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A comparative evaluation of direct and indirect digital impressions obtained from two dental scanners by their superimposition on CBCT image of prepared teeth to receive a prosthesis – An in-vivo study

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Abstract

Statement of the problem: The success rate of prosthetic treatment relies on several factors including dimensional accuracy, impression details and the corresponding models from which a restoration can be manufactured in the laboratory. The advent of intraoral digital scanners has emerged along with the development of Computer-Aided Design and Manufacturing (CAD/CAM) technology.

Purpose: The study aimed to determine the accuracy of direct and indirect digital impressions as compared to the original contour of the prepared tooth, as obtained from the patient's mouth using Cone Beam Computed Tomography (CBCT).

Materials and method. The study was conducted on 15 dentate individuals, aged 20-50 years, of either sex, fulfilling the inclusion and exclusion criteria, dividing them into three groups A, Band C(n =5 each). Tooth

preparation was done and CBCT images (Group 1) and indirect and direct digital impressions (Group 2-5) were obtained and grouped. The trueness and precision between the two different canners was obtained at 9 specified areas of interest. The data obtained was statistically analysed using IBM SPSS 20.0 version.

Results: Mean volumetric deviation (trueness) for all study subjects of Group 2, 3, 4 and 5 of Groups A, B and C at T_1, T_4, T_6, T_7, T_8, T_9 showed an insignificant difference statistically (p-value>0.05), whereas at T_2, T_3, T_5shows a significant difference (P-value<0.05) among all groups. Mean values of precision for all study subjects of Group 2, 3, 4 and 5 of Groups A, B and C at T_1, T_2, T_3, T_4, T_5, T_6, T_8, T_9 shows an insignificant difference statistically among all groups, except at T_7.

Conclusion: The study concluded that although 3Shape TRIOS 3 had disadvantages like lightly disturbing sound while scanning process continued, unlike CEREC Omnicam which had a soothing mobile cart sound and was more appreciated by the patients, the efficacy of 3Shape TRIOS 3 was better than that of CEREC Omnicam. The time required for scanning of half arch, dual arch as well as full arch by TRIOS 3 was almost half the time required for scanning by CEREC Omnicam. Overall results show that 3Shape TRIOS 3 had a comparatively higher trueness and precision than CEREC Omnicam mobile cart scanner.

Keywords: Trueness; Precision; CEREC Omnicam; TRIOS 3; Impression

Clinical Implications

Modern-day dentistry incorporates the use of intra oral scanners in day-to-day practice. As the use of scanners has been a boon to dental practice, minimizing different disadvantages of impression making manually by the use of impression materials, it will be successfully acceptable by many dentists only if replicates most of the important functions fulfilled by manual techniques such as conventional impression making. Thus, to prove its dexterity as a replaceable modality for making impressions in clinical set-up, it was extremely important to test the accuracy of the impressions made by scanners, both intraorally and extra-orally, keeping CBCT as a gold standard for comparison of the digital impressions.

Introduction

"Impression" in dentistry is defined as "a negative likeness or copy in reverse of the surface of an object; an imprint of the teeth and adjacent structures for use in dentistry". The success of prosthetic works depends on various factors like impression details, dimensional accuracy, andthecorrespondingmodelsfromwhicharestorationcanbe manufacturedinthelaboratory.[1]Varioustechniqueshave been currently employed for obtaining elastomeric impressions and for creating the gypsum models. Commonly used impression materials in these techniques are hydrocolloids polysulfides, condensation reaction silicones (C- type silicones), addition silicone Polyvinyl siloxane impression materials, hydrocolloids, polyether etc.[2]But most of these materials have disadvantages of poor taste, dimensional inaccuracy, and odour etc.

To conquer these disadvantages, inthemid-1980s digital impression and scanning systems were introduce dindentistry.[1] The introduction of intraoral digital scanners coincided with the development of Computer-Aided Design and Manufacturing (CAD/CAM) technology and Chair side Economical Restoration of Esthetic Ceramics (CEREC).In the present day scenario, different CAD/CAM systems are available for various dental applications. Each uses a specific, distinctive technique for impression making.

Fabrication of final dental restorations through conventional practices involves a technique sensitiveprocess.[3]Digitalscannersarebeing used to take images of the prepared teeth, leading to lesser use of conventional impressions, in the present day dental practice. Data is acquired using scanners having a high resolution camera with sensors, which collects images, designs the restoration using a software and finally manufactures the restoration with the help of a computerized milling device.

