BROAD VIEW ON DIGITALIZED TECHNOLOGY OF ARTICULATION – A REVIEW

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Abstract

Background of the study: Recently conventional method of articulation has become the oldest method for determining the jaw movementsthis method had few drawbacks. In-order to overcome this the virtual articulators were introduced by various authors. Now a days digital technology and virtual reality has become trend to produce a three-dimensional view which aids inclarity of diagnosis.
Purpose: The purpose of this review is to find out the newly found evolved methods for evaluating mounting, jaw relation, occlusion is totally a digital workflow.
Materials and methods: There are totally 50 articles out of which 25 articles were included and others were excluded. The articles were collected fromcomputerized databases such has google scholar, pubmed, scopus, web of science articles were then peer reviewed.
Results: Its showed that digital work flow method were more advantageous than conventionalmethod. It was more convenient for the dentist has well as patient due to reduced work time.
Conclusion: Thus transformation from the conventional methods to digitalized method had created a new trend and it had many newer techniques for the conventional methods.

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1. Introduction

Dentistry during the time of 18 centuries where involved. During that period the impressions where made of plaster of paris and waxes. In earlier stages the tooth was stabilized using the wires, similarly in early stages of dentistry forceps were not used. Only hand driven instruments were used during the early period after which water guided instruments were also used such that the treatment plan was restricted along with material availability and facilities.

Has years evolveddigitalization in the field of dentistry has become a very essential part involving development of digital outflow this included digital articulation to bring the stomatognathic system in harmony with the prosthesis. Thus impression making, models, virtual articulators, facebow and implants guided implant surgeries were digitized.

When it is comes to articulation the occlusal relation and occlusal equilibration is done before trying it into patients mouth. Using CAD-CAM the virtualization of the facebow transfer,articulation and occlusion was done.

Another name for virtual articulators is software articulators, they mainly use the jaw motion analyzer, they accelerate the movements of the mandibleby digitalizing the occlusal surface of the mandible. Major aim of the virtual articulator is to provide 3D visualising step up with accurate maxillomandibular relationships.It digitalizes the working methods by using single appointment. The only disadvantages of this method was that the occlusal discrepancy may be present which has to be corrected later by trimming the prosthesis. In-order to overcome disadvantages of the mechanical articulation the virtual articulation was being introduced.

2. Materials And Methodology

Based on the inclusion and exclusion criteria the articles were selected and were added. Various articles from the numerous electronic databases were selected and was included in the study. Totally about 50 articles were collected out of which 25 articles were selected.

The articles from sources such pubmed, scopus, web of science, google scholar were included in the study. These articles from the year 2017 to 2022 were selected. Search terms were virtual, digital, intraoral/ extraoral scanning, articulation, virtual facebow transfer are few terms that were used.

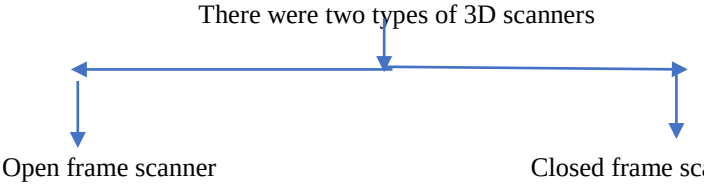
Inclusion criteria:
Different kinds of intraoral and extraoral scanning and its comparison
The hardware and software technologies that were used
Articulator and facebow and the method of digitalization

Exclusion criteria:
Accuracy of CAD-CAM.
Perspective of various virtual articulators.
The articles which were writtern Korean, Japenase, Chinese,
Flowchart based on the crieteria

There were two kinds of virtual articulators

1. Completely adjustable articulator
2. Mathematically stimulated articulator

Completely adjustable articulator.
It was introduced German scientist named Gaertner and Kordass it has helped in accurate reproduction of electronic jaw movement analyaser.
Mathematical stimulation articulator.
This also can be accurate for stimulation of the articulator movements.
The virtual articulators were also known as software articulators. These articulators helps in stimulating the movements of mandible. This virtual articulator is composed of incisal and condylar guide planes. The occlusal discrepancy can be corrected using this virtual articulator.In order produce occlusal movements without any hindrance.
At first the image is captured in 2D after which it is converted into 3D using the hardware this works under the principle of confocal microscopy laser scanning principle. The software helps in correcting the display of the color and the accuracy. There needleless image was captured and again this file was deleted.



