Design and Improvement on Oral Radiography Desktop

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ABSTRACT

The oral X-ray desktop is an attachment used together with the Orthopantomograph machine. The Orthopantomography machine is an apparatus for panoramic radiography which is generally it was a two-dimensional (2D) dental X-ray examination of the human upper jawbone (maxilla) and human lower jawbone (mandible). It is a device used to demonstrate the bones of the face, skull and soft tissue. The objectives of this project are to design an attachment for the Orthopantomograph machine and to fabricate the designed model as a prototype. This project involves the development of an attachment design and the study of the attachment effectiveness compared to the existing one. Therefore, the design was started with problem identification, followed by gathering information, concept generation, designs for human factor, fabrication, and product testing. Some of other sources were collected from the patient by doing interview session. For design stage, the dimension was completed using computational design software tools. The designed desktops undergone a testing process that attached to Orthopantomography machine in order to verify effectiveness. The data analysis by comparing result between the designed attachment and conventional desktop were completed in terms of effectiveness and other analysis related. The significance of this project is to improve the current X-ray image of Orthopantomography machine compared to the existing one for a large size of jaws.

Keywords: *X-ray; Orthopantomography; oral; design; dentistry.*

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Introduction

The word orthopantomography is a contraction of ortho-, a prefix meaning penetration of the X-ray beam perpendicularly to the entire tooth-bearing area, panoramic, meaning an overall complete view of the region in every direction, and tomography, a layered recording. On the other hand, the term pantomograph is a contraction of the word panoramic tomography. Orthopantomography is a relatively new method for radiographically examining the curved layers of the dentofacial region [1].

Orthopantomogram is a term used in the dentistry field which is can be illustrated as special X-rays of the lower face, teeth, and jaws. Orthopantomography also can be defined as a radiographic method for examining the curved layers of the jaws by "blurring out" structures not in a preselected plane. The main objective of orthopantomography is to produce roentgenogram (an X-ray photograph) of the entire dentoalveolar region on a single film without superimposition of other structures[2]. The dentoalveolar relating to a tooth and the part of the alveolar bone that immediately surrounds it. Therefore, the dentist could review the lower jaw image clearly. More than 20 muscles are involved in the process of mastication (chewing). The mandible or the lower jaw, is attached to the rest of the skull by muscles through a so-called temporo-mandibular joint. Thus, it cannot move as a free body in space as it is constrained by biological joints and muscles[3]. An Orthopantomogram provides a panoramic view of the mouth, teeth, and bones of the upper and lower jaws. In this system, the patient is immobile position while the X-ray tube and curved cassette rotate in opposite directions around the patient's head [4]. In addition, the curved cassette rotates around its own axis, describing a translation motion in relation to the patient's head. A narrow X-ray beam turns successively around three rotational axes. A concentric rotational axis is used for the anterior portion of the jaws, and two eccentric rotational axes are used for each side of the jaws[5].

In general, orthopantomogram demonstrates the number, position, and growth of all the teeth including those that have not yet surfaced or erupted. It is different from the small close up X-rays dentists take of individual teeth. This method is crucial in order to diagnosis symptom of unwanted diseases and applies prevention action. Some of researcher suggested Computed Tomography (CT) scan for diagnosis stage. However, the orthopantomogram is sufficient and reduce the medical cost.

The Orthopantomography machine was widely used in the dentistry field. There are few functions of this machine instead of capture X-ray image of human anatomic. The other function of Orthopantomogram is to scan object such as work piece to detect any internal crack for instance. It is very useful and has a multifunction machine. This function has already been used by the researcher for their research project purpose. In addition, the advantages of

using orthopantomography are simple operation procedure, adequate information for oral surgery and low radiation exposure[2].