With the advent of intraoral scanners (IOS), the clinician and dental technicians can estimate the impression quality in real time. The dentist can e-mail the image to the laboratory and the technician can check it accurately, even as soon as the image has been captured. If the dental technician is not convinced with the quality of received optical impression, he/she can immediately request the clinician to make another one without any loss of time and without calling the patient for a second appointment. This aspect amplifies and strengthens communication between the patient, dentist and the dental technician.

Optical impression is another powerful tool for patient communication. With optical impressions, patients can feel more involved in their treatment and an effective communication can be established; this emotional involvement may have a positive impact on the overall treatment.[4]

The purpose of this study was to determine the accuracy of direct and indirect digital impressions as compared to the original contour of the prepared tooth, obtained from the patient's mouth using Cone Beam Computed Tomography (CBCT). This study aimed to investigate whether digital impressions are as accurate as CBCT images, thusre cording the discrepancy between them by use of inspection software. It also served to identify the area soft he prepared teeth, where there cording are accurate as the original tooth contour and compare them with the areas where the accuracy is hindered.

Two different dental scanners were employed in this study to make digital impressions, first one directly on the prepared tooth and the second one, indirectly on the prepared cast by a conventional impression technique. Each of them was then superimposed on the CBCT image of the prepared tooth and its corresponding areas using an inspection software and differences were obtained. The study was based on the null hypothesis that there is no difference between the images and that the scanners are equally efficient.

Materials and Method

The study was conducted for a period of 18months f, in the Department of Prosthodontics and Crown & Bridge, on 15 dentate individuals, aged 20-50 years, gender being no bar, fulfilling the inclusion and exclusion criteria. Inclusion criteria includes any dentate patients requiring a single unit fixed prosthesis after root canal treatment, in posterior region of maxillary or mandibular arch, having an antagonistic tooth in the opposing arch as well as adjacent contacting teeth.

Exclusion criteria include patients having underlying medical conditions, periodontitis, poor oral hygiene and temporomandibular joint disorders. Informed consent was obtained from all study subjects after explaining them about study. Due to the pandemic of COVID–19, subjects were given self-declaration forms for approval which also assured them that adequate protection measures would be undertaken before, during and after the procedure has been completed. The ethical clearance was obtained from Institution's Ethics Committee (IEC) (GNIDSR/IEC/19-17).

All study subjects were then divided into three groups A, Band C(n =5 in each group).

Group A–Patients subjected to receive metal crowns;

Group B–Patients subjected to receive porcelain fused to metal crowns

Group C –Patients subjected to receive all ceramic crowns.

Diagnostic impressions were made using irreversible hydrocolloid impression material and diagnostic casts were poured in Type II gypsum product. Tooth preparation was done and CBCT images and digital impressions were obtained and grouped.

The subjects were asked to remove any metallic components like jewellery and eye glasses before CBCT exposure and were instructed to lie down in supine position,

withocclusalplanebeingparalleltothefloorsothechinwasraisedorloweredatanappropriatelevelasneeded.The setting for the dentulous patient and face size was selected (females were set to medium and males, to large field of view)and was set to 90 kilovolt and 7.1 mA. The images obtained were in DICOM (Digital Imaging and Communications in Medicine) which were converted into STL (Standard Tessellation Language) with the help of D2P (Dicom to Print) software by Graft 3D Healthcare Solutions Pvt Ltd, Chennai.

After completion of CBCT scans of the subjects' oral cavity they were subjected to intraoral scans using two different intraoral scanners; CEREC ® Omnicam (DENTSPLY Sirona) and 3SHAPE TRIOS 3 (3Shape).

CBCT images obtained from the patient's mouth were collectively named as Group1images. Digital impressions which had been procured directly from the patient's mouth were grouped as Group2 and Group3, for two different handheld intraoral scanners. Digital impressions obtained from patient's casts were grouped as Group 4 and Group 5, for the two different scanners.

The divergence sin the x-,y-, and z-axes between ach reference and test data seta nine specified contact locations were measured. The trueness and precision between the two different scanners was obtained. The nine specified areas of interest were located in the horizontal and vertical axes in these mentioned sites: the mesioocclusal and distoocclusal clearance, the distal and mesial interproximal contact points of the prepared tooth site and the buccal and lingual aspects, distal and mesial preparation margins and cuspal areas respectively.