Open frame scanner:
Has name suggest is an open adjustable scannerthese kind of scanners should be kept in a region were there is less light penetration. For attaining accuracy and stability the cameras were mounted. The 3D scanning is turnable for operating scanning. Remains in a fixed position while only the parts which were rotating rotates for scanning.

Closed frame scanner:
This is a closed frame scanner has the name suggest is a closed frame scanner camera isplaced inside the box. These scanners have high level of resolution. They are mainly used in the field ofgoldsmith and in dentistry.
Laser scanners and the hand held scanners are mainly used the data's are collected and saved has three dimensional space after which this can be converted into computer aided design. There are lots of virtual scanners wherein they are connected to the software. Mostly the three dimensional scanners were used for industrial purpose. So the CAD/CAM technologies have to be used by the dental technicians.
After virtual articulators are constructed the digital cast is being constructed. The scanning from the conventional cast to virtual cast is done using the scanner. These models where then scanned using the lab scanner.

Intraoral scanners
In the area of dentistry, data collection tools that measure three dimensional jaw and tooth structures transform them into digital data sets. Has the scanning takes place date is obtained. Intraoral scanner had three approaches like Powder painting scanner, Active wave-front sampling scanner, Parallel confocal laser scanner.

Powder painting scanner:
It works under principle of triangulation technique. It used a timed laser light that directed on the tooth structure that is then reflected back to the CCD camera. Then this data is captured to record the image . This scanner necessity of matting powder application - regarding the size of digitized area. Eg; Cerec Bluecam.

Fig 1: Cerec Bluecam.

Active wave-front sampling scanner:
Powder is necessary with this technique.Lens with a rotating aperture instead of using laser light to capture data of the prepared tooth. It allows to compute the data in video has well as models it in real time.Eg: Lava ® C.O.S.iv

Parallel confocal laser scanner
This parallel confocal laser scanner is a powder-free method were the laser beam falls onto the surface of the gingiva without the application of the powder. Once the camera is inserted intraorally scanning takes place where the reflection falls through the conscopic crystal which is projected to camera.Cerec ® Omnicamv.
Mostly scanners can be used according to the compatibility, the emergence profile, by using magnesium powder or titanium oxide which was applied on to tissue surfaces, software used, the different operation used and even final output of the file. These powders were basically used to intensify the scanning with better appreciation.
For certain scan, in-order to avoid the contamination of the models due to application of reflective powder were used. This procedure was carried by removing all thefood debris, then magnesium oxide and titanium oxide were applied on all the tissue surfacesafter which the scanner is inserted, scanning was done and information was transferred to software.
In itero and E4D groups, abutment scan withIn itero and E4D groups, abutment scan was finished first then other remaining teeth were scanned. Zfxintrascan and Trios, occlusal sweep has to be scanned and followed by buccaland lingual sweeps in case of maxillary jaw, in mandible scanning

buccal and lingual sweeps were changed. When scanning with Fastscan, posteriorparts on both side and anterior parts were scanned separately and made it one pieceafterwards.[12]
The abutment teeth was scanned first in scanners like itero scanners and E4D scanners.In scanners such as zfx and trios occlusal sweeps were first scanned after which buccal and lingual sweeps.

