2. Moulding

This is the first stage in modelling. A real sample of the human humerus (the anatomical structure to be produced) is carefully selected, and used as a reference for the model. Clay is also processed with water into a paste by kneading it while spraying water until soft and malleable and is used to form a mould. The clay used is a special kind of clay gotten from Obomanagu Ukwagba, Ngbo in Ebonyi State, Nigeria and prepared specially for artistic work and is without impurity, the mould is beaten into a desired shape with the aid of tea spoon.

2.3. Casting 1

This is the second stage of the modelling process, there are two ways to achieve this process, however second option was used in the course of this work.

Option 1: the casting is done directly on a sample of a real humerus, the bone was fixed in a place for stability. Oil was applied on the bone to prevent sticking when silicon is applied. The silicon was fixed on a gun for easy application while it is gently applied unto the bone. It was allowed to dry for 3-4 hours. After it dried, the other side of the bone fixed was also coated with silicon and also allowed to dry. The application of this option is that the model to be produced took the exact shape and size of the real bone; hence no modification can be achieved.

Option 2: the casting is done on the clay mould produced earlier, the mould is also fixed in place. Oil was added onto the clay mould to prevent sticking of silicon when added to the surface of the clay mould. Silicon is applied to the surface to an exact form, it is then allowed to set for 3-4 hours. After it dried, the other side of the bone fixed was also coated with silicon and also allowed to dry. The implication of this option is that the shape and size of the model to be produced can be determined by the clay mould, i.e. the shape and size of the clay mould as desired becomes the shape and size of the intended model. Also the mould appeared smoother as the clay mould is always smoother than the real mould.

2.4. Charging

Charging of the mould is done by pouring a mixture of chemicals consisting of resin, catalyst and accelerator. Few drops of catalyst was added to a few drops of resin and stirred. This mixture gave a purple colour and few drops of accelerator were added and stirring is continued. This changed the colour of the mixture brown. The accelerator was used to boost the action of the catalyst. The mixture of the two causes fast drying, hence, care should be taken to ensure fast application before it over dries. Also excess quantity of accelerator in the mixture of catalyst and resin can cause produce fire. Also some quantities of plaster of Paris, cement and water were mixed thoroughly. After spreading the mixture on the silicon mould, a fibre matt was laid on the mould and a second mixture of resin, accelerator and catalyst were applied using brush, while sponge is laid for POP and tea spoon was been used to apply. Apply a second coat of fibre matt and then the mixture. This process allowed the silicon to be more in contact with the bone or clay mould thereby allowing more precision of the bone or clay mould features on the silicon. Fibre matt itches the skin so should be restricted to the palm region when handling. The mould was then placed under the sun to dry for about 24 hours. This dry mixture of resin, accelerator, catalyst and fibre matt is called glass.

2.5. Casting 2

This is the fourth stage of the modelling; the fibre glass mould is placed on a bolt and cut opened into two halves using a saw. The cutting is limited to the fibre glass and silicon jacket only without reaching the bone or the clay mould. The silicon jacket was then separated from the fibre glass jacket and the real mould, a small quantity of resin was poured in a mixing container and few drops of catalyst added and stirred. Marble dust was added to thicken the mixture while stirring continues, oil was applied on the silicon jacket using a brush to avoid sticking of casting mixtures; however, caution was taken as too much mixture can cause floating thereby causing mixture not to take precise shape of the mould. Few drops of accelerator were added to the mixture to enhance fast drying. The mixture was poured into the silicon mould immediately ensuring it fills the two halves of the mould and then allowed to dry for about an hour. This was essential as the mixture of resin accelerator and catalyst is always very hot and was given time to cool and set before handling to avoid burning of the skin. When dried, the two halves of the model were coupled and fastened together with binding copper wire and same mixture was used in this casting stage to fill and seal the corners of the model to become a whole model, when dried, file and smoothen the rough edge.

2.6. Finishing

This is the final process of the modelling, the model is filed to a more desirable shape and smoothened using a sand pape, the one of Plaster of Paris is painted using a brush and milky colour of car paint, while the other one is unpainted. Small quantity of thinner is added to enable the paint dry faster, the milky colour is chosen to be close as possible to that of the human humerus, however the model produced in the course of this research is not painted as the natural colour from the casting mixture is similar to that of life bone, it is then polished with a no colour nail polish which has its base as ethyl acetate. The work can be wired to the other bone of the hand, which in turn is wired to the rest of the human skeletal model.