Case history, demographic data, details about tooth to be prepared and the values obtained at the nine aspects of the prepared tooth after superimposition of direct digital scans by two intraoral scanners on CBCT as well a sin direct digital scans (Type IV gypsum models) by the same scanners on CBCT of the patient' sarch (each patienthad36 values) were obtained on study proforma. The data obtained was tabulate din Microsoft Excel sheet and was statistically analyzed using IBM SPSS 20.0 version.

Results

The present study determined and compared the trueness and precision of two intraoral scanners by taking direct impressions of the prepared teeth and indirect digital impressions of the gypsum models of the same prepared teeth, and superimposing these images on the CBCT image of the same individual, in an inspection software. The data was statistically analysed.

Mean volumetric deviation (trueness) was obtained for all study subjects of Group 2, 3, 4 and 5 of Groups A, B and C at T_1 (mesio – occlusal clearance), T_4 (distal contact), T_6 (lingual aspect), T_7 (distal preparation margin), T_8 (mesial preparation margin), T_9 (cuspal area) showing an insignificant difference statistically (P-value>0.05) among all groups. Mean volumetric deviation (trueness) at T_2(disto–occlusalclearance), T_3

(mesial contact), T_5 (buccal aspect) shows a significant difference statistically (P-value<0.05) among all groups. (Table 1 – 9)

Mean values of precision (obtained as standard deviation of trueness) were obtained for all study subjects of Group 2, 3, 4 and 5 of Groups A, B and C at T_1 (mesio – occlusal clearance), T_2(disto–occlusalclearance), T_3 (mesial contact), T_4 (distal contact),T_5 (buccal aspect), T_6 (lingual aspect), T_8 (mesial preparation margin), T_9 (cuspal area) shows an insignificant difference statistically (P-value>0.05) among all groups. Mean precision at shows a significant difference statistically (P-value<0.05) among all groups at T_7 (distal preparation margin). (Table 10 – 18)

The intra group comparison for all groups except group C shows a statistically significant (P-value<0.05) difference at T_1. At T_2 intra group comparison shows an insignificant difference statistically (P-value>0.05) for all groups except Group A. At T_3, T_4, T_5 intragroup comparison shows an insignificant difference statistically (P-value>0.05) for all groups except Group B. The intragroup comparison for all groups except Group A shows a statistically significant (P-value<0.05) difference at T_6 and T_7. The intragroup comparison for all groups except Group C shows a statistically insignificant (P-value>0.05) difference at T_8. The intragroup comparison for all groups shows a statistically insignificant (P-value>0.05) difference at T_9.

Discussion

Accurate impressions are the important prerequisites for precise dental restorations. Studies by **Strub JR et al (2006)** and **Kapos T et al (2014)** have advocated that recent advances in technology like digital impression, crown fabrication procedures and their application in clinical practice is steadily increasing, leading to more accurately fitted milled restorations.[5, 6]

Intraoral scanners in fixed prosthodontics have advantages of better ability to manage soft tissues, visualization of subgingival margins, ruling out the possibility of distortion of impressions, laboratory production steps that may cause misfit, lessened transport time between clinic and dental laboratory and reduced patient discomfort, as stated by **Papaspyridakos et al (2016), Lin WS (2015)** and **Ting-Shu S (2015)**[7, 9]

It had been found that the CEREC Omnicam provided a smooth and seamless scanning experience. Regarding scanning speed, the 3Shape TRIOS 3 was as fast as CEREC Omnicam. It proved to be an efficient scanner with a realistic HD scanning aesthetic.[10, 13]**Flügge et al (2013)**[14] found that intraoral scanning was less precise than extraoral model scanning, indicating that the intraoral conditions contribute to the inaccuracy of scans. The accuracy can also be affected by the examiner's technical skill at intraoral scanning. To avoid such bias, in the present study, intraoral scans were obtained by the same examiner, who had experience with over 100 cases of intraoral scanning. Long scanning times might induce errors in the stitching process of the captured images; the scanning times tend to decrease as the operator experience increased. In this study, the half-arch scan time for the CEREC scanner was an average of 3-5 minutes, while the TRIOS scanner was an average of 1-2 minutes, which is half the time reported by **Lee KM (2018)** for full arch scanning.[15] However, further studies are needed to assess the scanning accuracy according to the clinician's experience.

