Review Article

A Swing Arm Design Dental Surveyor

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Abstract

The objective was to design and fabricate a dental surveyor using fewer complicated custom made industrial metal parts, thus minimizing production cost. The product design allows working with dental casts of varied dimensions. Current products were analyzed using machine design synthesis. The components of the new surveyor design are predominantly prefabricated objects. The formulation method is comparable with an inverse kinematic engineering approach. A swing arm dental surveyor design was found to be efficient for general dental use at a lower production cost. This article describes the design and assembling method of a dental surveyor made from local common products at low cost. The promotion of this product could stimulate end users to employ this novel instrument by which surveying dental casts can be done in a rapid manner and without restriction due to dental cast base thickness or size.

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Introduction

A dental surveyor, or surveyor, is a fundamental apparatus and a mechanical instrument used in dental profession. A surveyor is a paralleling mechanical instrument used in the construction of a dental prosthesis. A surveyor is used to locate and delineate the contours and relative positions of abutment teeth and associated structures (Academy of Prosthodontics, 2005) with the construction of the prosthesis. During the process of fixed prosthesis or removable prosthesis construction, the contours of the abutment teeth and associated structures in relative position to a selective path of placement and adjacent teeth are surveyed. A surveyor is used to guide, evaluate, and assist dentists or dental technicians in decision-making affecting prosthesis design and mouth preparation. The majority of dental surveyors used in dental education, commercial dental laboratories, and dental clinics are of a parallel arm design (Densply International, Inc. Ref 9363059; Engelmeier RL, 2002; Engelmeier RL, 2004). Most dentists may neglect the benefit of using this instrument, which can increase the precision and quality of the prosthesis. A conventional dental surveyor requires a standard trimmed base and average dimensions of the dental cast. In certain situations, such as untrimmed, extra-large or mounted casts, surveying is not suitable using a standard instrument. To promote surveyor use, eliminate restrictions in its use, and reduce its expense, this moderately technological instrument should have its design revised and be produced locally.

Materials and methods

The design method of this dental surveyor is comparable with an inverse kinematic engineering approach. This method achieves the objective of using mechanical joints, which is known as motion planning. The design process was defined to comply with the following guidelines: identification of the need, background research, goal statement, task specification, synthesis, analysis, selection, detailed design, prototyping, testing, and production. These criteria are the process of machine design.

The criteria were:

1) Mechanical control devices such as thumb screws, nuts, and complicated custom made metal parts must be minimized.

2) Instrument size and mass must be reduced.

3) The dimensions of a dental cast must not be a restrictive factor during surveying when the dental cast is on the surveying table.

4) The range of movement of the vertical arm, whose tip selectively attaches with surveying tools, must not be restricted at a longer moving range and not be restricted by the height and/or width of the dental cast.

5) Prefabricated parts are preferably used and most objects are available locally.

6) Custom made parts must be able to be fabricated by local community technology.

7) The design must not be a copy in part or a total copy of existing trademarked products resulting in the proposed design presented here violating intellectual property rights.

Additional criteria benefitting the dental community are:

1) The proposed design shall not be registered as intellectual property; therefore, the detailed design shall be published to the public.

2) Dental community members may purchase the parts described here and assemble them into their own dental surveyor.

Required Parts:

Prefabricated objects were carefully selected from local hardware shops and internet websites. These objects are:

1) A straight hollow carbon fiber tube 4 mm in diameter and 70 cm long.

2) A straight hollow carbon fiber tube 6 mm in diameter and 80 cm long.

3) Modeling clay 5 cm in diameter or a non-setting putty silicone of similar size.

4) A graphite rod for a press pencil, 2 mm in diameter and approximately 2.5 cm long.

5) A dental glass slab approximately 7.5 by 15 cm and 2 cm thick.

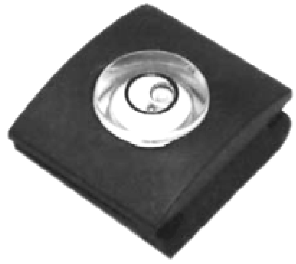
6) Gypsum panel nails with a ring or threaded finishing, 20-25 mm long, with a 2 mm shaft diameter and a 3 mm flat rounded head or brass nails of identical size. Measure the panel gypsum nails or the brass nails and their heads. This is done to calculate the amount of undercut formed by the nail head wing. It is necessary to inspect the shaft and the head to ensure they are concentric. These nails have a head wing 0.5 mm or 0.02 inch from the shaft.