Based on this situation, the design of the X-ray desktop has been a concern in order to enable the Orthopantomogram machine also can be used to scan another object. As a result, two types of X-ray desktop have been designed. Firstly, oral X-ray desktop designed to overcome the fuzzy image in X-ray result produced from conventional oral X-ray desktop. Next, another one is platform X-ray desktop in which it was designed to enable it to be used with another object which has bigger size dimension. This is an additional accessory that produced together with oral X-ray desktop as requested by a dentist from Universiti Teknologi MARA (UiTM) Sungai Buloh Campus. In general, the sharp and clear X-ray image is important for the dentist as they can use as references and detects any abnormal condition occur to the patient and allow to take fast action if required.

The study of the Orthopantomogram function and work principle was done based on Malaysian people. This study was held in Universiti Teknologi MARA (UiTM) Sungai Buloh Campus. From this study, the majority of the patient was a student which is a Malay and has regular skull size. At the same moment, there are few cases that patient with big skull undergone the X-ray and unable to capture proper X-ray image and some of them produce distort the image. The significance of this designed equipment is to provide better clarity of X-ray film result compared to result obtain from conventional X-ray desktop.

Methodology

The improvement design comprises of 6 stages of design process starting with problems identification until product testing.

Problem identification

The process started with problem identification process by doing an interview with the person in charge who conducts the Orthopantomogram radiography X-ray machine. The problem occurs when the result of X-ray image comes out are distorted. The problem was identified occurred due to incapability of Orthopantomogram machine to held on patients with big skull size. The end result, which is an X-ray image, is important to be as clear as possible in order to be used as references. This situation affects the radiography process as it has to redo the process. By repeating this radiography process, it consumes more time than the normal process. As a result, the number of the patient can be examined in one session is decrease due to time constraints. In addition, there are two types of oral X-ray desktop that has been identified for this project. The first one is oral X-ray desktop shown in Figure 1 and the other one is platform X-ray desktop shown in Figure 2. There are differences between these

two X-ray desktop in term of function. The oral X-ray desktop is used for mouth area X-ray while the X-ray platform desktop purpose is to scan the whole object (human skull).

Figure 1: Conventional Oral X-ray desktop.

Figure 2: Conventional platform X-ray desktop.

Gathering information

The data of information was referred to the problem statement and the document research related to the project such as material selection and other consideration. The document research was collected from our observation, journal related to the design and other sources found on the internet. Lastly, some information also obtained from the interview session with radiographer in Universiti Teknologi MARA (UiTM) Sungai Buloh. From this gathering information process, we were able to collect all information needed to perform design for oral radiography desktop.

Concept generation

The design will come out with three possible best designs that would be used in the designing process for the oral X-ray desktop. Each design has different mechanism usage method with the same outcome. The design is following the required criteria that need to follow in the Functional Decomposition Chart in Figure 3 and Figure 4. The Functional Decomposition Chart in Figure 3 elaborate more about oral X-ray desktop while the chart in Figure 4 is more about platform X-ray desktop. For both of oral and platform X-ray desktop, the sharp edge removal and lightweight product taken as the consideration. While the increase of bar height and stable deisgn were most highlighed features that need to be considered.

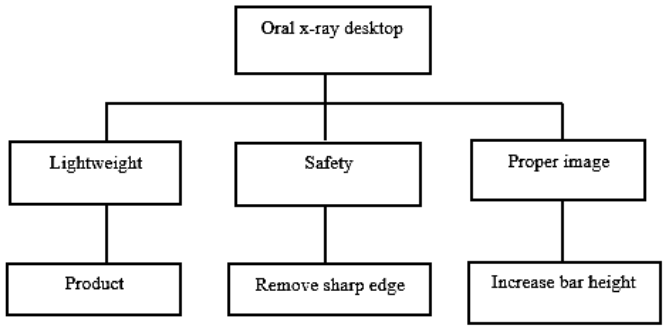

Figure 3: Functional decomposition of oral X-ray desktop.

