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Application of stereo lithography in orthodontics –a review

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Abstract:*The advances in digital imaging systems combined with the availability to register CBCT data with digital models had made possible in fabrication of orthognathic surgery, CAD/CAM designed splints ,customized brackets ,and indirect bonding systems. Thusstereo lithography is used in wide range of dentistry, which helps in creating asymmetries ,fabricating, coating and land marking synthetic mandible. This article describes about stereo lithography and its application in various fields of dentistry.*

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I. Introduction:

The availability of 3D dental model scanning technology, advances in digital imaging system, computer aided design and computer aided manufacturing technology are providing new possibilities in dentistry. fabrication of models is a clip of engineering research and it's a design as an intermediate step for developing concepts and bringing new steps. The stereolithographic models are used in creating mandibles with known amount of asymmetry.which helps in measuring asymmetrical shapes, as well as linear and angular measurements. Thus this article gives a brief idea about the wide use of stereolithographic in fabricating coating land marking synthetic mandible and measuring asymmetry.

II. Materials And Methods:

The topic was searched electronically in PUBMED. The following words were used in the search criteria: such as "Stereo lithography in orthodontics", "Stereo lithography in dentistry" and the 12 articles and 2 clinical trial were foundand collectedand the results were summarized in this article.

Table:

Sno	Topic	Study type	Sample size	Result	Conclusion
1	Fully customized placement of orthodontic miniplates:anovel clinical method	Invivo		The presented technique Minimizes intraoperative decision making, because the final position of the plate is determined presurgically reduces the duration of the procedure and improves its outcome.	A novel method for surgical placement of miniplates facilitates accurate adaptation of bone plates in anatomical site where Osseo integrated miniscrews is favorable.[1]
2	A comparative study of two different clear aligner systems	Invivo	20 patients	Comparison of two different clear aligner systems were done.	The two aligner were shown difference during the treatment fantasimino has elastic properties of high performance.[2]
3	Stereolithic mandible fabrication and image preparation	Invitro	34 patients	Synthetic mandibles ranging in asymmetry were successfully produced .a method for creating asymmetries,fabricating,coating and land marking the synthetic mandibles was formulated.	Asymmetries in the condyles, ramus and body of the mandible can be successfully designed using engineering software and rapid prototyping to construct a stl model of a human mandible.[3]
4	Three dimensionalevaluation of upper anterior alveolar bone dehiscence after retraction and intrusion in adult patient with bimax protrusion malocclusion	Invivo	20 patients	Significant difference were found.	For adult patients with bimax protrusion ,mechanobiological response of anterior alveolus should be taken into account during incisor retraction and intrusion pursuit of maximum anchorage might lead to upper anterior alveolar bone loss.[4]
5	Computer aided designing and manufacturing	Invitro		The 3d model and CBCT scan can be combined ,the lever arm vector can be virtually designed ,it can be saved and	The merged 3d model and CBCTscans enables improved accuracy of orthodontic appliance design and