Extra Oral Scanner
Here the scanning procedure is carried out externally.Eg. Impressions, models
Non – active scanner:
Otherwise known has contact scanner/mechanical scanner. In this reading is captured with the help of touch probe which has ruby ball at the tip which runs around the object line-by-line forming a 3D structure[1].
Example:
Fabrication - metal portions of single crowns and FPD partial denture.
Titanium coping - Combination method machine duplication and spark erosion.All ceramic crowns - combination with drybag pressing and sintering ceramic material.
Finally once the 3D images of the master dies acquired by scanning stylus it was sent to the processing centre. A good high resolution virtual models were obtained by caliberating the scanner according to manufactures instructions. Probe must be fixed at a 45-degree angle to the axis of rotation of the model. The tip of the contact probe was made up of sapphire ball of radius 0.5mm with a revolution of 360.

In order to achieve virtual master models with high resolution, the scanner was calibrated according to the manufacturer's instructions the settings of the scanner were adjusted to be used as measuring device. Probe must be fixed at a 45-degree angle to the axis of rotation of the model.A sapphire ball with a radius of 0.5mm formed the tip of the contact probe. 360 times for each revolution.In the surface digitization the software used to register the centre point of the contact probe.The collected points-radius of the sapphire ball. By combining the points with a polygon, a triangulated surface-model is created. When a fine-tipped probe is used as the contact probe, even if it is very precise, its takes time to scan the entire model surface.

Non- contact scanners:
This non- contact scanners are also known has Optical scanner or active scanner. A ray of light or laser is used in this scanner. Three-dimensional structures comes into play so called so-called 'triangulation procedure'.white light or laser used for surface data - projecting them on the object.Digital camera acts as receptor unit registered with the reflected patterns. Relationship between the light sources and the receptor unit, forms definite angle. This allows scanning of steep slopes of up to 85° then the refections captured and coverted to 3D data using triangular technology.Eg: Lava Scan ST, Everest Scan, Dentsply sirona.

Fig 2: Lava Scan

Drawbacks: Expensive, Long processing time, complicated mechanics.

Fabrication of Cast and Articulator:
Basically an articulator is used for producing relationship between maxilla and mandible. Facebow was used to engender the maxilla-mandibular relation.Bonwill's triangle and balkwill's triangle were determined based on there position. Using Bonwill'sthe association between lower anterior's and the condylar head on both sides were determined. For balkwills's angle the angle formed buy bonwill triangle and an imaginary occlusal plane[32].
The position of the cast and articulator were determined by two methods.
Which are as follows, with or without conventional cast and articulator
With conventional cast and articulator:

The process of digitalization into a virtual articulator was done simpler using the conventional articulator instead of starting from 1st step, since there was already existing maxillo-mandibular relationship made with conventional articulator. In conventional articulation centric relation is important which is recorded by using occlusal wax plate which was inserted inside patients mouth after which the facebow is inserted into external auditory meatus and the nasion relator was also placed along with Frankfort horizontal plane then, all the thumbscrew were tightened. Then bite fork along with silicone impression material is inserted into patients mouth in-order to record the maxilla relation with the TMJ. After which this record is transferred on to conventional articulator. Then the articulator is turned upside down and the cast is poured, again the articulator is turned and the lower cast is mounted.
Once the articulation is done the 3D scanner was used where the face bow is scanned after which complete articulator is scanned

Scanners used in dentistry:
Here the cast poured conventionally is placed on the mechanically driven articulator which is installed has virtual articulator, cast is placed scanner plate where the articulator, cast exclusively was scanned and transferred has 3D image now the position of jaw to the articulator has been determined.
Next scanning of the facebow being done based on which cast, the bite fork is scanned along with the reference points. Then the jaw position is determined using virtual cast and articulator. Using this maximum intercuspation was scanned. After its transformed into 3D file using reverse engineering software where futile documents are deleted. Then few elements for reference were generated to locate the models in cad-cam system[9,31].