3. Results

The result of the research showed various stages in the production of the model of the human humerus as shown below; Moulding, Casting 1, Charging, Casting 2, Finishing, each diagram is a picture of the humerus at every stage of production

Figure 1 First stage of modeling (moulding)

Figure 2 Second stage of modeling (casting 1)

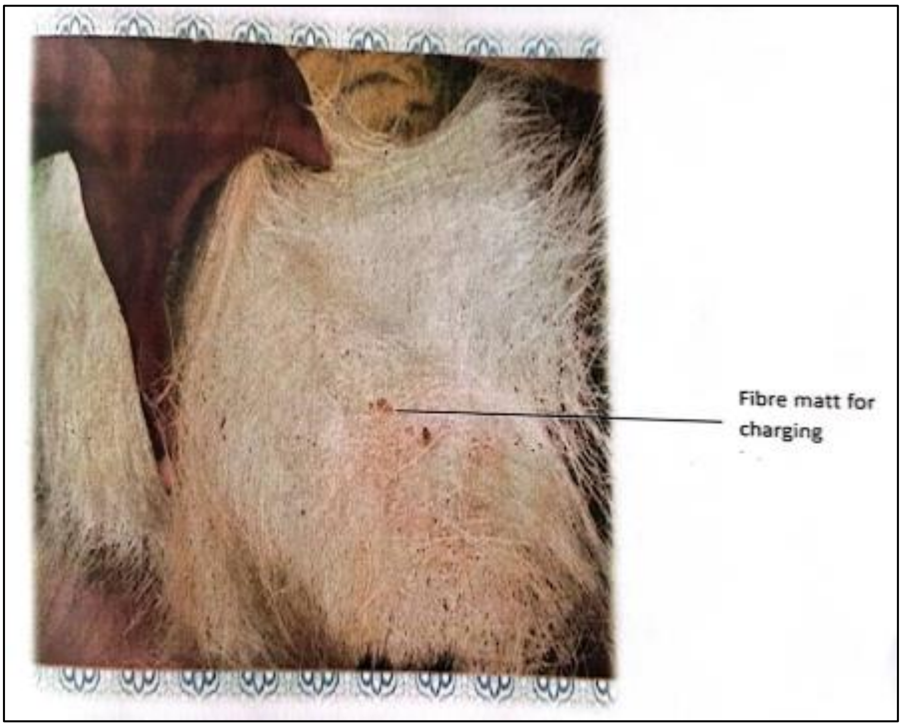

Figure 3 Third stage of modeling (charging)

