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Analysis of Root Resorption in Dentistry using Collaborative Tools & Strategies

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Abstract*— Engineering diagnostic tools have become increasingly more sophisticated like computer tomography (CT), magnetic resonance imaging (MRI), cone beam computer tomography (CBCT) and other imaging technology can now present patient data in many ways and with great clarity and accuracy. A strong software interface is needed to accept input from every brand of scanner to facilitate the selection of an anatomic structure visible in the medical images. Hence the purpose of this paper is to volumetrically evaluate root resorption during orthodontic treatment using MIMICS software and describe benefits of collaboration between two expertises. CBCT of 17 patients were taken pre-treatment (T1) and post levelling and aligning (T2) using KODAK 9000 machine. CBCT data were reconstructed with surface and volume rendering software (Mimics NV Belgium) and the volumetric images were modified to display the teeth from various orientations. Six anterior teeth were segmented and their roots isolated. Kruskal Wallis test was used to statistically evaluate root volume difference. The volume difference between two time intervals was statistically significant for all roots investigated (where significance value $p < 0.05$). The distal and palatal surfaces of lateral incisor, buccal surface of central incisor and distal surface of canine were more affected. The proposed work is first of its kind to analyse technically root resorption without extraction of teeth which enables a new quality of information sharing, collaboratively solving problem and integration of two different fields.

***Keywords*—Root Resorption, Tools, Strategies, Mimics, Collaboration, Digital volumetric tomography**

I. INTRODUCTION

The evolution of medical imaging has provided clinicians with the means of detailed views of structures and function of patient anatomy, that is a shift from 2 dimensional to 3 dimensional imaging. Further digital engineering and software packages provide qualitative visual inspection of these three dimensional images.[1] This combination of image data and computer modelling yields a variety of tools for visualisation, comparison and exploding various anatomic structures as well as is of great importance for treatment planning.

Root resorption in orthodontics has been described as an idiopathic and unpredictable adverse effect of orthodontic treatment. Traditionally root resorption has been detected through periapical radiographs, panoramic radiographs, subtraction radiography, scanning electron microscope, micro-computed tomography [2]. However, magnification errors and inaccurate reiterative abilities have made the usage of these aforementioned modalities questionable. Moreover, root resorption is a three dimensional phenomenon; and periapical radiographs, which are two-dimensional representations of three-dimensional structures, might not reveal the actual scenario. Although histological studies have shown accuracy, routine clinical application of the same is in ambiguity.

In the digital age, computers and information technology have become a critical factor in reducing costs and improving efficiency in medical and dental environments. Materialise’s NV (Leuven, Belgium)interactive medical image control system (Mimics) is an interactive tool for the visualization and segmentation of CT images as well as CBCT images and 3D rendering of objects. Therefore, in the medical field, Mimics can be used for diagnostic, or research purposes. For instance, image artefacts coming from metal can easily be removed. The object(s) to be visualized and/or produced can be defined exactly by clinicians.

Three-dimensional imaging can be obtained at any angle, offering optimum viewing, eliminating superimpositions and obtaining accurate measurements. Moreover, the radiation exposure is comparable to that from conventional radiographs. Hence, the purpose of this proposed work is to quantitatively measure the volume of external apical root resorption and surface resorption changes by using Limited volume Cone Beam Computed Tomography digital images using MIMICS software, and the benefits of team approach that is Engineers and Medical personnel to solve a problem.

II. METHODOLOGY

Patients reporting to the Department of Orthodontics and Dentofacial Orthopaedics, for the treatment were included in this proposed work, after getting an approval from the institutional review board and ethical committee, and patients’ consent. 17 patients (8 Males, 9 Females), with an age range of 12-20 years formed the samples.

Patients with no history of orthodontic treatment and full complement of teeth present were used. Any evidence of pulpal infection or pathology to teeth were excluded.

A. Collection of Data

Three-dimensional images of maxillary anterior teeth were taken just before treatment (T1), and after the completion of levelling and aligning phase (T2) which lasted for 6 months after beginning of treatment. Images were acquired using a machine (KODAK 9000) with x-ray source potential of 70 kVp, 10 mA having exposure time of 10.8 seconds. The Digital Imaging and Communication in Medicine (DICOM) data of the patients were imported into MIMICS x 64 (14.12) software. This programme manually segments the tissues according to the density values which are called Hounsfield units (HU). 3D data were reconstructed with surface and volume rendering, and the volumetric image was manipulated to display the root surfaces from various orientations. Threshold values were set individually with regard to each patient. The same HU were used for the segmentation of each patient's before and after records.

