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Contemporary digital software applications in orthodontics: A review

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Abstract

Orthodontic technology has advanced significantly, allowing an orthodontist to precisely design the course of therapy. The software enables the analysis of dental mobility and the provision of digital treatment choices. Cephalometric analysis, digital imaging, intraoral and extraoral image capture, morphing capability to show patients what their teeth could look like after treatment, case presentation capability, treatment planning capability, and oral maxillofacial surgery applications are typical features of orthodontic practice software and orthodontic digital treatment planning systems. You can give patients graphics through these technologies that will assist them in understanding the benefits of proceeding with orthodontic or surgical-orthodontic therapy. Since patients can now comprehend and see the treatment plan, communication between clinicians and patients has also become easier due to digitization. Thanks to digital orthodontics, getting a healthier and straighter smile is much easier. Because of this, the majority of this assessment is based on software that is currently accessible for orthodontic applications.

Keywords: Technology; Digital software; Digital imaging; Cephalometric analysis; Treatment planning system

1. Introduction

The development of 3D dental arch models is one of the advancements that has had the biggest impact on modern orthodontics. Other innovations that have transformed the field include the adoption of new digital technology into routine clinical practice. Many physicians are now more familiar with digital technology thanks to the ability to digitize plaster models or take direct 3D pictures of arches using intraoral scanners. This revolution has numerous benefits: virtual models eliminate the need for the stone cast, make storage operations simpler, and 3D models can be utilized for dental diagnosis just as precisely as a stone cast[1]. The most common format for storing and displaying digital 3D models is STL (Standard Triangle Language). The format for evaluating models has developed into the industry standard. The STL format is monochrome since it lacks color mappings. The reference formats for colour texture are ply and obj (Object File Wavefront 3D), if you would also like to add that (Polygon File Format). Through the use of digital models, the diagnostic technique has been modified, enabling virtual simulation of the patient and dental motions and simplifying and improving traditional orthodontic evaluations[2]. Additionally, the method offers greater control throughout therapy because of its decreased invasiveness and capacity to overlap the models. Thanks to the application of very accurate polymers and 3D printing technology, any orthodontic product may be manufactured[3]. An entirely digital process, on the other hand, may be controlled: various devices can be manufactured without the need for prototypes by employing specialist software to design them digitally.[4] In summary, the use of digital models is essential to scientific research. This digital revolution has affected the orthodontic world, but there are some negative aspects, including the need for the clinician to learn how to use new software[5]. Two primary categories of software can be distinguished in this context: open-source software and dedicated software, which are created by orthodontic companies. Because dedicated software is meant for non-expert users, it typically has a much more user-friendly interface and is easier to use and intuitive overall. However, the cost of purchasing or renting can be prohibitively high. As a result, younger physicians who possess a greater proficiency with digital tools have started to show a growing

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interest in open-source software. Some of the software offered by these programs is free or available on a "pay-as-you-go" basis, making them an extremely intriguing resource. On the other hand, drawbacks include a somewhat steep learning curve. This study aimed to showcase and understand some of the most well-known open-source programs for 3D model analysis and modeling devices in Orthodontics.

Various Software available for model analysis

1.1. OrthoAnalyz®

- Analysis and diagnostics based on 3D models. Integrates with DICOM data, 2D images (photos, ceph, etc.), and patient information.
- Enables 2D and 3D measurements and Standard Analysis (Bolton, etc.). No modification of the tooth positions.
- Scans can be easily based to create Digital Study Models and quickly retrieved for routine assessment. Treatment needs can be determined by using a range of measurement tools with several built-in analysis functions such as PAR, Bolton, IOTN, and Space Analysis.
- A more thorough assessment can be provided by integrating CBCT scans onto the surface scan to assess bone density and root positions. (Fig 1)
- Advanced treatment diagnosis and planning can be delivered using advanced features such as Virtual Setups for quickly presenting treatment options such as traditional 'Kesling' setups.
- Occlusal interferences can be assessed by utilizing Virtual Articulators and the defined treatment plan shared with a 3Shape-enabled lab to assist with the provision of appliances or clear aligners to meet the planned treatment outcome.

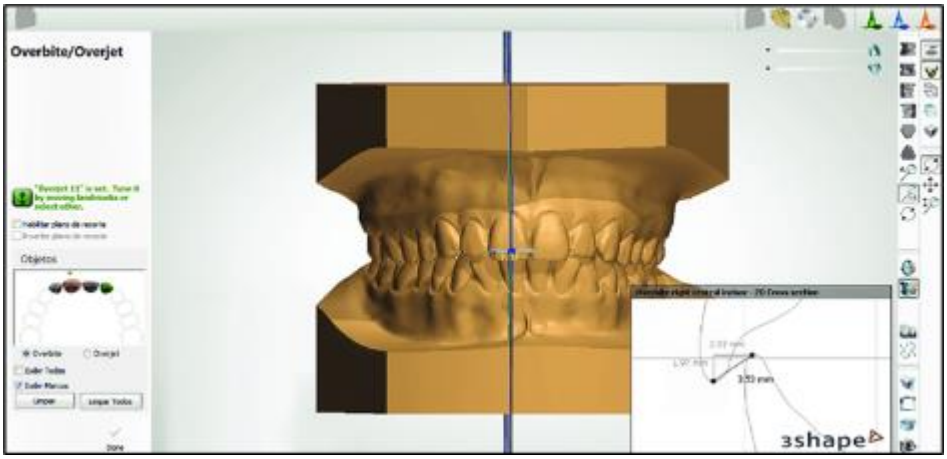

Figure 1 Overbite measurement in the digital model using the Ortho Analyzer software[6]