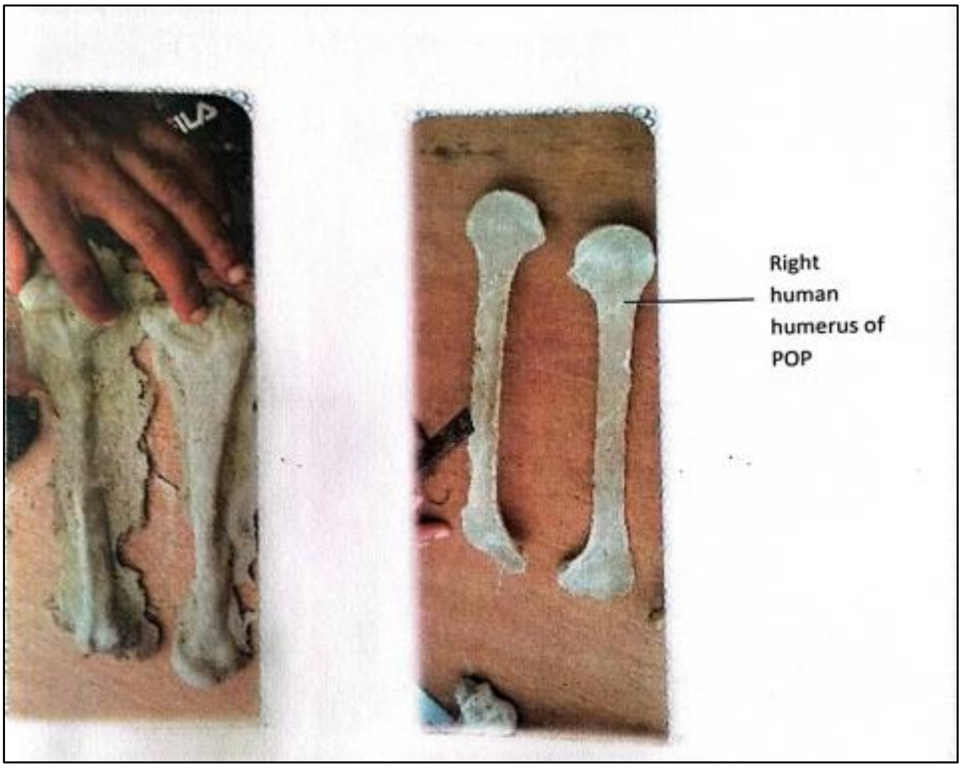

Figure 4 Fourth stage of modeling (casting 2)

Figure 5 Fifth stage of modeling (finishing)

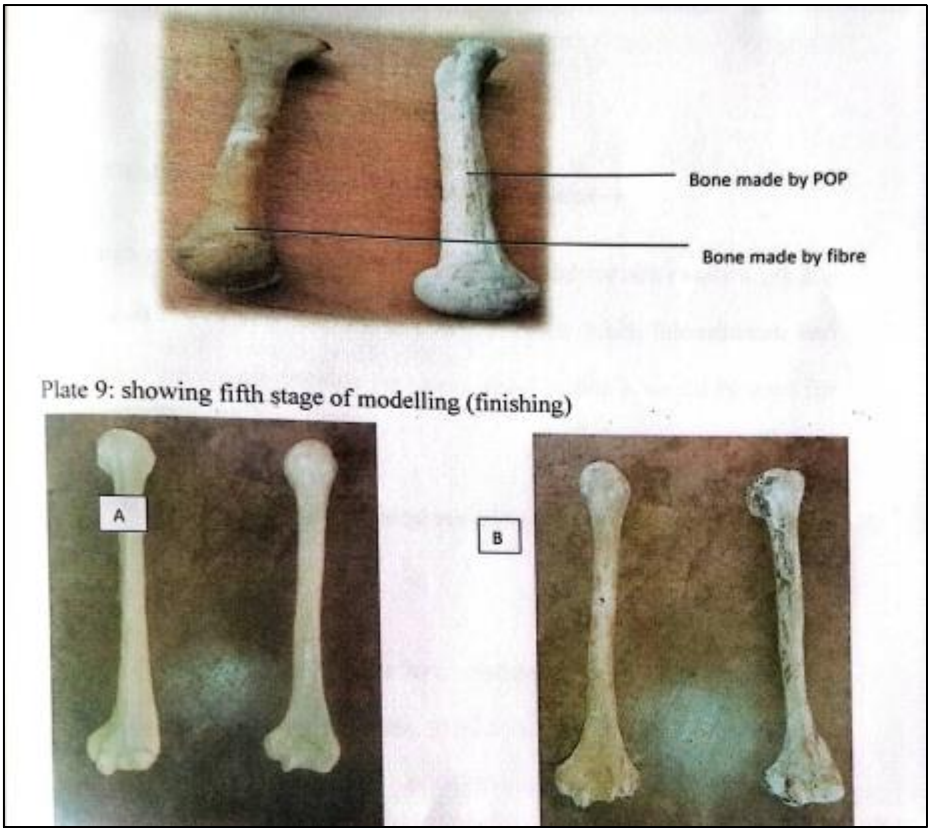

Figure 6 Bones showing (A) plaster of Paris and (B) fibre

4. Discussion

Medical educators use models to allow representation of the anatomy in more effective form than the cadaver [12-14], or in accordance with institutional requirements or societal morals [15-17]. Still anatomical models enable the user to get out of the messiness, annoyance or complication of a cadaveric cleavage and can help elucidate features or functions of an anatomical arrangement that is not easily seen in nature. Models prove extremely helpful in describing both the relationships; of the anatomy, as well as the mode of operation in structures that might be too small to be properly seen in a cadaver or simply confined by other structures. Accurate anatomical models can therefore be used to study anatomy rather than relying on existing models which may be inaccurate in making decisions. The application of anatomical models to the medical curriculum has been documented to be effective in teaching and learning anatomy, but the shape of the model and how the model is presented can influence effectiveness in learning [18- 21].