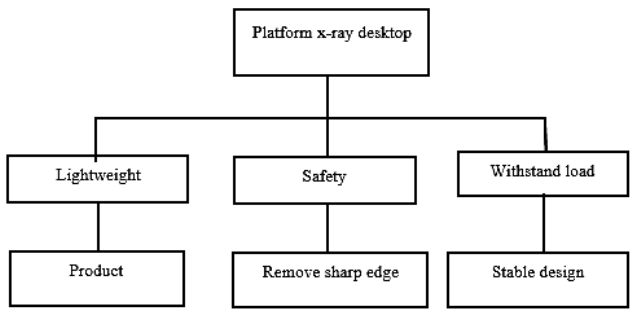

Figure 4: Functional decomposition of platform X-ray desktop.

Designs for human factor

The designed product needs to consider the human factor features such as user's safety and comfortability aspect. For this project, there are some criteria and features that have been considered in this oral X-ray desktop. Sharp edge part usually exists after the prototype undergone a cutting process. It is important to remove the uneven edge surface in order to avoid risk to the user such as minor cut or abrasion on their face. Therefore, the sharp edges existed in plastic Perspex material was removed by using sandpaper instead of grinding. The sandpaper grade used was a Silicon Carbide Abrasive Sandpaper (CC45P). Apart from that, the plastic Perspex material was chosen as it is light weight and portable to carry or attach to Orthopantomogram machine without worry it will fall onto user's feet. It also a good material for first prototype before fabricating a new product. Most importantly, the product could prevent the user from any injuries.

Fabrication

The fabrication stage was done by undergoing a specific process which are cutting, drilling, welding, assembly and finishing processes. Approximately, the total duration of fabrication stage took a month. This stage needs to be conducted meticulously in order to ensure the prototype is in a good quality. Technically, before the fabrication stage starts, preparing the material selection is a crucial in order to decide the cutting method. Therefore, select the best material by referring to the engineering drawing. The fabrication process involved milling machine, bench cutting machine. As a safety precaution, it is compulsory to wear Personal Protective Equipment (PPE) such as safety goggles before conducting the fabrication process. Most of the fabrication process was carried out in the workshop with preferred equipment and assistance.

Cutting

Basically, the cutting process started with tracing on the plastic Perspex material by referring to the printed technical drawing. Perspex is the short terminology from polymethyl methacrylate. This drawing on the plastic Perspex material helps to make sure the material is in a dimension tolerance. The cutting process was performed by using a saw cutting belt. As a result, the plastic Perspex material was perfectly cut. To be precise, cutting by using CO_2 laser is preferable[6] and very minimal error. As we consider it as a prototype and lowering the cost, cutting the Perspex using saw cutting belt is acceptable.

Milling

The milling process of a plastic Perspex was done by using a milling machine. The purpose of the milling process is to reduce the thickness of a standard size of plastic Perspex currently in the market which is 15 mm into 8.3 mm. In order to proceed with milling process, the technical drawing need to be adapted into the monitor or control system and decide the cutting tool. In addition, milling process also able remove unwanted plastic prospect material and make a U-shape.

Drilling

The machining process by a drilling machine on the Perspex surface proceeded with 6 holes in total. There are two types of hole produced which is blind hole and through hole with a diameter of 10 mm each. The risk of drilling on Perspex surface is cracking. To overcome the cracking defect, do not push hard at the diameter center onto the surface like metal. At the same time, the number of clamp need to be balance between the holes to avoid vibration.

Welding

For this design, the welding process is required to join metal part to build a stand attachment for oral X-ray desktop. Perspex is not suitable for an extreme

high temperature especially during deciding welding method. Thus, the Gas Metal Arc Welding (GMAW) was considered as a suitable joining method for Perspex surface. During GMAW process, the deposit is delivered to the base material within the inert gas shield. The melting of the wire and the liquid metal transport are carried by the heat and electromagnetic forces produced by the electric arc which glows between the base material and the deposit wire, without any additional electrodes or plasma sources[7]. The GMAW welding machine is available in the Faculty of Mechanical Engineering's welding workshop. Finally, the mild steel flat plate and the hollow tube were selected and joined.