1.2. Digimodel®

- Visualization of the upper and lower models, separated or occluded, in different views, using a click, on the software's initial screen;
- Possibility to visualize models to establish malocclusion classification; Automatic calculation of overjet and overbite in two clicks (no need to mark points for these tasks);
- Individual tooth-length measurements and annotations (3 clicks: 1 for tooth selection, and 2 for marking points);
- Automatic calculations of arch-length and tooth-size discrepancies (it is needed that teeth dimensions are already marked). (Fig 2)

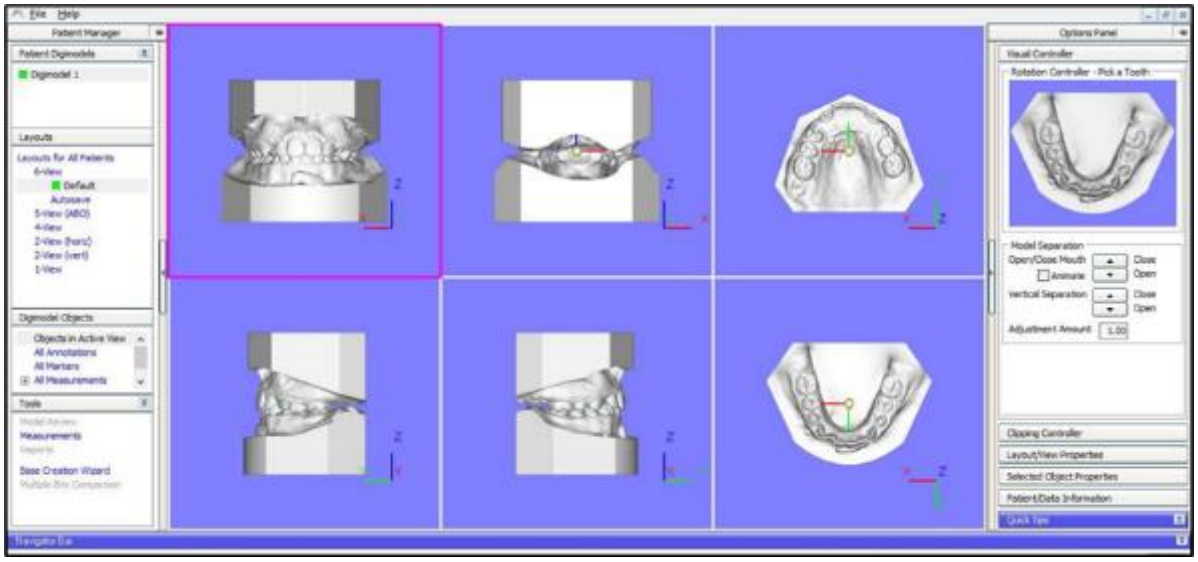

Figure 2 Digimodel® software program interface[7]

1.3. OrthoCAD™

OrthoCAD™ models have all the advantages of plaster models, apart from being able to hold the casts 'in your hand' and provide the clinician with a bit more:

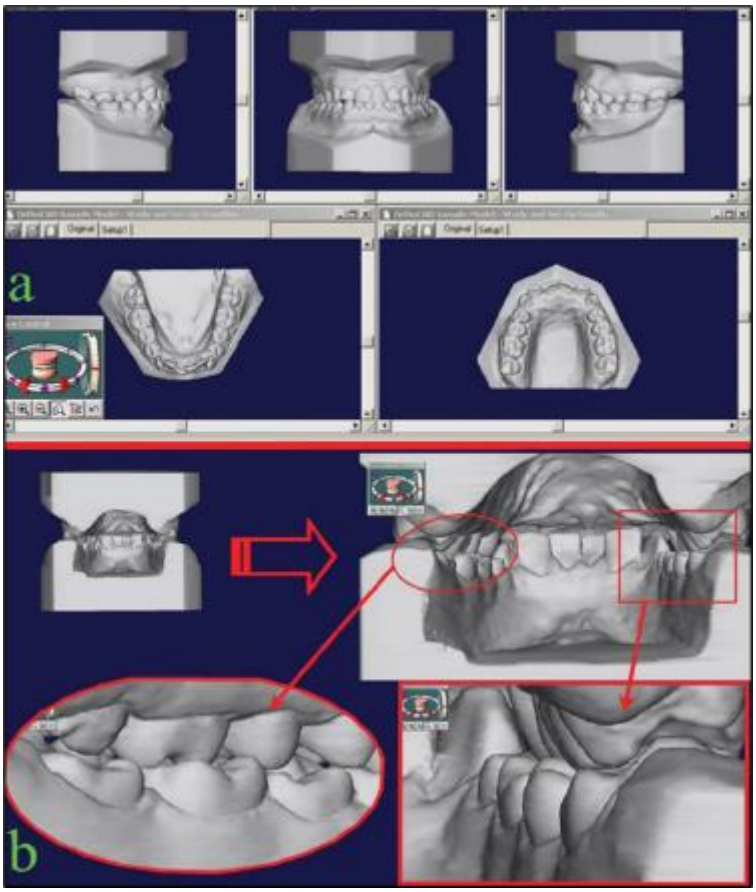

Figure 3 The penta-view of OrthoCAD. The operator can browse and view the models separately and together from any direction and in any desired magnification on the screen. (b) Lingual aspects of the upper and lower teeth can be seen and assessed using OrthoCAD™ manipulation tools

- A more straightforward and efficient technique for gathering and storing data from the "virtual" model
- Easier integration and preservation of digital photos, X-rays, and clinical notes into the patients' "digital" files; (Fig 3)
- Easy transfer to other members of the patient's healthcare team via printouts or email attachments; easier retrieval and display with the patient's other clinical data, particularly at the chairside.
- One apparent drawback of "virtual models" is their inability to be mounted and articulate the temporal-mandibular joint function of the patient. The jaw alignment evaluation software does, however, take a partial approach to this[8].

1.4. BibliocastCecile3®

Cécile3, a digital modeling analysis software, was created in 2003 by Bibliocast, Montreuil. Some advantages of this software include the possibility of performing space analysis and creating virtual set-ups for treatment planning purposes. Nevertheless, there is a lack of literature concerning its measurement validity, reliability, and or reproducibility.