Without conventional cast and articulation:
Major disadvantage of using an intra-oral scanner was transferring of the cast which has been digitized into virtual articulator. Since the previous techniques used had association between maxillary and mandibular jaws, TMJ, Dentist and technicians which was done according to conventional articulators. Whereas compared to the previous technique, the virtual articulator reduces the time consumption.
Virtual facebow:
Using the intra-oral and extra-oral scanners the virtual cast was taken. With 3 reference points such has infra orbital point, head and TMJ. Out of these patient's head is the fixed point and its fixed by belt. These three points were scanned using pointer and the information is transferred to software. After which most prominent cusp of the maxillary arch is determined using articulating paper which is then scanned. All these six point were transferred to the software with the help of reverse engineering software the digital pointer was arranged in a exact position and the image is formed,this was then transferred to virtual articulator for positioning the maxilla after which the virtual mandibular cast oriented in correct position.

fig 3: virtual face bow

Jaw motion:
Basically, virtual articulators are piquancy for jaw motion. The centric relation, retrusion, protrusion, lateral movements can be created using these articulators which make it easier for the technician to fabricate a crown with better accuracy.
There are two types of articulators which comes in-order to stimulation:
1. Completely adjustable
2. Mathematically stimulated

Mathematically stimulated articulator:
This articulator receives information from conventional articulators and this is converted automatically to stimulate the jaw motion like mechanical articulator. Using this the bennet angle can also be stimulated.

Completely adjustable articulator:
This articulator records the exact movement of mandibular jaw with the help of electronic jaw analyser which is also known has jaw motion.

Jaw motion analyser:

Jaw motion analyser stimulates the exact jaw motion. This is made up ofa head bow, bitefork, sensor pen, lower jaw sensor. There is a sensory component that is a receiver and transmitter[23].

Head bow: Made up of eight ultrasonic transmitters with continues transmission of pulse this device helps to calculate the lower jaw with a transit time of the impulse with both transmitter and receiver which has the microphone in it using a triangulation method.

This device is connected to software,then computer is being installed after which the bite is attached. Now the head bow is placed on the head of the patient and then nose supporter. Then with help of the sensor pen pointer, the infraorbital point, TMJ were recorded according to the software.

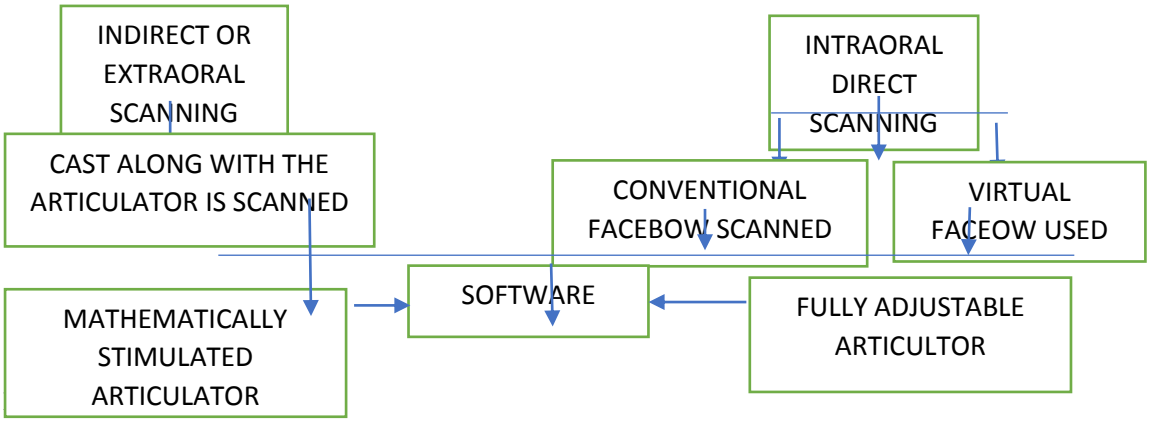
This device which is used for tracking the reading was extracted in numbers according to the motion of the patients jaw in retrusion, laterotrusion and protrusion.The articulators which can read these numbers are stratos 300, sam, fully adjustable articulator.