B. Volumetric analysis of roots and their surfaces

On these 3D images, six anterior teeth from right canine to left canine were segmented cautiously. After segmentation each individual tooth was separated from the other and adjusted for 3D orientations. The roots were separated from crown according to the plane parallel to cement enamel junction passing through the maximum contour of cementoenamel junction (CEJ) on the labial surface. Each root was isolated and colour-coded and the volume was calculated for the same using the programmed software. The same measurement protocol was applied for all the six anterior teeth of pre and post levelling and aligning records.

The centre of gravity of each root was identified using 3-Matic module in the software and was oriented in two mutually perpendicular planes such that the centre of gravity coincides with the intersection of two planes. This helped in segmenting the root into four different parts (mesial, distal, palatal and labial). The volume of each cut surface was tabulated. The same procedure was repeated for all the six anterior teeth in the pre-treatment and post levelling and aligning images. The diagrammatic representation of the method used is described below.

C. Statistics

The means of pre-treatment and post levelling and aligning root volumes for all the teeth and the surfaces were calculated. Analyses for changes in the overall root volume and for each surface (mesial, distal, labial and palatal) were conducted using non-parametric tests. Kruskal Wallis test was used to compare the difference of pre and post levelling aligning volumes for all the six anterior teeth and between the four surfaces.