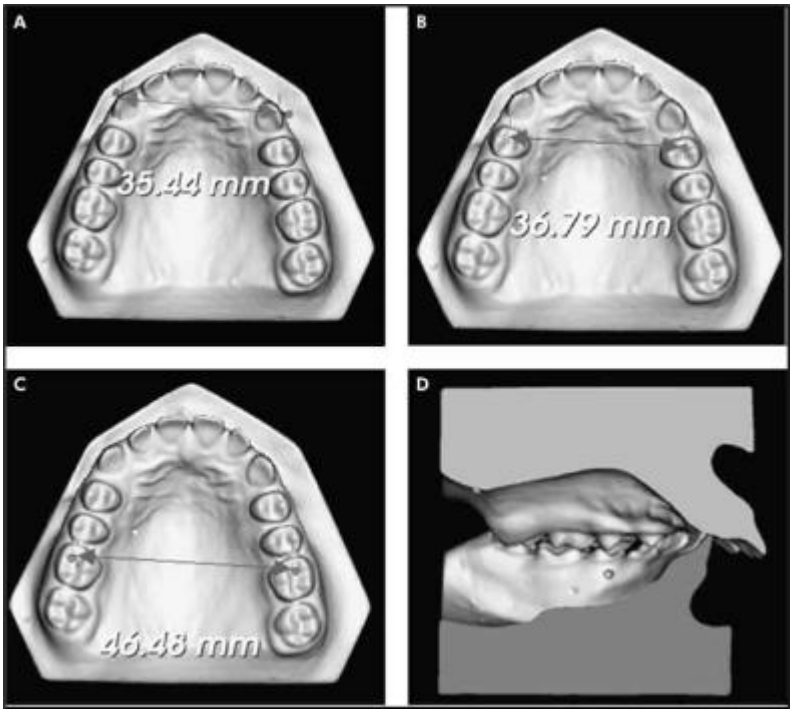

Figure 4 Measurements of (A) inter canine, (B) inter premolar, (C) intermolar, (D) overjet and overbite using the Cécile3 tool

The advantages of this software include the possibility of performing space analysis and creating virtual setups for treatment planning purposes**.** Determination of tooth-size discrepancy and Bolton ratios (Fig 4) using bibliocast Cécile3 digital models[9].

1.5. GeoDigm Emodel®

The time required to complete a Bolton analysis emodel, the Bolton ratio, and the overall arch length can all be measured with accuracy and speed. Making a treatment plan with software can be helpful, but the procedure needs to be simple, and the accuracy and speed of measuring the overall arch length, the Bolton ratio, and the time to perform a Bolton analysis emodel. software can be beneficial in making a treatment plan, but the process must be easy.

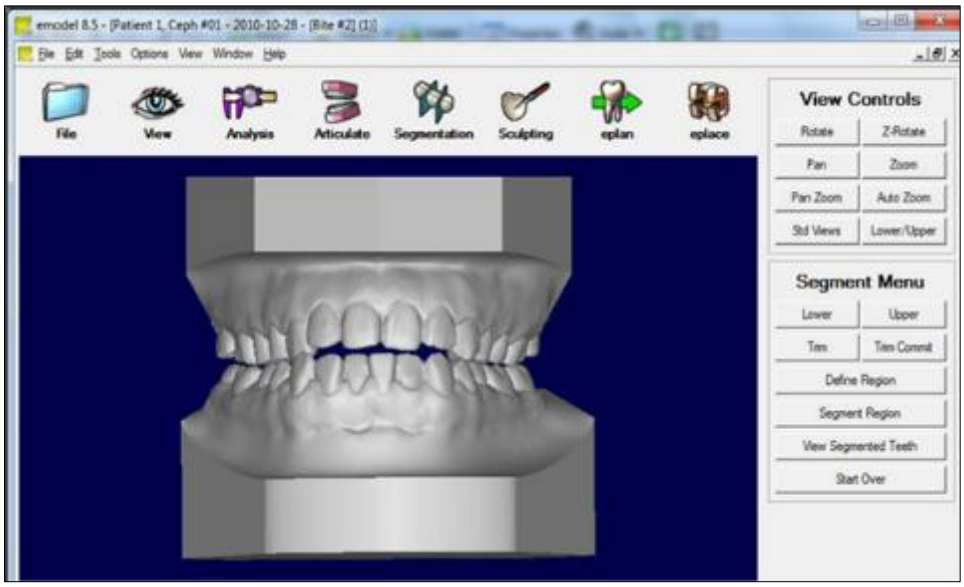

Figure 5 Emodel® software interface for space analysis.[11]

and occlusal technique, measuring each mesial-distal tooth width from the standard occlusal aspect, is the best combination of accuracy, repeatability, and speed of measurement and therefore the best choice for routine digital measurement of mesial-distal tooth width numbers must be accurate to be valuable.[10] The software makes use of the most popular space analysis. (Fig 5)

1.6. OrthoInsight

For treatment planning, including extractions, space closure, and dentition auto-alignment, Ortho Insight 3D software replicates tooth movement. To reduce chair and treatment times, precisely set the brackets before transferring them to the patient. It is claimed that the program will save lab and storage expenses for orthodontists while assisting them in designing precise orthodontic equipment.