	of lingual fixed orthodontic appliance using 2d/3d registration software and rapid prototyping.			exported.it can be converted to fabricate the bracket and premature contacts can be eliminated and chair side adjustment is reduced.	manufacturing of kilbon appliance results are1) use of auxiliary wires reduced the distortion of the appliance during the casting.2)wire diameter should be larger than 0.9mm to withstand retraction force.[5]
6	Rapid tooling for customized removable oral appliance	Invivo		Customized soft oral appliance was more comfortable to use and, there was exact fit and it is user friendly.	The customized soft orthodontic appliance made from silicone could be manufactured by making a mould with stereo lithography from somos protogen o-xt 18420 material. Theappliance with moderate force was more efficient but caused a slight unpleasantsensation. Small force version was more comfortable for the patient.[6]
7	Measurement of orthodontic force extended on the upper right central incisor with the increase of the distance of tooth movement and thickness of the aligner.	Invitro	6 patients	The orthodontic forces increased with the thickness of the aligner at the same distance of the tooth movement($p<0.05$). The orthodontic force was (1.237), (1.543), (3.602), (6.734) n when the labial movement of upper central incisor was 0.3 mm with the aligner ($p<0.05$). The orthodontic force of the aligner of 0.8mm were (1.354), (1.288), (1.479), (1.799) n when the right central tooth labial movement at 0.6, 0.9, 1.2, 1.5. Mm.	The orthodontic forces increased with the increase of the distance of the tooth movement and the thickness of aligner.[7]
8.	Comparison of 3 dimensional dental models from different sources diagnosis and surface registration accuracy.	Invitro	3 patients	The virtual scan method had highest correlation with manual method. Surface overlap correlation was observed between the virtually scanned models and e models. The mean serial difference between the stereo lithography shells of these 2 model system were 0.14 and 0.13 mm for the maxillary and mandibular arches respectively.	3 digital model system provide diagnostic information similar to caliper measurements with varying degrees of agreement limits. A strong surface match correlation was observed between the virtual scanned models and the e models, indicating that these could be used interchangeably.[8]
9	A digital process for additive manufacturing of occlusal splints.	Pilot study		The digitally manufactured occlusal splints was used for six months along with conventional splint. They were same and did not show any significant difference.	Occlusal splints using digital technology might reduce costs, working time and chair side time. Accuracy can be improved.[9]
10	Accuracy of surgical positioning of orthodontic miniscrew with a computer aided design and manufacturing template.	Invitro	11 patients	The distance for the placement of aminiscrew between 2 roots was 4.12mm (sd,0.25mm; range, 3.7-4.5 mm). The placed miniscrews showed an average angular deviation of 1.2 degrees(sd, 0.43 degree;range 0.6 degree-2.41 degree)compared with the plan, whereas the mean linear distomesial deviation was (sd,0.13 mm;0.15-0.6 mm)at the tip.	The template has high accuracy and will be especially useful for patients who require precise miniscrew placement.[10]
11	Clinical application of a stereolithographic surgical guide for simple positioning of orthodontic miniplates.	Invivo	1 patient	The surgical guide was easily placed intraorally and permitted simple and rapid placement of mini implant. The site of implant placement was accurate , while vector varied slightly from the planed vector.	A post placement cacti demonstrated accurate placement of the mini implant position and clinical position .[11]
12	Validation of align technology's treatlll digital model superimposition tool and its case application			the results showed that the digital superimposition was reproducible, and after multiple trials the error decreased. The average error in x, y,z,rx,ry,rz after 10 trials was determined to approach approximately 0.2 mm in translation and less than 1 degree in rotation ,with a standard deviation of 0.15 mm and 0.7 mm, respectively. The treatment outcome from a single invisalign treated bicuspid extraction case was also evaluated tooth by tooth in x,y,z,rx,ry,and rz dimentions.	Using the palate ,as a stable reference seemed to work well and evaluation of the single case showed that many ,but not all, of the planned movements occurred.[12]

13	A new protocol for planning distraction osteogenesis of the mandible.	Invitro		On x axis the difference between the predicted position for the condylar marker and the actual position of the stereolithographic models was 0.6 +/-1.1 mm. on the y axis, the difference between the predicted position for the condylar marker and the actual position on the stereolithographic models was -0.9+/- -2.6 on the z-axis, the difference between the predicted position for the condylar marker and actual position of the marker on the stereolithographic models was 0.04 +/-0.8 mm. There was excellent correlation between the predicted and the actual measurements for the x,yand z axes:0.98,0.93,and 0.98,respectively.	The results indicate that the combination of this planning process and surgical process and surgical technique was very accurate .the use in clinical practice will allow the clinician to improve the clinical outcome of patients treated with distraction osteogenesis.[13]
14	Results of measurement of pre and post-operative milling models of orthodontic surgical treatment of dysnathia patients.	Invitro	15 patients	The mandibular corpus had been shifted between 1 and 3 mm forward in The group of patients with mandibular retrognathism And by the same Distance backward in the first group. In the group with ventral shifting, The intercodylar distance increased by 2.9 mm, while it decreased by 1.9 Mm in patients with the mandibular backshift operation. Furthermore, the Distance between the muscular process increased by 6.6 mm in first group And decreased by 1.6mm in the second. The bone angle decreased By 1.6 degrees in patients after ventral shifting and increased by 1.7 Degrees in the dorsally shifted group. Contrary changes in The left and right Gonion angle were seen: if the right is decreased, the left increased. The Same situation was found in Both groups.	We noted remarkable Changes in the condylar position and anatomy after Sagittal splinting of the mandible.[14]