The standard deviation of this trueness value was obtained after 3 superimpositions of each digital on the corresponding CBCT scan and this value was obtained as the precision of the scanner. The null hypotheses were, no significant difference would be found in the direct and indirect digital scan accuracy (trueness and

precision) of the 2 different IOSs and no significant difference would be found between preparations of all metal, metal – ceramic and all ceramic prostheses. Among these, the alternative hypotheses obtained during completion of the study were, that there was a statistically significant difference found between the direct and indirect digital scan accuracy (trueness and precision) for the nine specified sites which shows, this section of the null hypothesis was rejected as indirect digital scan proved to be better than direct digital scan. Although, it was also found that there was no statistically significant difference between metal, metal – ceramic and all ceramic groups which accepted the second part of the null hypothesis.

The present study revealed that the trueness and precision of CEREC Omnicam was found to be lower for distal and mesial preparation margins, distal and mesial contact areas in Groups A, B and C, mesio – occlusal clearance, disto – occlusal clearance and cuspal areas in Group A and B subjects, as the space available between prepared teeth and their adjacent teeth was presumably lesser.

However, the mesio and disto occlusal clearance and cuspal areas in Group C subjects was presumably larger than the other two groups, as the teeth prepared in Group C subjects were to receive all ceramic crown. Due to the greater space available in these areas CEREC Omnicam had a relatively greater accuracy than 3Shape TRIOS 3, although any such space availability constrains were not found in case of TRIOS 3, which could hamper the accuracy of TRIOS 3. It consistently maintained its accuracy (trueness and precision) at all the 9 areas of superimposition.

In accordance with the present study, **Winkler J**et al.[16] estimated trueness and precision of two widely used intraoral scanners (TRIOS 3, 3Shape and CS 3600, Carestream) and concluded that CS 3600 and TRIOS 3 intraoral scanners show good performance. In a study by **Roig et al.**[17]TRIOS 3 and CS3600 were found to be more accurate than closed tray conventional technique elastomeric impression, CEREC Omnicam and 3M True Definition scanner. **Renne et al.**[18]reported that regarding scanning time, TRIOS was found to have the best balance of speed and accuracy.

From the previous discussion and the conflicting outcome of the studies, the scanning systems, scanner acquisition process and powder application do not appear to be major influencing factors on the accuracy of IOS. The included studies revealed multiple variables that can influence the accuracy of IOS, such as span length, scanning sequence and scanned surface morphology.

While IOS can be safely used to acquire diagnostic models and treatment planning purposes, some recommendations are required for definitive prosthesis fabrication. According to the current level of evidences, IOS should only be used for short-span prosthesis that follows a confirmative occlusal relationship with the opposing arch. This is facilitated by scanning the maxillary and mandibular arches when they are at maximal intercuspation. For longer span prosthesis, in addition to accurately recordine tooth surface, the occlusal relationship has to be registered, which is very difficult to record by IOS after preparing several teeth.[19, 21]

This study was an attempt to clarify the variations between CEREC Omnicam and 3Shape TRIOS 3 intraoral scanners, as well as their capabilities to scan the prepared teeth in oral cavity and the gypsum models poured from elastomeric impressions. These scans were superimposed on CBCT scans which were taken as a reference. A 3D comparison followed after this, in X, Y and Z coordinate axes. The supporting literature found

on this study was not adequate, therefore more number of such studies must be undertaken in future so that there can be more aspects unfolded about intraoral scanners and their services to mankind.

Conclusion

The present study concluded that CBCT could be used as a reference for superimposition of direct and indirect digital scans. DICOM to STL conversion directly in D2P software resulted in no difference in accuracy of the original CBCT scan. But, the conversion of CBCT to NNRD format followed by NNRD to STL conversion in 3DSlicer resulted in some difference in accuracy, which was within the permissible range. Although 3Shape TRIOS 3 had disadvantages like lightly disturbing sound while scanning process continued, unlike CEREC Omnicam which had a soothing mobile cart sound and was more appreciated by the patients, the efficacy of former was better than that of latter. The time required for scanning of half arch, dual arch as well as full arch by TRIOS 3 was almost half the time required for scanning by CEREC Omnicam. Overall results show that 3Shape TRIOS 3 had a comparatively higher trueness and precision than CEREC Omnicam mobile cart scanner.

The limitations of the study were:

1. The bite scan of the models as well as of the patient could not be used for measuring the differences in mesio – occlusal and disto – occlusal clearance. Therefore, the original separate dual arch scans of both intraoral and gypsum models were combined to measure the same.
2. Subjects underwent exposure to radiation only for the purpose of research.
3. The study was expensive, time consuming and required great expertise at digital scanning.
4. Very few supporting articles were found in favour of CBCT vs intraoral scanning.