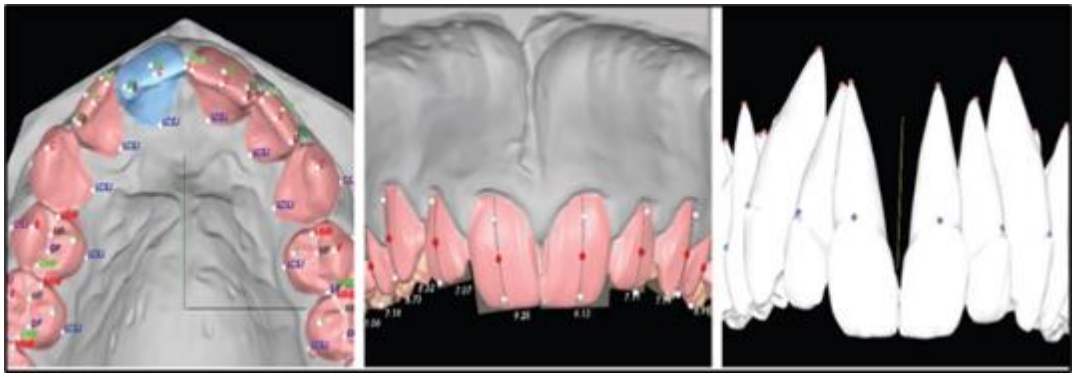

Figure 6 The Ortho Insight 3D® software workflow. Left: tooth segmentation landmark placement. Center: Facial axes are set. Correct: Built virtual roots that are prepared for STL file export[13]

The validity of digital models generated with Ortho Insight 3D® software for predicting root inclination was examined by Dastoori et al. in their study, which used CBCT as a reference standard (Fig 6). The use of CBCT has significantly increased the range of imaging[12].

2. Various Software for cephalometric analysis

2.1. OnyxCeph

It is created for patient education, treatment planning, diagnosis, and archiving. This software processes data in two dimensions (2D) and three dimensions (3D). Image import, image adjustment (classify and crop image), mirror image,

model base (modify models and attach base), segmentation, and cephalometric analysis and measures (separation and completion) With the use of these 2D and 3D image data, Ricketts Visual Treatment Objective, superimposition, image editing, data export, copy/save/send/display/print image, treatment simulation, slide show, and online/offline reports are available. (Fig 7)

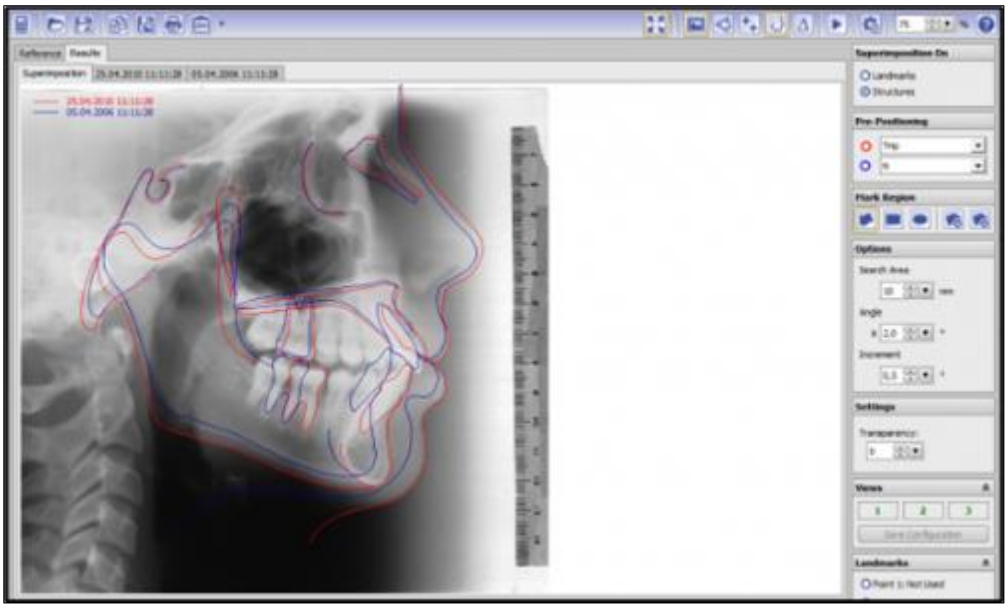

Figure 7 Superimposition tracing using the OnyxCeph interface

Onyxceph uses a cross-hair cursor while some software like vistadent (version 7.33 and 8.01) uses a conventional pointer that obscures the landmark. Other authors related the same difficulties in landmark identification with the cursor obscuring landmarks so that it can be one reason for the good reliability and reproducibility of most of the measurements in this study by Onyxceph imaging software[14].

2.2. Dolphin Ceph Tracing

Ceph Tracing allows you to analyze cephalometric radiographs and create progress superimpositions quickly and accurately**.**

Lateral Cephalometric Analysis for Orthodontic and Surgical Use (Fig 8)

- Holdaway, Alabama, Burstone, Gerety, Bjork, Alexander (Vari-Simplex), Ricketts, McNamara, Steiner (Tweed), Jarabak, Roth, Sassouni, McLaughlin, Downs-Northwestern, and numerous additional variations—more than 400 in total—are examples of lateral analyses.
- Grummons, Grummons Simplified, Van Arsdale, and Ricketts are examples of frontal analysis.
- Bolton and Schwarz's analysis.
- Automated tooth and cephalometric structure templates, encompassing the developing third molar, inferior alveolar canal, mastoid process, nasal cavities, orbits, zygomatic arch, soft tissue profile, airway, symphysis, maxilla, mandible, condyle, and plenty more.
- Presentation in a professional manner: measuring table, superimposition, tracing, and image.
- The "Downs Wiggle Gram" norm deviation display
- Completely adjustable norms, structure, and cephalometric analysis.
- Standards divided into groups based on age, gender, and ethnicity.

Figure 8 Cephalometric tracing done using Dolphin Imaging technology

2.2.1. Superimpositions

- Easily place tracings over radiography pictures or the patient's lateral photo.
- Utilize conventional superimposition references, such as SN at Sella, Frankfort at Porion, Na-Pg at ANS-PNS, Na-Ba at CC, Na-Ba at Na, ANS-PNS at ANS, and Go-Me at Me, to overlay tracings of various time points.
- several superimpositions.
- Free-form overlaying.
- Ricketts superimposition in five parts.
- For study purposes, determine the "average tracing" from a sample of patients.
- From your current tracing superimpositions, create default settings[15].