Product testing

During product testing stage, the prototype produced will undergo a few tests in order to ensure that all features function well as per required including the dimension inspection.

Figure 5: Human skull model set up on platform X-ray desktop.

Figure 6: The (a) front view and (b) side view.

After passing all of the inspection test, the product was conducted together with the real patient (subject) and Orthopantomogram X-ray machine. In order to produce the best image quality, the image need to be sharp and precise. It is a part of the dentists' and medical doctors' concern during diagnose process. Apart from medical purposes, orthomantomogram also reliable for forensic purposes such as determine the skull age from human cadaver. The mandible is the largest, strongest and the most durable bone in the facial skeleton. Its morphology changes as a consequence of tooth loss, which can be expressed as a widening of the mandibular angle, referred to as gonial angle (jaw angle) [8].

There are two types of X-ray desktop used in this testing process which is oral X-ray desktop and platform X-ray desktop. Oral X-ray desktop was tested on the real patient while platform X-ray desktop was tested on a human skull named as "Phantom". The main purpose of this testing is to obtain X-ray image from Orthopantomogram machine for both types of X-ray desktop. The Figure 5, Figure 6(a) and Figure 6(b) shows the human skull was placed at set up on platform X-ray desktop. This set up was assisted by a radiographer to aid the X-ray image process.

Result and Discussion

Both of oral X-ray and platform X-ray desktop were tested by attaching to the Orthopantomogram machine. Both have the same function which is to hold specimen. The different is oral X-ray desktop will need the patient to bite the biting groove while the platform X-ray desktop provides a place to put an

object that needs the X-ray image. For this product testing sessions, a patient involved in testing the oral X-ray desktop while for platform X-ray desktop use a human skull as a specimen.

Result in form of X-ray image obtained from both tested product and compared to the result obtained from conventional desktop available. There is some comparison can be a highlight to show the improvement image by using this product. Figure 7 shows the X-ray image obtained from the conventional desktop. From this X-ray image result, we would able to identify and highlight defect parts in the X-ray image. The X-ray image was generated by software used in Radiography Unit in Faculty of Dentistry. The X-ray image divides into four parts which are (a) Top, (b) 3D view, (c) Front and (d) Side. In general, it able to shows clearly details structure of the patient skull and if there is any abnormality such as fracture and bone dislocation. This diagnosis process will conduct by radiographer in charge. Based on the scope of study for this project, we concerned about the best improvement design of oral X-ray desktop that will produce better image quality in terms of clarity and sharpness compared to the available conventional oral X-ray desktop**.**

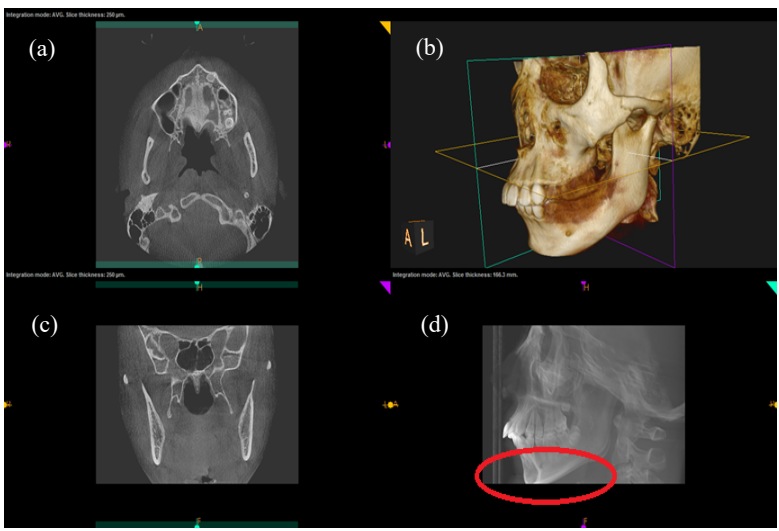

Figure 7: Conventional X-ray image.