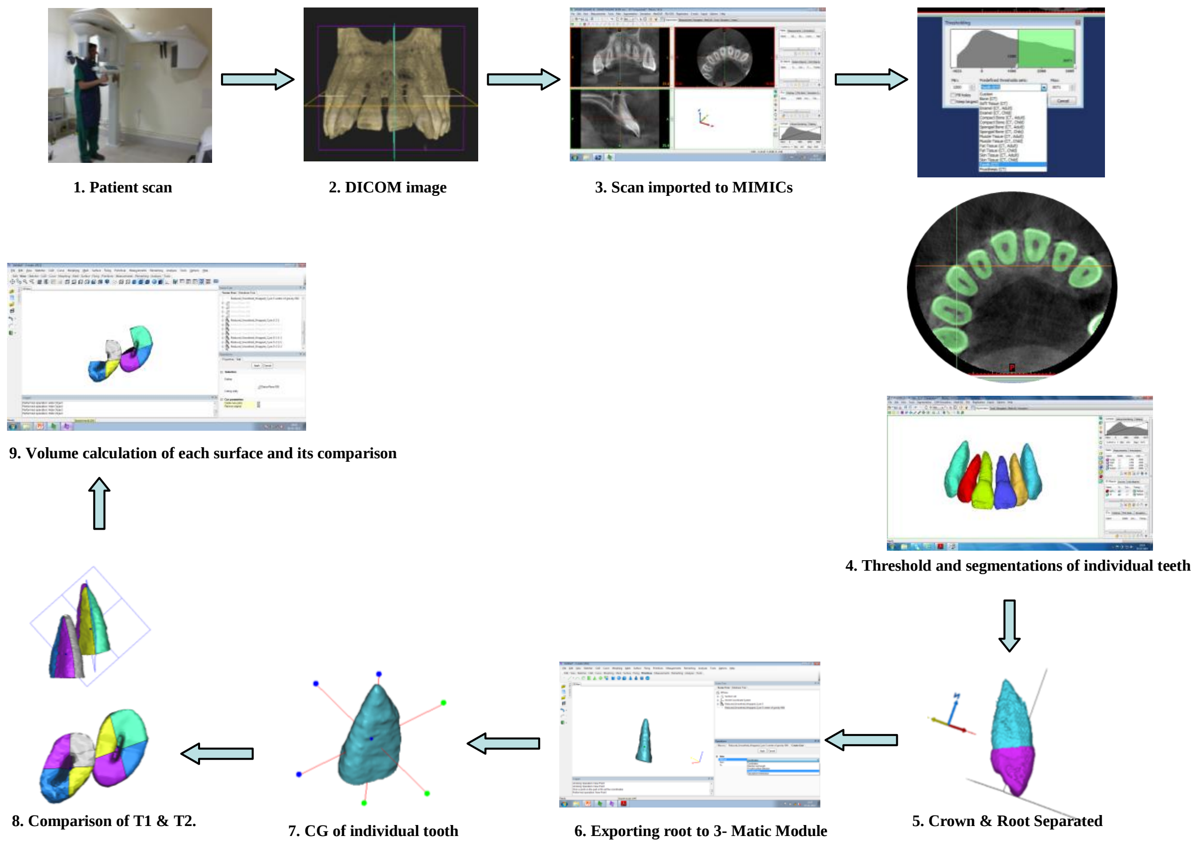

Fig. 1 Illustration of the method used

III. RESULTS

Table 1: **Comparison of root volume loss between six anterior teeth using KW test**

	Teeth	N	Mean Rank
Differences	Right canine	17	27.74
	Right lateral	17	78.00
	Right central	17	58.82
	Left central	16	46.31
	Left lateral	17	73.94
	Left canine	17	20.91
	Total	101	
Chi-Square		53.134	
p value		0.001	

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Table 2: **Comparison of root volume loss of mesial surface between six anterior teeth using KW test**

	Teeth	N	Mean Rank
Differences	Right canine	17	10.80
	Right lateral	17	37.30
	Right central	17	20.10
	Left central	17	19.80
	Left lateral	17	38.50
	Left canine	17	11.25
	Total	102	
Chi-Square		34.713	
p value		0.032	

Table 3: **Comparison of root volume loss of buccal Surface between six anterior teeth using KW test**

	Teeth	N	Mean Rank
Differences	Right canine	17	23.20
	Right Lateral	17	35.00
	Right Central	17	49.00
	Left Central	17	48.00
	Left Lateral	17	34.50
	Left canine	17	21.30
	Total	102	
Chi-Square		48.135	
p value		0.025	

Table 4: **Comparison of root volume loss of distal surface between six anterior teeth using KW test**

	Teeth	N	Mean Rank
Differences	Right canine	17	32.90
	Right lateral	17	53.90
	Right central	17	15.20
	Left central	17	13.90
	Left lateral	17	45.20
	Left canine	17	29.90
	Total	102	
Chi-Square		52.758	
p value		0.001	

Table 5: **Comparison of root volume loss of palata surface between six anterior teeth using KW test**

	Teeth	N	Mean Rank
Differences	Right canine	17	23.90
	Right lateral	17	48.70
	Right central	17	33.65
	Left central	17	31.50
	Left lateral	17	46.00
	Left canine	17	32.85
	Total	102	
Chi-Square		46.348	
p value		0.012	

IV. INTERPRETATION OF RESULTS

The differences between the pre-treatment and the post levelling and aligning volumetric measurements were statistically significant. The overall root volume loss was in the order of lateral incisor greater than central incisor followed by canine as described in table 1. The lateral and central incisors showed more volumetric loss for mesial and buccal surfaces as described in tables 2 & 3. In spite of reduced overall volume loss, the canine showed more of volumetric loss for the distal surface as compared to that of lateral and central incisors as described in table 4. Volumetric loss for the palatal surface was demonstrated as higher in the lateral and central incisors as compared to the canine as described in table 5. Overall the volumetric loss for all the four surfaces was found to be statistically significant. There was no statistically significant difference between the right and left sides.

V. DISCUSSION

Team approach is not unique or new to the discipline of human communication sciences. Models for teaming and the dimensions for team effectiveness have been in place for many years, they derive from the human relations model of management [3]. The team approach can be referred to as collaboration of two fields which otherwise would be unthinkable or very complicated to realise. It allows successful team work disregarding the locations where the partners are and the time to which they want or can interact. [7] This paper presents a collaborative way to achieve common objectives with the aid of software tolls and strategies between two teams combining expertise and experience, one from health care the other from engineering which helped to define the benefits and challenges of team based approaches and also facilitates more effective problem solving, innovation and situation based learning.