2.3. OrisCeph

Rx Ceph OrisCeph More than 30 preset procedures can be used to rapidly and simply realize cephalometric tracings. When inserting anatomical structures and cephalometric points, the application can provide you with guidance. Parametric values and normograms allow you to view the diagnosis in real time. Morphing and VTO: By altering the growth, the nomogram with the values and the final measurement based on the values of the completed cephalometric tracing are obtained. Figure 9 You can resize and draw anatomical structures using your sophisticated graphics tools. values are calculated differently because the X-setting rays cause the profiles to move automatically[16].

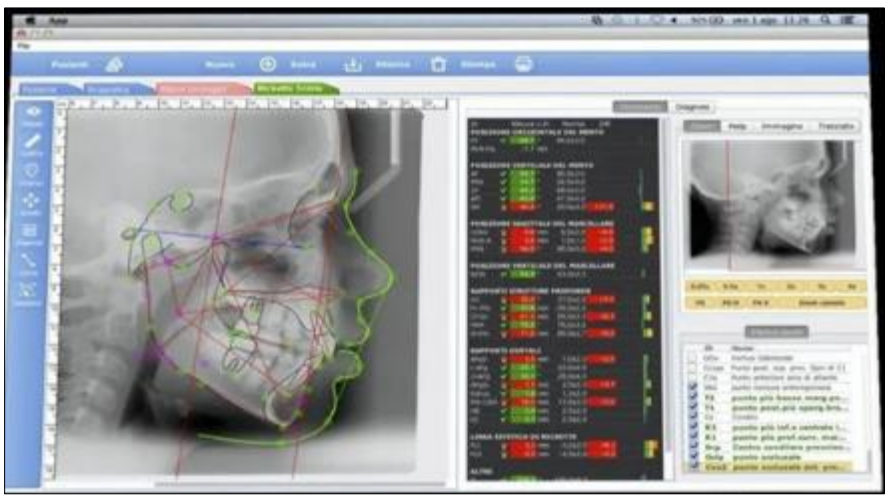

Figure 9 Cephalometric tracing done using OrisCeph Rx CE software interface

2.4. Facad®

Facad is a software program used for orthodontic tracing, cephalometric analysis, and visual diagnostic imaging, as well as for treatment planning with soft tissue profile prediction for both orthodontics and maxillofacial surgery. This program is meant to be used by dentists, orthodontists, and orofacial surgeons.

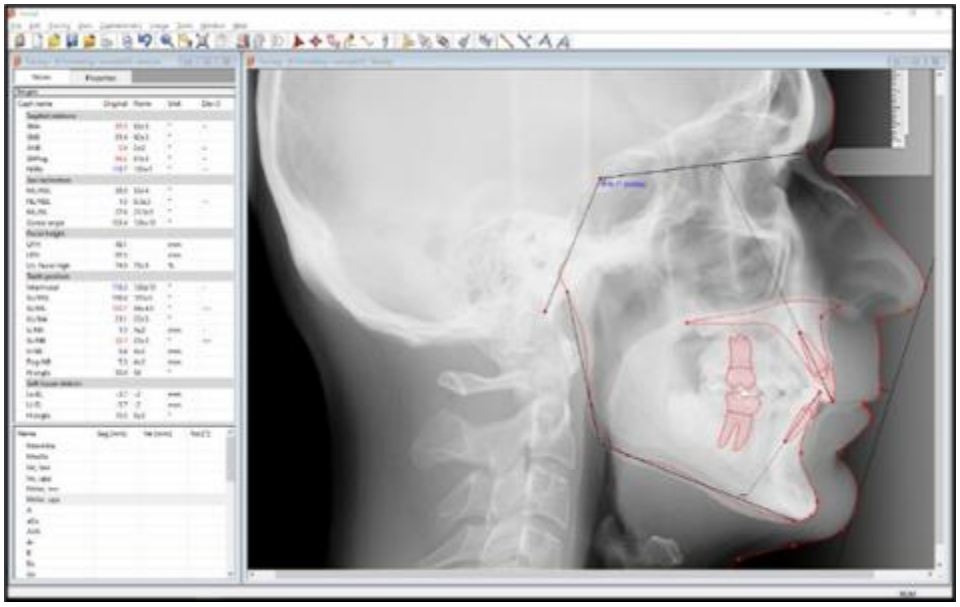

Figure 10 Cephalometric analysis using Facad using a software interface

2.4.1. Cephalometric analysis (Fig 10)

- Routine analyses that are predetermined.
- Analyses lateral to
- frontal (PA) examinations
- Analyses of cast models
- Adjust and create custom analysis.
- Modify the norm intervals according to the chosen metrics.
- Utilizing a measurement library, construct analyses.
- Cephalometric lines, values, and measurements are presented graphically flexibly.

2.4.2. Superimposition

- A profile shot with a see-through effect can be superimposed over a lateral x-ray.
- With a see-through effect, superimpose two X-ray images.
- Several tracings can be superimposed at once.
- Report analysis values concurrently from each stacked tracing
- Compare a treatment plan with a post-treatment tracing, i.e., overlay tracings before, during, and after treatment. Overlay tracings during expansion.
- Measure the variations in tracing lengths (distances) in a superimposition.
- Several techniques for aligning the tracings included:
- Rotate by a reference line and fixate tracings at a marker of reference
- Maximum correspondence with two or more reference markers
- alignment by hand and application of anatomic structures
- Follow Professor Arne Björk's Structural Method (with implant lines)[17].

2.5. Nemoceph

In just a few minutes, NemoCeph makes it possible to trace a cephalometry. You will automatically receive a cephalometric conversion, areas of overlap, and growth prediction. These are automated procedures that impact the treatment's precision, timeliness, and quality. (Fig 11).