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Legend Tables and Figures

Table 1: Values of trueness of all study subjects of all groups at T_1

Patient	GROUP A				GROUP B				GROUP C			
	Group 2	Group 3	Group 4	Group 5	Group 2	Group 3	Group 4	Group 5	Group 2	Group 3	Group 4	Group 5
1	0.031	0.008	0.016	0.011	0.058	0.012	0.034	0.013	0.016	0.033	-0.003	- 0.011
2	0.041	-0.012	0.032	-0.010	0.050	0.027	0.033	0.022	0.013	0.011	0.00	0.002

3	0.042	-0.016	0.028	- 0.001	0.042	-0.011	0.022	-0.002	0.012	0.027	0.012	0.018
4	0.034	0.032	0.021	0.013	0.038	0.012	0.033	0.015	0.011	0.032	-0.011	-0.016
5	0.036	-0.012	0.022	- 0.002	0.033	-0.005	0.040	-0.003	0.021	0.025	-0.003	- 0.011
MEAN	0.0368	0.000	0.0238	0.0022	0.044	0.007	0.0324	0.009	0.0146	0.0256	-0.001	-.0036
SD	0.0046	0.020	0.0062	0.0096	0.009	0.0151	0.0065	0.011	0.004	0.009	0.008	0.0137

Table 2: Values of trueness of all study subjects of all groups at T_2

Patient	GROUP A				GROUP B				GROUP C			
	Group 2	Group 3	Group 4	Group 5	Group 2	Group 3	Group 4	Group 5	Group 2	Group 3	Group 4	Group 5
1	0.036	0.012	0.022	0.002	0.046	0.028	0.015	0.010	0. 012	0.022	- 0.007	0.012
2	0.068	0.010	0.014	0.005	0.045	0.027	0.011	- 0.001	0.023	0.028	-0.034	0.001
3	0.043	- 0.032	0.026	- 0.003	0.035	0.027	0.013	0.008	0.023	0.025	0.034	0.012
4	0.053	0.013	0.016	0.009	0.033	0.023	0.004	0.006	0.011	0.013	0.021	0.008
5	0.042	- 0.016	0.012	- 0.007	0.028	0.018	- 0.009	- 0.005	0.016	0.026	- 0.003	0.002
MEAN	0.048	-.0026	0.018	0.0012	0.037	0.0246	0.0068	0.0036	0.02	0.0228	0.0021	0.007
SD	0.0125	0.0203	0.0058	0.006	0.008	0.0041	0.0097	0.0063	0.006	0.0059	0.026	0.005

Table 3: Values of trueness of all study subjects of all groups at T_3

Patient	GROUP A				GROUP B				GROUP C			
	Group 2	Group 3	Group 4	Group 5	Group 2	Group 3	Group 4	Group 5	Group 2	Group 3	Group 4	Group 5
1	0.034	0.029	0.008	0.003	0.025	0.024	0.012	0.008	0.018	0.023	- 0.011	0.022
2	0.043	0.033	0.015	0.008	0.024	0.016	-0.014	-0.001	0.019	0.027	0.007	0.017
3	0.067	0.037	0.018	0.003	0.037	0.022	0.005	0.004	0.026	0.028	0.013	0.017
4	0.045	0.022	- 0.004	- 0.002	0.028	0.014	0.015	- 0.006	0.043	0.072	0.014	0.012
5	0.047	0.025	0.018	0.011	0.042	0.024	0.013	0.002	- 0.003	0.017	- 0.003	0.019
MEAN	0.0472	0.0292	0.0110	0.0046	0.0312	0.0200	0.062	0.0014	0.0206	0.033	0.004	0.0174
SD	0.0122	0.006	0.009	0.005	0.008	0.005	0.0119	0.005	0.017	0.022	0.0107	0.004

Table 4: Values of trueness of all study subjects of all groups at T_4

Patient	GROUP A				GROUP B				GROUP C			
	Group 2	Group 3	Group 4	Group 5	Group 2	Group 3	Group 4	Group 5	Group 2	Group 3	Group 4	Group 5
1	0.048	0.022	0.014	0.005	-0.003	0.034	- 0.007	0.012	0.019	0.017	0.042	0.037
2	0.045	0.032	- 0.018	0.007	0.053	0.036	0.074	0.083	0.012	- 0.017	0.027	- 0.012