III. Result:

Jan hourfar et al, conducted a study to present a new clinical technique for the placement on mini plates and evaluated that the presented technique minimizes intraoperative decision making, because the final position of the bone plate is determined presurgically reduces the duration of the procedure and improves its outcome.[1]

A comparative study done by federica ercoli et al, in 20 patients to compare two different clear aligner systems evaluated that there is no difference in satisfaction, improvement of irregularity index, speech impairment and mean wear time.[2]

Shawn russett et al, conducted a study for stereolithographic mandible fabrication and image preparation on 34 patients and concluded that synthetic mandibles ranging in asymmetry were successfully produced. a method for creating asymmetries, fabricating, coating and landmarking the synthetic mandibles was formulated.[3]

Qing –yuan guo et al conducted an invitro study for three dimentional evaluation of upper anterior alveolar bone dehiscence after retraction and intrusion in adult patient with bimax protrusion malocclusion and noted that there was significant difference in both of them.[4]

Soon –yong kwon et al, conducted a study for manufacture of computer aided designing and manufacturing of lingual fixed orthodontic appliance using 2d/3d registration software and rapid prototyping and noted that the 3d model and cacti scan can be combined ,the lever arm vector can be virtually designed ,it can be saved and exported.it can be converted to fabricate the bracket and premature contacts can be eliminated and chair side adjustment is reduced.[5]

Mika salmi et al did an invivo study for rapid tooling of customized removable oral appliance and evaluated that customized soft oral appliance was more comfortable to use and, there was exact fit and it is user friendly.[6]

Akyalcin et alconducted an invitro study for comparison of 3 dimensional dental models from different sources diagnosis and surface registration accuracy on three patients and evaluated that ,the virtual scan method had highest correlation with manual method . Surface overlap correlation was observed between the virtually scanned models and e models. The mean serial difference between the stereo lithography shells of these 2 model system were 0.14 and 0.13 mm for the maxillary and mandibular arches respectively.[8]

Liu et al conducted an invitro study on 11 patients to determine accuracy of surgical positioning of orthodontic miniscrew with a computer aided design and manufacturing template and he evaluated that the distance for the placement of aminiscrew between 2 roots was 4.12mm(sd,0.25mm; range, 3.7-4.5 mm). The placed miniscrews showed an average angular deviation of 1.2 degrees(sd, 0.43 degree;range 0.6 degree-2.41 degree)compared with the plan, whereas the mean linear distomesial deviation was (sd,0.13 mm;0.15-0.6 mm)at the tip.[10]

Kim sh et al , conducted a study to evaluate clinical application of a stereolithographic surgical guide for simple positioning of orthodontic miniplates and evaluated that the surgical guide was easily placed intraorally and permitted simple and rapid placement of mini implant. The site of implant placement was accurate , while vector varied slightly from the planed vector.[11]

Miller et al conducted a study for validation of align technology's treatlll digital model superimposition tool and its case application and evaluated that the digital superimposition was reproducible, and after multiple trials the error decreased. The average error in x,y,z,rx,ry,rz after 10 trials was determined to approach approximately 0.2 mm in translation and less than 1 degree in rotation ,with a standard deviation of 0.15 mmand 0.7 mm,respectively. The treatment outcome from a single invesalign treated bicuspid extraction case was also evaluated tooth by tooth in x,y,z,rx,ry,and rz dimentions.[12]