In addition, Figure 7 shows the X-ray image obtained from the conventional oral X-ray desktop. The image was taken from a male patient. From this X-ray images result, the red highlight shows the jaw of the skull image was cut accidentally. This case does not happen regularly which is can be converted into ratio 1:10 to the normal patient. Based on our observation and explanation from radiographer staff, this situation happens due to the

patient have a big skull compared to the normal patient. By referring to the working principles in Figure 8, head positioning must be tipped forward and with radiographic baseline horizontal and perpendicular to the film. Thus, the head must be adjusted correctly and parallel to the X-ray source and X-ray film. If any of part such as jaw or nose not in this parallel line, the extended part would not appear in the X-ray image result. Normally the case happens to the patient with a big skull as per mentioned.

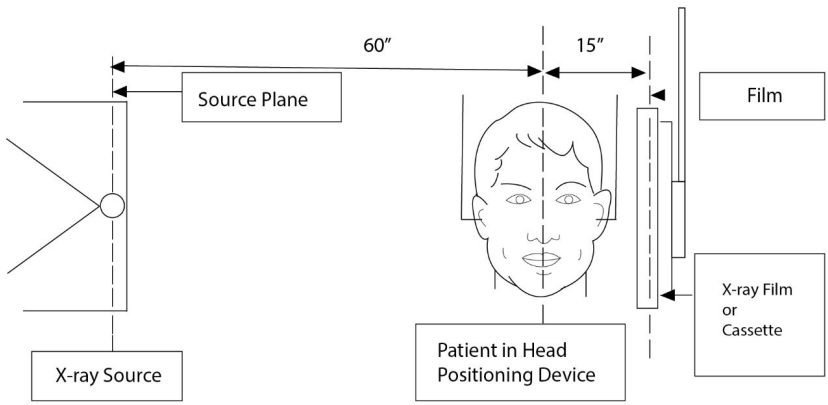

Figure 8: Patient head positioning principle.

To obtain the best image for the big skull size by using conventional oral X-ray desktop, the radiographer needs to lower the Orthopantomogram machine desk as lowest as possible in order to fit the patient's head without allowing his upper head touches the top of Orthopantomogram machine. If the upper head touches the top, the Orthopantomogram machine cannot provide a full surface required that enable the X-ray to scan. Therefore, the remedies was taken by increasing the height of the conventional oral X-ray desktop bar in Figure 9 after considering the Orthopantomogram machine cannot change too much setting. Besides that, it is preferably not to do any interruption due to its functionality. Specifically, the bar height was increased from 83 mm to 130 mm. At the same moment, the designed oral X-ray desktop has the possibility to use with another Orthopantomogram machine that has the same specification in another health institute such as government hospital and private hospital which can be meant as universal.

Figure 9: Height of the conventional oral X-ray desktop bar.

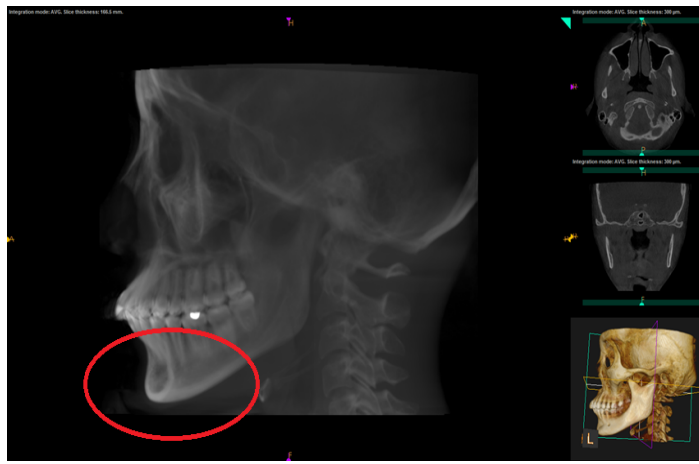

Figure 10: Oral X-ray desktop image

Figure 10 shows the X-ray image obtained after using oral X-ray desktop. The image result produced was complete, compared to the X-ray image taken by using the conventional oral X-ray desktop especially at the red highlighted part which looks clean without cut and parallel to the X-ray film. At this point, the patient that undergone X-ray process by using oral X-ray