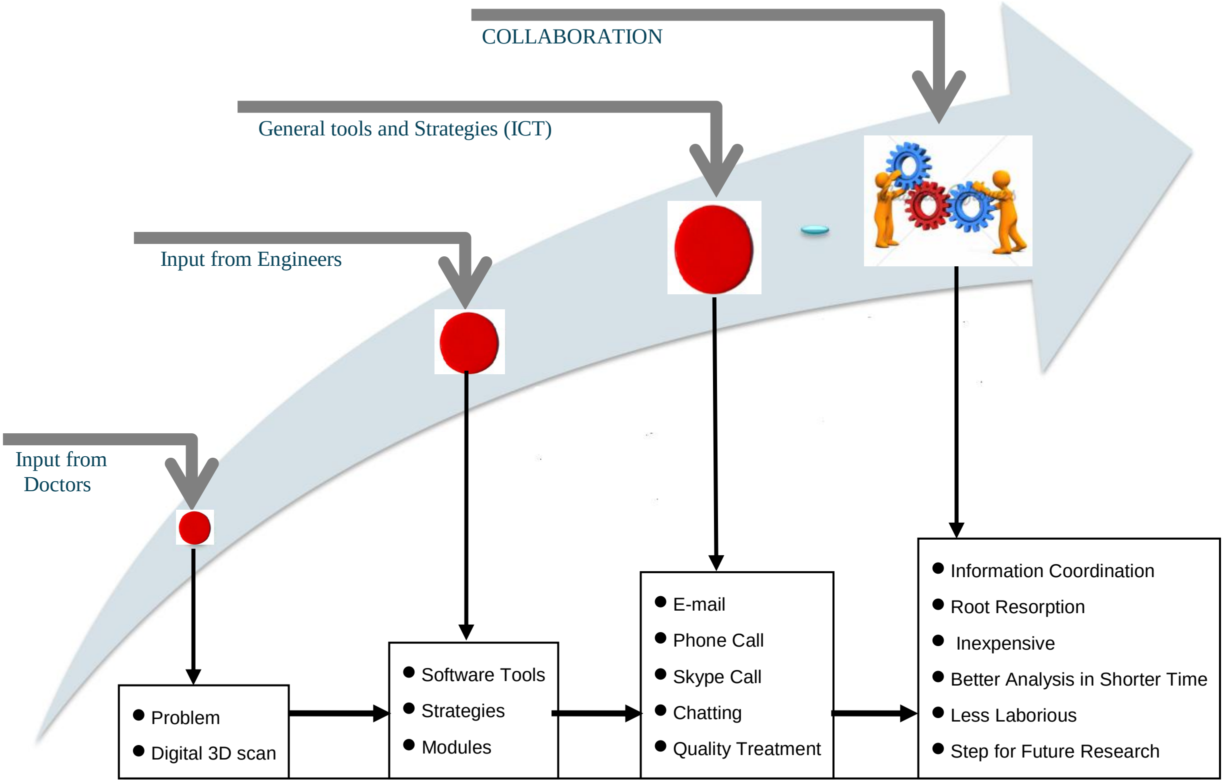

Fig. 2 Collaborative Synthesis

As described in the above diagram a solution based communication between a Doctor and an Engineer with proper communication tools (email, phone calls, skype, chatting), with desired information of problem, thorough understanding of the goal to be achieved, can result in successful collaboration between two expertise.

From a technological point of view this paper starts with patients scanning system. Radiographs, histological sections, and scanning elsectron microscope (SEM) provide 2D evaluations of root resorption. E.K.M.Chan [5] reviewed in literature that studies using histologic sections have proven to be laborious and technique sensitive. Moreover 2D evaluations allowed only mesial and distal aspects of the root. Whereas 3D images offer the possibility of assessing the root surface not displayed on conventional radiographs and creating scenes similar to previous ones despite changes in tooth/root positions. For visualization of subtle anatomic structure, factors such as voxel size scatter radiation, gray scale bit depth and artifacts caused by metallic objects are important. Moreover, smaller voxel size and field of view are needed. The smaller the voxel size the higher the spatial resolution, and the smaller the field of view the lesser the noise from scatter radiation.[6] Therefore, currently limited volume CBCT images also called as digital volumetric tomography (DVT) images were used to evaluate volumetric changes in the root six months after the orthodontic treatment. The unit had the voxel size of 100µm x 100µm x100 µm and field of view of 55cm.