Gateno j, et al conducted an invitro study for determining the accuracy for planning distraction osteogenesis of the mandible and evaluated that on x axis the difference between the predicted position for the condylar marker and the actual position of the stereolithographic models was 0.6 +/-1.1 mm .on the y axis, the difference between the predisted position for the condylar marker and the actual position on the stereolithographic models was -0.9+/- -2.6 on the zaxis , the difference between the predicted position for the condylar marker and actual position of the marker on the stereolithographic models was 0.04 +/-0.8 mm. There was excellent correlation between the predicted and the actual measurements for the x,yand z axes:0.98,0.93,and 0.98,respectively.[13]

Schultes k et al did a study for the measurements of pre and post operative milling models of orthodontic surgical treatment of dysnathia patients and found that

The mandibular corpus had been shifted between 1 and 3 mm forward in The group of patients with mandibular retrognathism and by the same Distance backward in the first group. In the group with ventral shifting,The intercodylar distance increased by 2.9 mm, while it decreased by 1.9Mm in patients with the mandibular backshift operation.furthermore, theDistance between the muscular process increased by 6.6 mm in first group

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IV. Discussion:

Application in diagnosis:

Stereolithographic provides diagnostic information analogous to caliper measurements with varying agreement limits. It showed least mean biases when virtual models were scanned. The virtual scanned models and emodels showed strong surface correlation which indicated that it could be used interchangeably.[8]

Application in distraction osteogenesis:

For mandibular transverse arch deficiency, mandibular midline distraction osteogenesis is available as a treatment option. The surgeon can predict the amount of transverse expansion that can be gained through this procedure which was presented by model study technique. The mandibular cast is mounted on a semi adjustable articulator, by utilizing the three dimensionalstereo lithography model measurements.by using the inter occlusal record the maxillary model is mounted onto an articulator. Fabrication of acrylic straps were done which relate the condylar elements of articulator to right and left mandibular dental segments. At the midline the mandibular cast is sectioned the hemi mandibular segments are rotated laterally until the desired midline expansion is achieved, in the new position the mandibular model is luted.it provides valuable information for the surgeon and the orthodontist about the post expansion relationship of the maxillary and mandibular arches.[15]

This also helps in the invitro accuracy of new protocol for planning process and surgical technique for distraction osteogenesis in mandible.[13]

Application in mini implant placement:

For accurate placement of the mini implant stereolithographic can be made as a surgical guide. The surgical guide was placed easily intra orally which was simple, accurate and rapid placement of mini implant.[11]

Application in surgery:

In milling models of orthodontics surgical treatment of dysgnathia:

Diagnosis of craniofacial disharmonies is made by three dimensional realization of CT by models produced by milling machine and stereolithographic. To verify the results of the operations involving sagittal splitting of the mandible three dimensional milling models were used. This showed remarkable changes in condylar position and anatomy after sagittal splitting of the mandible.[14]

Application in manufacture of occlusal splints/ oral removableappliance:

Manufacture of occlusalsplints by digital process is evaluated. Modern digital technology enables us to manufacture clinically functional occlusal splints which reduces cost, dental technicians time and chair side time. Thiswas made by taking an alginate impression of upper and lower jaws of a patient with temporomandibular disorder, owing to cross bite and were of teeth, and then digitalized by table laser scanner. The scanned model was repaired using the 3data expert software, and a splint was designed with the viscam rp software. A splint was manufactured from a biocompatible liquid photopolymer by stereo lithography. The system employed in the process was sla 350. The splint was worn nightly for six months. The patient adapted to the splint well and found it comfortable to use. The splint relieved tension in the patient's bite muscles. No sign of tooth wear or significant splint wear was detected after six months of testing.[9]

V. Conclusion:

The advancement and availability of the 3d dental model scanning technology provides new and novel method that can be applied in the various fields of dentistry that are easy for evaluation that are useful for the treatment and it helps in comparison for pre and post treatment plans. Models can be saved and exported.it can be converted to fabricate at same time which is time consuming. Thus the advancement in the 3d technology is a boon and it should be utilized in an appropriate method.

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