desktop has almost the same size of the skull to the patient that perform X-ray using conventional oral X-ray desktop.

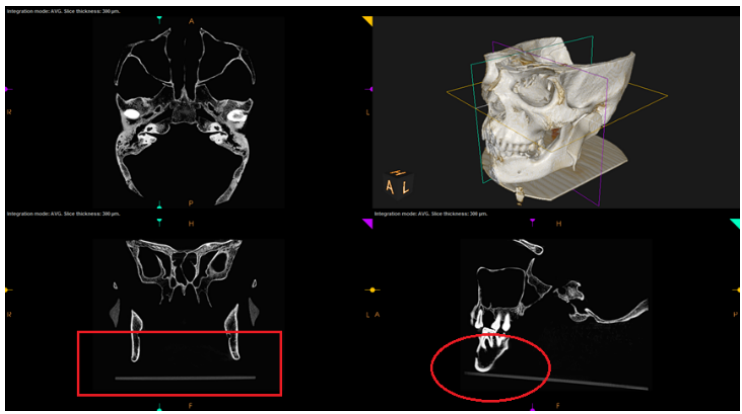

Figure 11: Platform X-ray desktop image.

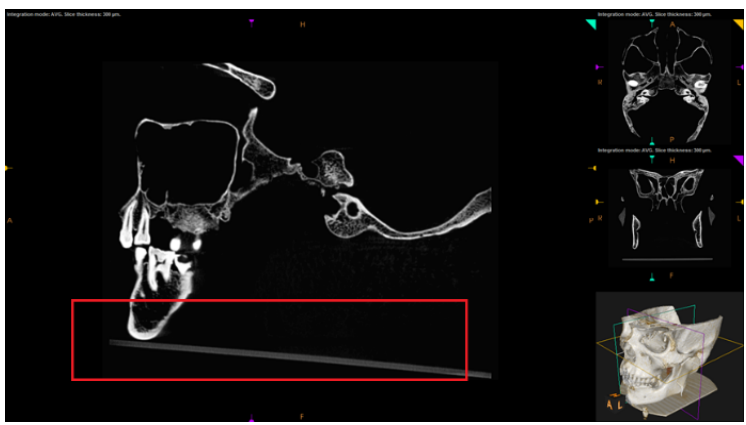

Figure 12: Platform X-raydesktop image.

Figure 11 and Figure 12 shows the result from Orthopantomogram machine that undergone an X-ray process on a human skull as a sample by using platform X-ray desktop. This platform was designed due to the incapability of the conventional platform X-ray desktop to support big size object. The main cause from its small size of platform space and shaky when undergoing X-ray process with a big or heavier object. Figure 13 shows the conventional platform X-ray desktop and compared to the designed platform X-ray desktop in Figure 14 in terms of dimension. This setup and testing

process were also assisted by a radiographer. The testing process held at Faculty of Dentistry Universiti Teknologi MARA (UiTM) Campus of Sungai Buloh.