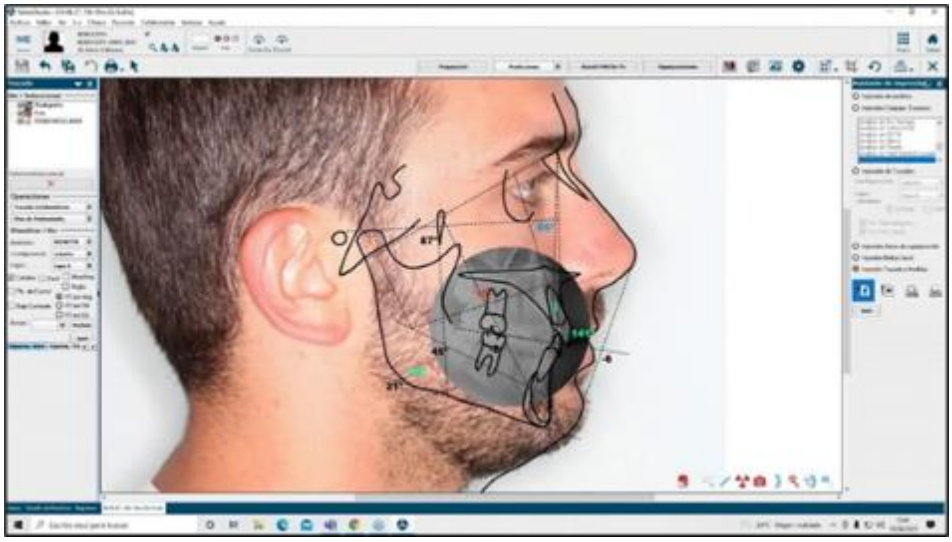

Figure 11 Cephalometry Analysis done using NemoCeph software interface

NemoCeph is software designed for lateral, frontal, and face cephalometric study.

- Cephalometry can be implemented using any universal analysis.
- By default, it includes the most widely used Personalized cephalometric analyses;
- Overlaying cephalometric analyses with patient photographs;
- Developing treatment plans for orthodontics (VTO, STO, and morphing);
- Integrating with Dr. Arnett's module; predicting the patient's soft tissue behavior (morphing);
- Creating presentation layouts according to the series you wish to use;
- Connecting to NemoBox to share orthodontic cases with physicians, labs, or patients; and multidisciplinary integration with any of NemoStudio's Suite Modules of Nemotec[18].

2.6. Planmeca Romexis®

Romexis Cephalometric Analysis provides simple-to-use tools for rapid and effective picture analysis. In a matter of seconds, the software's automatic tracing tool positions the points and soft tissue silhouettes on a cephalometric image, giving you more time to analyze the study's findings. The software automatically superimposes profile pictures, tracings, and X-ray images from various treatment stages (Fig 12).

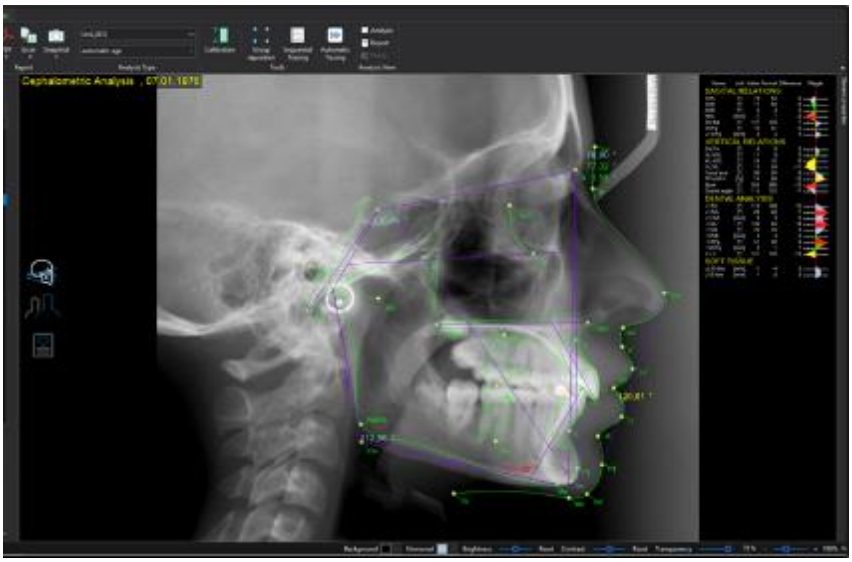

Figure 12 Romexis® Cephalometric Analysis module using software 6.3

It allows you to simulate surgical and orthodontic treatments by creating a cephalometric visual treatment objective (VTO) with a prediction image[19].

2.7. AudaxCeph

Automating tasks with Artificial Intelligence. It's quick, efficient, and an essential tool for your orthodontic practice. Obtain measurements for treatment forecasts, simulations, projections of skull growth, and treatment plans. Save valuable time by allowing artificial intelligence to quickly and accurately position cephalometric markers. Arrange all the paperwork associated with your course of treatment into separate containers so you may access them at any time. At all times, be prepared to show and explain to your patients how their orthodontic treatment is progressing. There are two versions of our cephalometric software, each with a distinct set of capabilities. However, the same cephalometric engine is included in both editions, allowing for quick and accurate readings (Fig 13).