But this technique has some disadvantages such as need for exceptional device and this device does not have a particular format with a digitalized data. Sothe number from this recording was used. This number is taken into account to stimulate the jaw motion[18]

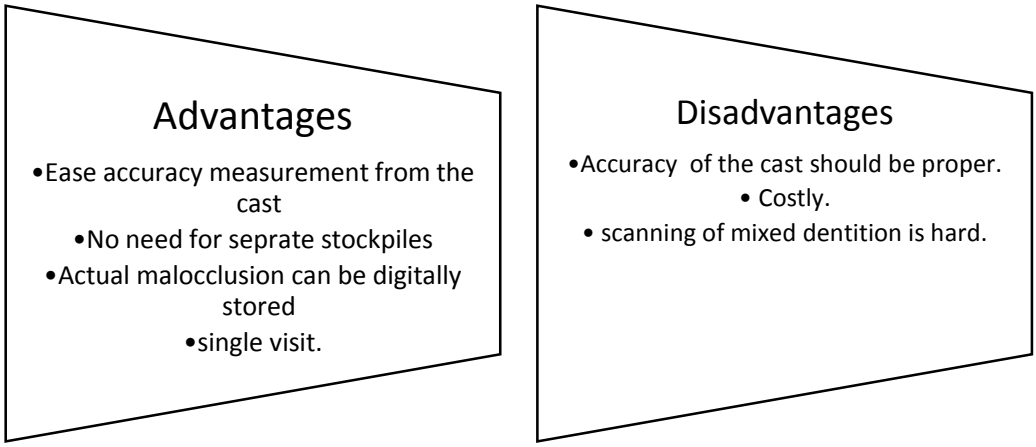
Fig 4: Jaw Motion Analyzer

While using a virtual articulator the data's are transmitted to digital software in order to obtain a successful prosthesis. Usually all the data such as impression, model, jaw relation, jaw movements, TMJmovements were sent to the digitalized CAD-CAM software where the designing was done whereas as scanning is done intraoral which already has inbuilt virtual articulators along with the facebow.

Here is the schematic representation of the Data



This digitalization were used in prosthesis fabrication such as veneers, crowns inlays,onlays fixed partial dentures, implant prosthesis and ortho appliances. In recent times the usage of virtual articulators have been escalated[33].



Correlation between Direct and Indirect scanning:

Indirect scanning	**Direct scanning**
These scanners can be used in lab.	More comfortable for the patients.
But it can cause physical and chemical damage.	Portrayal of real time and color
Temperature and humidity can cause distortion of the cast.	Virtual follow-up

CBCT

This Cone Beam Computed Tomography was used to convert 2D image into 3D image by using a structure gantry which rotates. Normal movement of the patient's jaw will be very hard using the virtual articulator. By Overall analysis its believed that the CBCT records the skull and jaws of the patient more accurately[6].

Usually using CBCT the 3D image was produced. This image can be sliced using the software. Then the virtual intraoral scanning of the model is attached along with the virtual CBCT skull bec of CBCT's poor expression of occlusal surface. Here the tracking device were attached to the patients reference points. The maximum intercuspation was scanned with of 3D scanners[34].

Surface Details

A better veracity and good surface details reproduction aids in successful outcome of the prothesis. Basically the accuracy refers to the trueness that is actual measured standard value. Precision means the value is more than one. If suppose the value is measured around 50mm once again the values were measured same then its called precision in values. But when the difference in valuesis not same extends upto10mm or lessthen trueness becomes a question mark.

Intra Oral Scanner

Systematically analysis between two scholarly articlesare made, there values differ based on the object size which varies and the limitation of the laboratory the average value is usually high or low. If the value isincreased then accuracy becomes low. If the accuracy is high the value becomes low. If any of the value is low with other one high the it falls into middle accuracy.

Intra Oral VS Extra Oral Scanners

Basically extra oral scanners are more accurate than the intra oral scanner. The accuracy between the intra and extra oral scanners were less, since they were used by cast fabrication and impression along with silicone. But the level of accuracy between the intra oral and extra oral scanners were compared, its was concluded that extra oral scanners are better.

3. Conclusion

The virtual articulators are playing major role in digital dentistry. These virtual articulator, virtual model and its relationship between stimulating jaw motion. Its started by scanning the virtual model using intra oral scanner and then articulation by virtual facebow using different software.

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