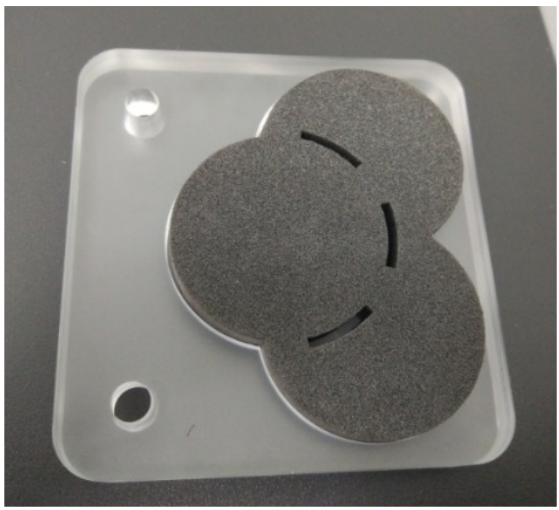

Figure 13: Conventional platform X-ray desktop.

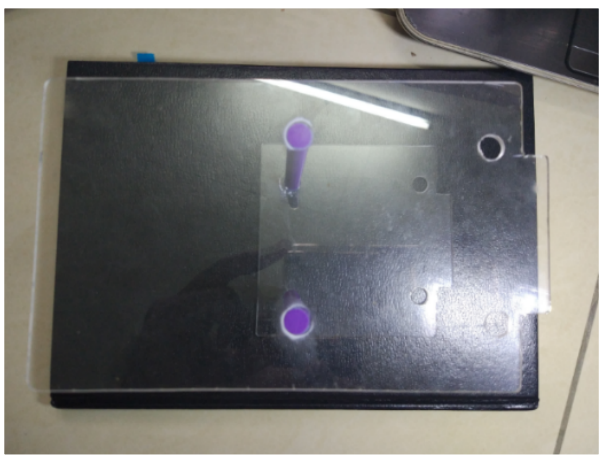

Figure 14: Designed platform X-ray desktop.

There was slight difference between the conventional oral X-ray desktop product in Figure 15 (a) and designed platform X-ray desktop in

Figure 15 (b) in terms of dimension. Overall, the designed platform X-ray desktop is more stable compared to the conventional product to support large object size.

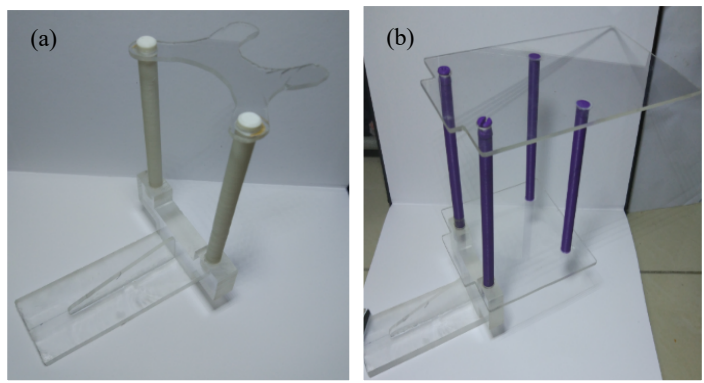

Figure 15: The (a) conventional platform X-ray desktop and (b) platform X-ray desktop prototype.

Conclusion and Recommendations

The study carried out has been successfully met the objectives of this project which is to improvise the best design of oral X-ray desktop and fabricate it according to the desired criteria and functionality. The testing process was done at Faculty of Dentistry in Universiti Teknologi MARA (UiTM) Sungai Buloh as they equipped with Orthopantomogram machine. From the X-ray image result obtained from both oral X-ray desktop and platform X-ray desktop, there is improvement can be a highlight compared to the conventional X-ray desktop. At the same time, the platform X-ray desktop can be used to place big object for X-ray process purpose due to its bigger platform compared to the small size platform in conventional platform X-ray desktop. The final results show that both of the designed oral X-ray desktop and platform X-ray desktop are necessary to overcome the issue of distorted image such as jaw cut. As a significance of this project, the implementation of the designed X-ray desktop can overcome problem faced by the radiographer and improve the performance of Orthopantomogram machine. In the future, this design could be improved with a stronger but light material to build the platform and bar. Consequently, the stability of X-ray desktop will be more secured during X-ray process due to vibration from Orthopantomogram machine.

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