7) A selfie stick used to mount with a camera, with an overall length of 85-105 cm and a hollow thread at its base. It will be mounted with a camera holder at its base. The cell phone holding part must have an exposed metal design at its tip.

8) A small camera mounting set with a suction cup base.

9) A push pin permanent magnet, containing a cylindrical shaped magnet 4 mm in diameter.

10) A plastic circular bubble set typically used for camera hot-shoe affixation.



11) Stainless steel hard wire 0.6-0.8 mm in diameter and approximately 10 cm long, to be shaped as the bubble level set holder

12) A 10 cm diameter glass and stainless steel cup working as a surveying table. Placing one cup on top of another cup will create minor surface frictional resistance as one cup rocks against the other cup.

13) A PVC tube 16 mm in diameter, 81 cm long, two end caps, liquid PVC glue, and two floor care pads (to plug inside the PVC cap). These parts are assembled into a carbon tube container.

The following Figures illustrate the method to assemble the swing arm surveyor.

1. Base

The base is composed of the glass slab, the small camera holder, and the selfie stick. The selfie stick is connected to the camera holder via a screw. The camera holder attached to the silicone suction cup is adhered to the glass slab. Lubricate the suction cup with small amount of water to assure adhesion.

2. Swinging vertical arm

The swinging vertical arm is composed of the two carbon tubes, with the 4 mm diameter tube inserted into the 6 mm diameter tube. To make the vertical arm, the 6 mm diameter carbon tube is glued to a push pin permanent magnet at one end. The push pin magnet holder is trimmed into a cylindrical shape and is fit and glued to the hollow part at the top of the 6 mm carbon tube. The carbon tube 6 mm in diameter and 80 centimeters long then connects to the adjustable length metal selfie stick via magnetic force. As a result, the vertical arm is attached to the selfie stick and can swing. The magnet, which has a 350-400 gram-force, is suitable to hold the carbon tube. The carbon tube can be disassembled from the selfie stick by hand-force. The lower part of the vertical arm is composed of the 4 mm diameter and 70 cm long carbon tube. One end of the 4 mm diameter carbon tube is inserted into the 6 mm carbon tube. The outer surface of the 4 mm diameter tube loosely fits into the 6 mm diameter tube. This orientation allows a varied linear vertical arm length. The slight loose-fit between the two tubes is adjusted by wrapping the 4 mm tube with adhesive tape on the outer surface on both ends. The other open end of the 4 mm tube is attached to the surveying tool. Epoxy resin or cyanoacrylate glue is used to secure the modified push pin plastic handle into the 6 mm carbon tube.

3. **Surveying tools**

The surveying tools are detachable parts, consisting of two pieces, one with a graphite rod and another with an undercut gauge. The graphite rod containing section is a carbon tube 4 cm in diameter and 2 cm long assembled with a graphite rod 2 mm in diameter inserted at one end. The other end has a headless nail shaft affixed to the carbon tube by glue. The nail shaft is fit into the 4 mm vertical arm carbon tube via frictional resistance. If the nail shaft is loose, wrapping it with shrink polymer tube for electrical wire results in a better fit. The graphite rod works as both an analyzing tool and a drawing tool. The other surveying tool is the undercut gauge and is of similar design. The undercut gauge is comprised of a headless nail shaft affixed to a 2 cm long and 4 mm diameter carbon tube at one end. The other end has a nail with its head. Both nail shafts are affixed to the carbon tube by glue.

4. **Surveying table**

There are two forms, a single cup or two cups. The first form is a polymer cup filled with modeling

Fig. 1 Left, Proposed surveyor design with the 85 cm long selfie stick. The overall height from the suction cup to the push pin magnet is 95 cm. In this orientation, the working vertical arm ranges from 85-90 cm; however, under other circumstances, it can be extended to 130 cm. Middle, The pivot universal joint via magnetic force. Right, Another surveyor design of similar concept using a camera tripod stand instead of the suction cup and the glass slab, this resulted to overall weight reduction.