3	0.035	0.013	0.022	0.008	0.028	-0.004	0.032	0.062	0.018	0.019	0.024	0.031
4	0.034	0.011	0.013	0.003	0.007	0.008	0.102	0.112	0.022	0.181	0.029	0.190
5	0.037	0.025	0.014	0.002	0.010	0.011	0.012	0.014	0.018	0.017	0.018	0.019
MEAN	0.039	0.021	0.009	0.005	0.019	0.017	0.043	0.0566	0.0178	0.0434	0.028	0.0530
SD	0.006	0.008	0.0155	0.003	0.022	0.017	0.0448	0.0436	0.004	0.0784	0.009	0.079

Table 5: Values of trueness of all study subjects of all groups at T_5

Patient	GROUP A				GROUP B				GROUP C			
	Group 2	Group 3	Group 4	Group 5	Group 2	Group 3	Group 4	Group 5	Group 2	Group 3	Group 4	Group 5
1	0.030	0.008	0.024	0.008	0.065	0.012	0.032	0.005	0.022	0.003	0.029	0.003
2	0.033	-0.005	0.026	-0.006	0.052	0.016	0.036	0.007	-0.019	0.018	-0.014	0.004
3	0.024	-0.015	0.012	-0.017	0.042	0.003	0.033	0.003	0.013	0.011	0.012	0.001
4	0.027	0.011	0.018	0.017	0.032	0.015	0.025	0.011	0.017	-0.018	0.019	-0.002
5	0.039	0.012	0.031	0.015	0.033	0.014	0.024	0.008	0.025	0.015	0.025	0.010
MEAN	0.0306	0.0022	0.022	0.003	0.0448	0.012	0.0300	0.0068	0.0116	0.0058	0.0142	0.0032
SD	0.0057	0.0118	0.007	0.0145	0.0138	0.005	0.0052	0.003	0.0177	0.145	0.0170	0.004

Table 6: Values of trueness of all study subjects of all groups at T_6

Patient	GROUP A				GROUP B				GROUP C			
	Group 2	Group 3	Group 4	Group 5	Group 2	Group 3	Group 4	Group 5	Group 2	Group 3	Group 4	Group 5
1	0.042	0.008	0.036	0.006	0.065	0.012	0.050	0.009	0.022	0.013	0.018	0.003
2	0.033	0.011	0.018	0.008	0.041	0.014	0.036	0.003	0.027	0.021	0.033	0.002
3	0.056	0.012	0.080	0.009	0.044	0.015	0.041	0.008	0.018	0.011	0.024	0.000
4	-0.034	0.014	-0.038	0.002	0.024	-0.013	0.019	-0.005	0.017	0.018	0.019	0.001
5	0.036	-0.014	0.038	- 0.009	0.054	0.014	0.051	0.040	0.018	0.010	0.023	0.005
MEAN	0.0266	0.006	0.0268	0.0032	0.0456	0.0084	0.0394	0.011	0.0204	0.0146	0.0234	0.002
SD	0.035	0.011	0.0428	0.00733	0.0153	0.0120	0.013	0.0171	0.0041	0.0047	0.006	0.0019

Table 7: Values of trueness of all study subjects of all groups at T_7

Patient	GROUP A				GROUP B				GROUP C			
	Group 2	Group 3	Group 4	Group 5	Group 2	Group 3	Group 4	Group 5	Group 2	Group 3	Group 4	Group 5
1	0.073	0.051	0.024	0.000	0.036	0.029	0.012	0.008	0.034	0.013	0.021	0.008
2	0.031	0.023	-0.011	- 0.001	0.053	0.015	0.014	0.006	0.041	0.014	0.013	0.004

3	0.047	-0.023	-0.010	- 0.017	0.081	- 0.015	0.015	-0.001	0.043	- 0.014	0.032	-0.019
4	0.052	0.037	0.021	- 0.006	0.063	0.038	0.017	0.013	0.059	0.018	0.031	0.004
5	0.042	0.025	0.011	0.011	0.043	0.023	0.019	0.014	0.031	0.023	0.015	0.014
MEAN	0.049	0.0226	0.007	-.0026	0.055	0.018	0.0154	0.008	0.0416	0.0108	0.022	0.002
SD	0.0155	0.0278	0.0166	0.0101	0.0176	0.0202	0.003	0.006	0.0109	0.0144	0.008	0.0125