Models may concentrate opinion on selected features of an anatomical setting that are valuable in educational goals of the curriculum. Well-accurate models are also allowable by medical or dental students to aid in guide cadaver dissection by granting a perfect sight to enable in a means of an arrangement toward a structure or area. Anatomical models are valuable learning resources within the institution or setting which does not have the necessary space, expenditure, or administrative effort to afford cadaveric dissection or specimen preservation. It is due to these causes that it will always be possible to rely on a finely humerus model of anatomy. Surface model of humerus and parametric model of modified cloverleaf plate may be applied to: the production of bone and plate models via use of traditional or additive technology, generation of test models in the Finite Element Analysis (FEA), preoperative orthopaedics and other potential application to medicine and engineering. Findings reported in this study in the geometrical and anatomical accuracy of human humerus surface model and the parametric model of the cloverleaf plate are satisfactory enough.

Fredieu et al., 2015, [22] reported that many different materials can be used to print a 3D object was what we found in fig 1 and through the various processes that we utilised in the production of the model of the human humerus using different local material. Moreover, there are various materials or colours which may be applied. This capability enables the use of complex designs of hard, soft, opaque and transparent ones. An object can be made with thermoplastics such as acrylonitrile butadiene styrene (ABS) and polylactic acid (PLA) as well as using ferrous and nonferrous metals, ceramic, elastic polymers, and numerous other opaque, coloured, and transparent proprietary materials, plus supporting materials that can be dissolved or washed away during post production processing. The material selection is to be done on esthetic, structural, and practical aspects, strength, colour, flexibility, opacity, stability, and costs are to be considered. Also, the printing step might involve such post-processing of the object that it would have strength, durability or transparency so that powder-binder printers deposit a layer of powdered material, then a binding substance. Selective application of colours in the binder material can be done. Unique benefits include the printing speed and multiple colour printing of an object of which our results also demonstrated strength and stability of materials, this is in close association with the opinions made by [22] Fredieu et al., 2015, where different materials had dissimilar effects on both accurate printing and after printing. When cooled ABS is extremely stable in configuration and appearance over time. Nonetheless, polyjet and SLA developing materials can undergo changes in size, clarity and softness. dimensional accuracy is not that crucial in the construction of an anatomical model used in medical education [23].

Studies have found that the students exposed to the 3DP anatomy models will show the same or improved test scores membership in contrast with students of the previous anatomy instruction tools e.g. computer software and cadavers [20, 24, 25]. Moreover, 3DP models of anatomy can supplement or improve other learning methods, which, as already demonstrated, can contribute to and improve deep learning and conversations between students [26]. It is also implied in literature that the quality and detailing of the 3DP model can also help in attaining greater levels of successful learning outcome [27]. Personal 3DP anatomical models have been more recently found to offer value in supplementing the curriculum and more established learning methods that are based in laboratories [28, 29, 30]. Although the use of 3DP anatomical models in medical and surgical training and education has become common [31, 32, 25], the question of how effective they are in other fields of health education is not thoroughly studied [33].

From our findings, it was unearthed that the study were not without challenges which included though not limited to durability and cost, although permission was taken by the village head permit me dig small quantity of clay soil for moulding but their youth felt reluctant and declined angrily, the probable reason for the decline was because they were afraid it could be used for ritual purposes. A number of anatomical models have been created using various materials e.g., wax, wood, papier- mache, plastic, glass, etc. The most contentious, though furthest detailed technique of specimen preparation to date is and ideally became plastination, invented by the German surgeon Gunther von Hagens, by which real human bodies became preserved as smell-free and aesthetics looks to be used as teaching and exhibitory models. Although, there are different forms of models in the world, the lifespan of the models varies. For example, POP anatomical model though fragile is better than wood model in terms of longevity. Moreover, models made with fibre last longer than the one made from wax, provided that accurate care is given by teachers and students handling these models durability is prolonged [34].

5. Conclusion

The methods presented in this paper enable creation of humerus bone surface model and customized molding, casting parametric geometrical models (surface, solid). The main benefit of these methods application is the ability to create geometrical models of as a teaching tool for better understanding of what is been taught. Due to insufficient fund, production of models using local materials around us should be embraced. As medical personnel requires models for consultation and possible treatment to diseases, while teachers need them as teaching aids to foster learning by the students. Also such local models are more appreciative by the users; hence use of anatomical models is highly encouraged.

Compliance with ethical standards

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Disclosure of conflict of interest

No conflict of interest was declared by the authors.

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