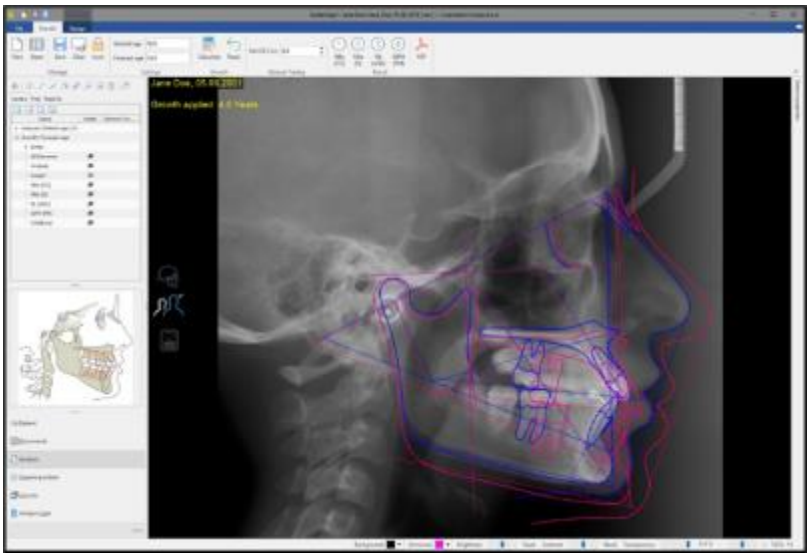

Figure 13 AudaxCeph software interface cephalometric tracing is applied

The AudaxCeph SuperEasy's simplicity is empowered with Artificial Intelligence which instead of you places cephalometric points of soft and hard tissue landmarks in seconds. Cephalometric visual treatment objective VTO, STO, planning, simulation, and prediction can be done interactively. Superimposition is done automatically, manually or structural superimposition with extensive reporting capabilities[20].

2.8. AutoCEPH©

- A 2-D cephalometric analysis program called AutoCEPH© helps maxillofacial and orthodontic surgeons analyze patients. The Centre for Dental Education and Research (CDER), AIIMS, New Delhi, India, and CSIR-Central Scientific Instruments Organisation, Chandigarh, India, worked together to develop it.
- After mapping landmarks, a curve can be automatically traced, and the resulting curves can be readjusted (Fig 14).
- It includes seventeen distinct analyses, each with a graphic representing a different parameter.
- Three Posterior Anterior Analysis, or 3 PA Analysis, has sophisticated visuals.
- Autoceph provides six different kinds of superimpositions to its customers.
- It supports several image formats, including uncompressed DICOM,.jpg,.png,.tiff, and .bmp.
- Management of patient repositories.

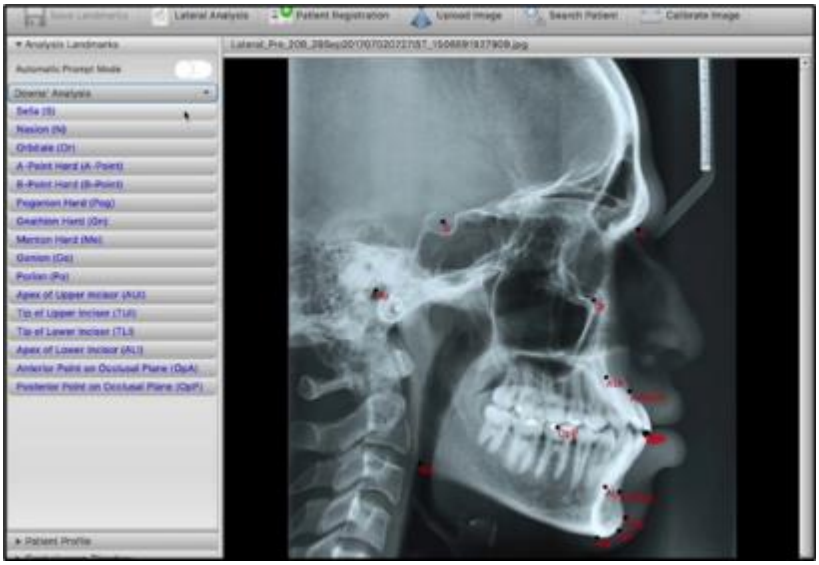

Figure 14 AutoCEPH© cephalometric analysis software interface

- Users can oversee treatment records and reports for specific patients.
- It Uses the zoomed pane to plot landmarks accurately. Better visibility and localization of landmarks are provided, along with a dynamic tile view of the cursor position on the cephalogram.
- Every landmark help image and its definition are shown in the help image region when the landmarks are plotted on the cephalogram[21].

3. Various software for smile analysis and smile design

3.1. SureSmile®

The streamlined patient overview, user-friendly interface, and treatment planning capabilities of Dentsply Sirona's SureSmile® (OraMetrix, Dallas, Tex Aligner Software) will facilitate increased efficiency and improve workflow management. Using the OraScanner (OraMetrix), a light-based imaging tool that projects a precisely structured grid onto the teeth, the SureSmile procedure starts with a direct 3-dimensional scan of the patient's dentition. The operator can plan therapy, make diagnoses, and model outcomes with the help of the Windows-based program. The software serves as an interface that allows users to view the dentition's 3-dimensional model from pre-selected angles, including frontal, lateral, posterior, and occlusal views (Fig 15).

Figure 15 SureSmile® treatment planning management software interface

- A new program called SureSmileTM Simulator is intended to give you a personalized glimpse of a confident grin as well as a customized 3D representation of your potential new smile. With the use of software, you may see a three-dimensional representation of your smile that could result from the SureSmile Clear Aligner procedure.
- Prospective Opportunities: A personalized 3D preview will help you see the possibilities of your new smile. Before you even begin therapy, observe how your teeth move in front of your eyes.
- Strengthen Your Choice: By talking about the aesthetic and dental health advantages of orthodontic treatment, you can make informed decisions regarding your oral health journey.
- Your Way, Your Smile: You and your doctor can take an active part in your smiling journey with the aid of the SureSmile Simulator. Investigate several options jointly and establish expectations that coincide with the [22].

3.2. Smile Designer Pro

Smile Designer Pro is designed from the ground up to meet the specialized needs of dental practitioners. Using simple photos, you can design a case in just a few minutes. With a single click, generate a realistic simulation of the outcome and start getting your patient excited about the potential transformation (Fig 16).