Table 8: Values of trueness of all study subjects of all groups at T_8

Patient	GROUP A				GROUP B				GROUP C			
	Group 2	Group 3	Group 4	Group 5	Group 2	Group 3	Group 4	Group 5	Group 2	Group 3	Group 4	Group 5
1	0.012	0.015	- 0.002	-0.007	0.088	0.033	0.019	0.013	0.031	-0.033	0.024	-0.045
2	0.023	0.027	0.003	0.001	0.043	0.024	0.014	0.005	0.042	0.033	0.041	0.013
3	0.028	0.032	0.008	0.006	0.047	0.018	-0.004	-0.003	0.032	0.003	0.028	0.009
4	0.027	0.029	0.015	0.012	0.053	0.052	0.018	0.008	0.058	0.018	0.027	0.008
5	0.024	0.022	0.017	0.012	0.042	0.035	0.022	0.006	0.052	0.024	0.039	0.013
MEAN	0.0228	0.025	0.008	0.0048	0.0546	0.032	0.0138	0.0058	0.043	0.009	0.0318	-0.004
SD	0.0063	0.0067	0.00798	0.008	0.0192	0.0129	0.0104	0.0058	0.0119	0.0259	0.0077	0.0250

Table 9: Values of trueness of all study subjects of all groups at T_9

Patient	GROUP A				GROUP B				GROUP C			
	Group 2	Group 3	Group 4	Group 5	Group 2	Group 3	Group 4	Group 5	Group 2	Group 3	Group 4	Group 5
1	0.038	0.028	0.012	-0.001	0.054	0.067	0.011	0.009	0.019	0.031	0.006	0.016
2	0.027	0.024	-0.006	-0.004	0.035	0.045	0.013	0.013	0.014	0.036	-0.007	0.009
3	0.029	0.017	0.008	0.003	0.015	0.021	0.020	0.022	0.013	0.044	-0.015	0.016
4	0.032	0.012	0.019	0.013	0.023	0.031	0.015	0.016	0.016	0.038	0.004	0.009
5	0.042	0.036	0.016	0.017	0.043	0.034	0.023	0.022	0.023	0.054	-0.004	0.001
MEAN	0.0366	0.0234	0.098	0.0056	0.034	0.0396	0.0164	0.0164	0.017	0.0406	-0.003	0.0102
SD	0.0062	0.009	0.009	0.009	0.0155	0.0175	0.0049	0.0056	0.0041	0.009	0.0102	0.006

Table 10: Values of precision of all study subjects of all groups at T_1

Patient	GROUP A				GROUP B				GROUP C			
	Group 2	Group 3	Group 4	Group 5	Group 2	Group 3	Group 4	Group 5	Group 2	Group 3	Group 4	Group 5
1	0.041	0.008	0.006	0.001	0.012	0.000	0.003	0.001	0.000	0.000	0.001	0.000
2	0.026	0.013	0.011	0.000	0.002	0.001	0.002	0.001	0.001	0.000	0.000	0.000

3	0.009	0.003	0.003	0.002	0.009	0.008	0.000	0.001	0.001	0.001	0.001	0.001
4	0.000	0.000	0.000	0.000	0.002	0.001	0.002	0.001	0.041	0.008	0.006	0.001
5	0.017	0.008	0.005	0.001	0.009	0.001	0.008	0.000	0.009	0.001	0.008	0.000
MEAN	0.0186	0.006	0.005	0.0008	0.007	0.002	0.003	0.0008	0.0104	0.002	0.0032	0.0004

Table 11: Values of precision of all study subjects of all groups at T_2

Patient	GROUP A				GROUP B				GROUP C			
	Group 2	Group 3	Group 4	Group 5	Group 2	Group 3	Group 4	Group 5	Group 2	Group 3	Group 4	Group 5
1	0.020	0.013	0.000	0.000	0.004	0.003	0.002	0.001	0.004	0.003	0.002	0.003
2	0.000	0.000	0.000	0.000	0.008	0.007	0.003	0.002	0.003	0.001	0.004	0.004
3	0.011	0.000	0.002	0.000	0.003	0.005	0.003	0.001	0.000	0.005	0.001	0.002
4	0.002	0.001	0.000	0.000	0.004	0.007	0.003	0.01	0.011	0.005	0.004	0.001
5	0.013	0.001	0.003	0.001	0.017	0.005	0.003	0.003	0.003	0.002	0.001	0.003
MEAN	0.0092	0.006	0.0014	0.0002	0.007	0.005	0.003	0.003	0.004	0.003	0.002	0.003