Fig. 2 In confined spaces, a metal biscuit box can replace the glass slab base and the selfie stick. The push pin magnet attaches to the metal box with sufficient force to hold the carbon fiber tube. This technique provides extra working length to the vertical arm, which is useful in certain circumstances.

clay or moldable non-setting putty silicone. The second form results from placing two different cup materials on top of each other. The upper cup is filled with modeling clay. The two cup form makes a quickly adjustable table plane. The single cup table results in a longer working time compared with the double cup table because the modeling clay must be formed into the desired plane; however, it provides good stability to the dental cast. The single cup table also works with less grip-force control.

Discussion

Because the demand for dental surveyors is limited, specific part molding and mass production are to be avoided for logistic and economic reasons. The proposed surveyor design can result in work simplification at a lower production cost. This product is an alternative mechanical design fabricated with common accessible components and preformed materials. The design can be easily assembled by end users. This machine design can be used in dental offices and chair-side laboratories. Work accuracy is not significantly affected, even though the vertical arm is not parallel by its definition in prosthodontics terms. This minute error can be easily explained. Theoretically, the normal working length of the swing arm from the pivot joint to the tip of the graphite rod is 90 cm. When a molar tooth is 1 cm wide bucco-lingually and the distance between the contralateral first molar is 5 cm, algebraic geometry shows that the survey lines from this swing arm dental surveyor should be quite similar to that of a conventional surveyor, considering the acute angle of the swing arm formed between two points. If a reference point is set at a selected survey line on one tooth. The survey line on the opposing side of this tooth is 0.64 degrees different and 3.18 degrees different across the same arch on the opposing molar. Algebraic geometry also indicates that the height of the survey lines will be higher compared with the survey lines made using a paralleling instrument. The trigonometric functions of a non-parallel vertical arm with an acute angle does not meaningfully affect the height of other survey lines on the same dental cast that would result in difficulties in inserting the prosthesis. With regard to instrument design, the method of establishing reference guide plane markings is different. It takes more time to set and position the bubble level.