Mimics enable different types of measurement to be performed. Point-to-point measurements are possible on both the 2D slices and the 3D reconstructions. Accurate measurements are possible on the basis of the grey values using the threshold method. These methods are ideal for technical CT users. Segmentation masks are used to highlight regions of interest. Mimics enable to define and process images with several different segmentation masks. To create and modify these masks, the following functions are used

- Thresholding is the first action performed to create a segmentation mask. You can select a region of interest by defining a range of grey values. The boundaries of that range are the lower and upper threshold value. All pixels with a grey value in that range will be highlighted in a mask.
- Region Growing will eliminate noise and separate structures that are not connected.
- Editing (draw, erase, local threshold): manual editing functions make it possible to draw, erase or restore parts of images with a local threshold value. Editing is typically used for eliminating artifacts and separating structures.
- Dynamic Region Growing segments an object on the basis of the connectivity of grey values in a certain grey value range. It allows for easy segmentation of tendons and nerves in CT images, as well as providing an overall useful tool for working with MRI images[8]

MIMICs x 64 (14.12) with 3-Matics had inherent tool to separate the tissues according to their density in Hounsfield units. In the present work each tooth from its pre and post levelling and aligning scans was threshold, segmented in the proprietary software and exported to 3-Matics. In this module the tooth was cut into its crown and root part using a plane parallel to the cementoenamel junction passing through the maximum contour of CEJ on labial surface. Separation was performed because of brackets on the anterior teeth which caused artifacts at the crown structure. The centre of gravity was identified for individual root and the coordinates of the same were applied to the same root in the post levelling and aligning image. This inbuilt tool in the software enabled to separate the mesial, distal, labial and palatal surfaces and calculate the volume for the same. Separating the teeth from the other tissues and locating the centre for root was of great importance which minimized the error of segmenting the teeth manually and cutting the root into 4 parts in a similar way in pre and post scans.

The proposed work is the first in literature in which 3D measurements were performed to assess the root volume loss of all the four surfaces of root. Literature is replete in studies which described volumetric loss of root evaluated after extraction of teeth [9]. The above described technique is non- invasive, less laborious, accurate and provides a scope of use of softwares which will help in future research. All these technologies are in a formative stage, lessons are to be learnt, experiments must be performed and a careful monitoring is required to get well equipped with this technology. For Doctors: software tools, money and time are required but along with time, learning from engineers (expertise in softwares) will help in applying this technology to patient diagnosis. Doctors must get involved in this process, to ensure that they add their considerable knowledge and expertise to that of engineer. Techniques should be developed which will apply all these technologies for patient care and will have considerable human involvement.

VI. CONCLUSION

Collaboration work includes the patients, doctors and engineers with software tools and only collaboration can provide the specific solutions which helps in quality treatment. The work provides a method for accessing root resorption and provides the following advantage: In vivo studies can be done, surfaces which cannot be visualized in 2D images can be seen in tomographic images, specific tooth or root surfaces demonstrating resorption can be easily quantified for volume loss. Therefore a CBCT can provide more valid and accurate information about root resorption and may be of significant value during treatment, and for research purposes.

REFERENCES

[1]. Ian Gibson: Advanced Manufacturing Technology for Medical Applications Reverse Engineering, Software Conversion and Rapid Prototyping.

[2]. Tom Wierzbickia; Tarek El-Bialyb; Saleh Aldaghreerc; Guang Lid; Michael Doschake :Analysis of Orthodontically Induced Root Resorption Using Micro-Computed Tomography Angle Orthod. 2009; 79:91–96.

[3]. Camille Catlett and Anita Halper: Team Approaches: Working Together to Improve Quality: 1999. ASHA

[4]. Baysal et at:Evaluation of root resorption following rapid maxillary expansion using cone-beam computed tomography: Angle Orthod; 2012

[5]. E.K.M. Chan: Exploring the third dimension in root resorption Orthod Craniofacial Res 7, 2004; 64–70

[6]. Baysal et at: Evaluation of root resorption following rapid maxillary expansion using cone-beam computed tomography: Angle Orthod; 2012

[7]. Veronica Serran, Thomas Fischer Collaborative innovations in ubiquitous system J Intell Manuf, 2007; 18:599–615

[8]. Ellen Dhoore: Software for medical data transfer, Textbook of Advanced Manufacturing Technology for Medical Applications Chap 5, 79 -104.

[9]. Eugene Chana and M. Ali Darendeliler: Physical properties of root cementum: Part 5.Volumetric analysis of root resorption craters after application of light and heavy orthodontic forces Am J Orthod Dentofacial Orthop 2005;127:186-95.