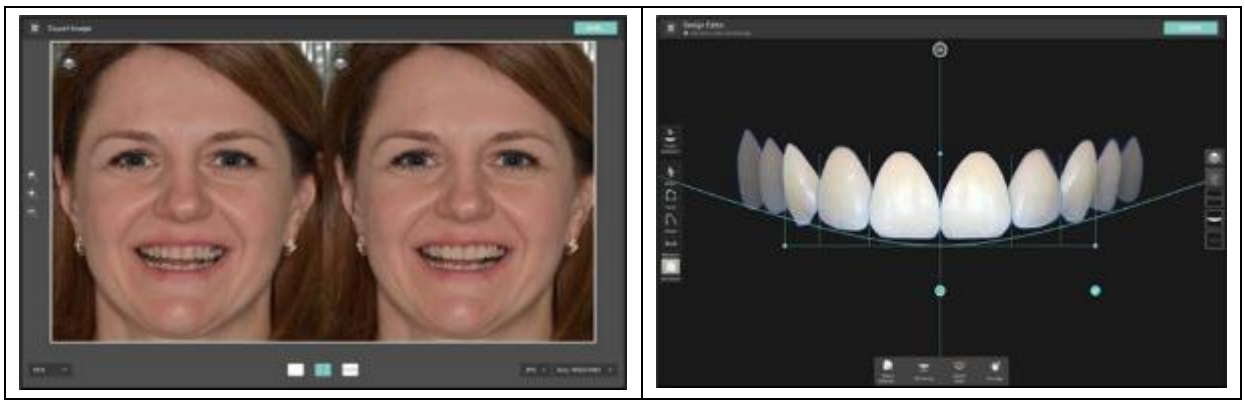

Figure 16 Smile Designer Pro software interface after and before with smile stimulation

With the help of our DSD software, which is based on the Digital Smile Design technique, you may produce a cosmetic treatment plan and simulation that you can show patients, improving the appearance and functionality of your smile rehabilitation cases. Because of its ease of use, an assistant can do 90% of the work, saving the dentist or technician a great deal of time. You can and will increase cosmetic case acceptability and patient satisfaction with the result using a 10-minute smile design plan. Meet expectations by connecting to a CAD/CAM workflow for the most advanced digital .

3.3. NemoSmile Design 3D

A mock-up created by NemoSmile Design enables the patient to see his course of therapy before it begins. The digital wax-up and virtual photographic simulation of the Smile Design is executed by the software by utilizing the 3D flow of the Smile Design. To make it easier to analyze a patient's smile and achieve the ideal aesthetic balance between the grin and the patient's face, the NemoSmile Design program creates a "Smile Frame," a collection of references and guidelines. An extremely useful, simple-to-use, and intuitive interactive tool for doctor-patient communication is NemoSmile Design.

You can import records as a series of photographs into NemoSmile Design 3D and view them in presentation layouts that correspond to the kind of series you want to utilize. Accurate horizontal alignment is crucial for manipulating the image. The scaling and rotation tools supported on horizontal and vertical reference guides enable you to quickly and accurately focus and standardize your diagnostic photographs. The same thing happens with the models. It is important to calibrate them perfectly with the photograph so that they adjust perfectly (Fig 17).

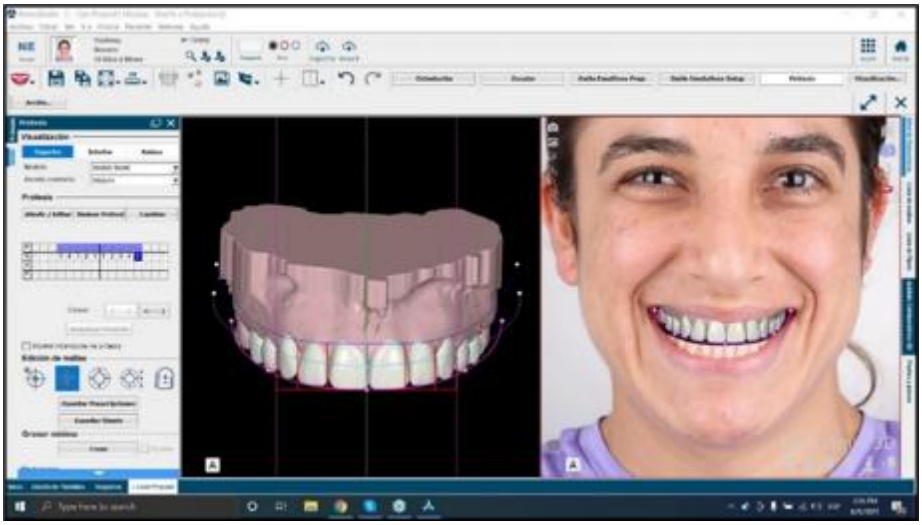

Figure 17 Smile design using horizontal calibration with patient smile image using NemoSmile Design 3D software interface

NemoSmile Design 3D lets you analyze your patients' smiles in three dimensions using digital printouts. The three-dimensional grin assessment of your patients can incorporate the benchmark facial and labial framework thanks to projective photographic mapping. After determining the Arch Curve and the desired Segment to work with, we choose the teeth from the extensive collection and adjust their position, rotation, and shape to get the ideal grin. After the mock-up is complete, it needs to be calibrated using a photo to produce a virtual mock-up. Finally, it needs to have any last tweaks made to ensure that the mock-up perfectly complements the patient's features[24].

4. Conclusion

NemoSmile Design 3D lets you analyze your patients' smiles in three dimensions using digital printouts. The three-dimensional grin assessment of your patients can incorporate the benchmark facial and labial framework thanks to projective photographic mapping. After determining the Arch Curve and the desired Segment to work with, we choose the teeth from the extensive collection and adjust their position, rotation, and shape to get the ideal grin. After the mock-up is complete, it needs to be calibrated using a photo to produce a virtual mock-up. Finally, it needs to have any last tweaks made to ensure that the mock-up perfectly complements the patient's features.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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