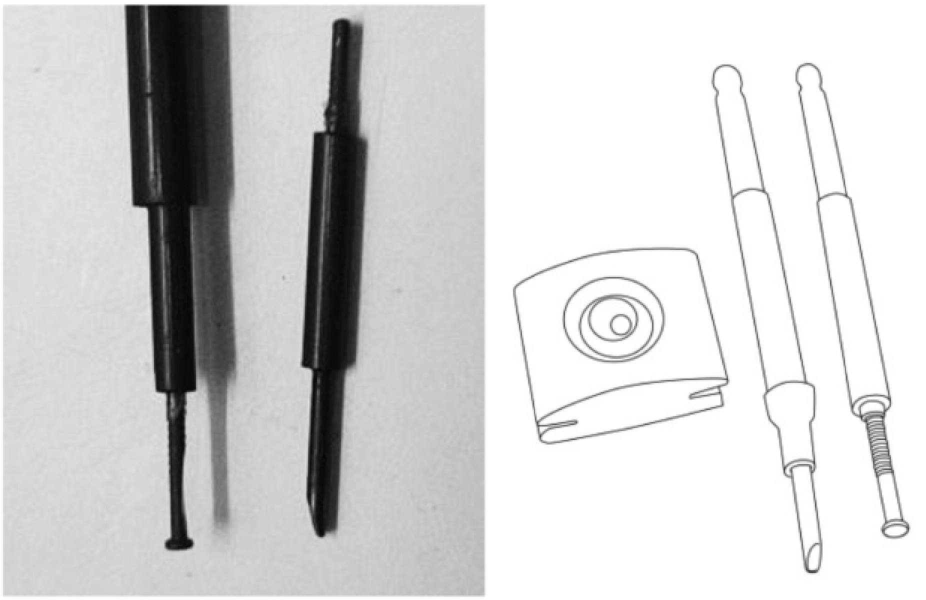


Fig. 3 Left, The object on the left shows a surveying tool; an undercut gauge connected via the nail shaft with the 4 mm diameter carbon tube, which in turn is inserted into the 6 mm carbon tube. These parts work as the vertical arm in a linear configuration. The undercut gauge consists of the 4 mm diameter and 2 cm long carbon tube and two gypsum nails, one nail at each end. The nail is a ring shank nail or a nail shaft with ridges or grooves along its shank. The nail head is 3 mm in diameter and the nail shaft diameter is 2.0 mm. Therefore, the nail becomes a 0.5 mm or 0.02 inch undercut gauge. To alter the surveying tool to use greater undercut gauge values, modification can be done at one side of the nail shaft by grinding it. Grinding the shaft makes a 0.75 mm or 0.03 inch undercut gauge on the other side of the nail. In contrast, to make a 0.25 mm or 0.01 inch undercut gauge, one side of the nail head wing can be ground or trimmed. To assure accuracy, measurement of the undercut gauge should be made using a Vernier caliper. The other end of this undercut gauge is a headless nail shaft or another cylindrical object, glued to the 4 mm carbon tube. This part is not seen in the Figure because it is inserted into the 6 mm carbon tube. The objects on the right show diagrammatic figures of the bubble level set, the drawing tool and the undercut gauge. A graphite rod is fit into the 4 mm carbon tube via frictional resistance or glue. At the other end, a headless gypsum nail or another cylindrical object is glued to the carbon tube. This configuration is linear and becomes the complete vertical arm. Both surveying tools are detachable.

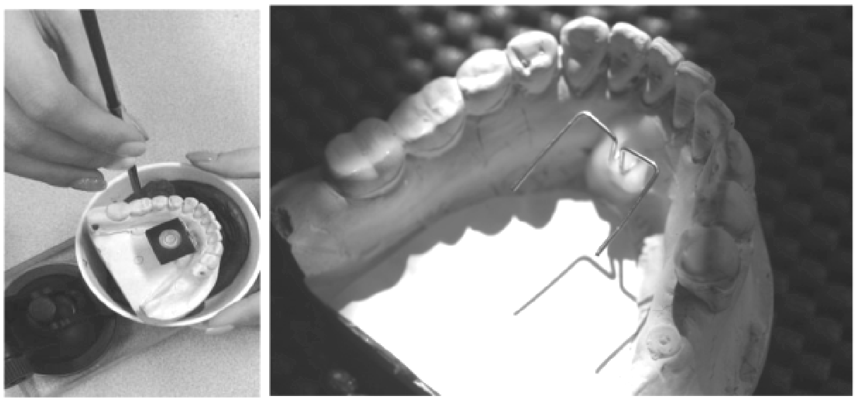


Fig. 4 A preformed 0.6-0.8 mm diameter hard stainless steel wire spring is used to hold the bubble level set. This wire item is hand-made. After a path of placement is selected, both the wire and the bubble level set are secured onto the dental cast with self-cured acrylic resin or secured with a hot glue polymer (via a heated gun type injector). The bubble level set is detachable and can be removed and re-used for other dental casts.

Fig. 5 In addition to surveying standard size dental casts, the surveying table lined with modeling clay is a stable surface for placing other objects such as acrylic dentures, mounted dental casts (with an articulator mounted ring), extra small dental objects or untrimmed dental casts. The figure demonstrates a technique to identify excessive undercuts at the rim of a denture base. These projections obstruct denture insertion. The projection contours of the acrylic denture base are marked with the side of the graphite rod.

Fig. 6 A sixteen mm diameter PVC tube used for electrical wiring with its end-cap is used as the carbon rod container. Only one end cap is glued. The other end has a removable cap.

The materials and design of the swing arm surveyor result in increased working performance such as working with a light touch, a light weight freely moving vertically, easy handling, and an easily adjusted working table. Therefore, this new design converts dental surveying into a rapidly completed task. The adjustable length of the carbon tubes can cope with extraordinarily thick dental casts, such as mounted dental casts. The modeling clay in the open cup can stabilize extraordinarily wide dental casts, such as maxillofacial dental casts or untrimmed base dental casts. The PVC tube package designed to protect the double carbon rods is an economical design. In addition, considering to another piece of package, there are many prefabricated plastic or aluminum boxes available in local markets that can be used to contain the components of the new surveyor. These boxes can be customized with colors and designs. However, more importantly, they can be used to secure the components, and have additional space for dental casts that are adequately cushioned.

Conclusion

This swing arm dental surveyor design produces a mechanical instrument whose component parts are prefabricated objects for non-dental purposes. They are easily acquired items that are low cost and easy to assemble. Dental community members may purchase the parts described here and assemble them into their own dental surveyor by which surveying dental casts can be done in a rapid manner and without restriction from dental cast dimension.

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