Table 12: Values of precision of all study subjects of all groups at T_3

Patient	GROUP A				GROUP B				GROUP C			
	Group 2	Group 3	Group 4	Group 5	Group 2	Group 3	Group 4	Group 5	Group 2	Group 3	Group 4	Group 5
1	0.023	0.003	0.001	0.001	0.009	0.008	0.007	0.002	0.009	0.003	0.001	0.004
2	0.002	0.001	0.000	0.002	0.006	0.004	0.003	0.002	0.001	0.002	0.003	0.001
3	0.009	0.006	0.002	0.000	0.006	0.007	0.005	0.001	0.002	0.002	0.000	0.001
4	0.008	0.000	0.003	0.001	0.009	0.007	0.006	0.002	0.003	0.002	0.004	0.003
5	0.003	0.008	0.004	0.003	0.006	0.003	0.002	0.000	0.002	0.003	0.001	0.001
MEAN	0.008	0.002	0.0014	0.007	0.006	0.005	0.0014	0.003	0.002	0.0018	0.002	0.002

Table 13.Values of precision of all study subjects of all groups at T_4

Patient	GROUP A				GROUP B				GROUP C			
	Group 2	Group 3	Group 4	Group 5	Group 2	Group 3	Group 4	Group 5	Group 2	Group 3	Group 4	Group 5
1	0.003	0.000	0.003	0.001	0.005	0.006	0.003	0.001	0.001	0.003	0.002	0.001
2	0.003	0.002	0.000	0.001	0.005	0.004	0.003	0.002	0.011	0.002	0.003	0.003
3	0.004	0.002	0.000	0.001	0.010	0.006	0.004	0.001	0.011	0.000	0.002	0.000
4	0.011	0.008	0.006	0.004	0.001	0.001	0.000	0.000	0.014	0.002	0.001	0.001
5	0.012	0.000	0.001	0.001	0.004	0.003	0.002	0.001	0.002	0.011	0.011	0.001

MEAN	0.007	0.002	0.002	0.002	0.005	0.004	0.002	0.001	0.008	0.004	0.004	0.001

Table 14: Values of precision of all study subjects at all groups at T_5

Patient	GROUP A				GROUP B				GROUP C			
	Group 2	Group 3	Group 4	Group 5	Group 2	Group 3	Group 4	Group 5	Group 2	Group 3	Group 4	Group 5
1	0.023	0.005	0.000	0.000	0.017	0.006	0.004	0.003	0.011	0.004	0.003	0.002
2	0.000	0.000	0.000	0.000	0.013	0.003	0.005	0.001	0.003	0.004	0.002	0.005
3	0.003	0.001	0.002	0.000	0.006	0.003	0.002	0.001	0.005	0.003	0.001	0.003
4	0.002	0.003	0.001	0.000	0.004	0.006	0.003	0.002	0.003	0.004	0.001	0.000
5	0.103	0.014	0.013	0.008	0.007	0.006	0.003	0.001	0.002	0.002	0.002	0.001
MEAN	0.026	0.005	0.003	0.002	0.009	0.005	0.003	0.002	0.005	0.003	0.002	0.002

Table 15: Values of precision of all study subjects at all groups at T_6

Patient	GROUP A				GROUP B				GROUP C			
	Group 2	Group 3	Group 4	Group 5	Group 2	Group 3	Group 4	Group 5	Group 2	Group 3	Group 4	Group 5
1	0.001	0.006	0.001	0.006	0.008	0.007	0.005	0.001	0.002	0.003	0.002	0.000
2	0.008	0.002	0.000	0.000	0.006	0.005	0.003	0.001	0.009	0.002	0.004	0.001
3	0.101	0.100	0.010	0.001	0.005	0.004	0.002	0.002	0.011	0.001	0.003	0.001
4	0.008	0.010	0.002	0.002	0.007	0.003	0.002	0.001	0.004	0.003	0.004	0.003
5	0.008	0.007	0.004	0.002	0.003	0.005	0.001	0.002	0.003	0.003	0.002	0.001
MEAN	0.025	0.025	0.003	0.002	0.006	0.005	0.003	0.001	0.006	0.002	0.003	0.0012

Table 16: Values of precision of all study subjects at all groups at T_7

Patient	GROUP A				GROUP B				GROUP C			
	Group 2	Group 3	Group 4	Group 5	Group 2	Group 3	Group 4	Group 5	Group 2	Group 3	Group 4	Group 5
1	0.018	0.015	0.101	0.002	0.002	0.001	0.002	0.000	0.004	0.003	0.002	0.001
2	0.007	0.007	0.003	0.000	0.010	0.005	0.006	0.003	0.002	0.003	0.004	0.003
3	0.008	0.004	0.001	0.003	0.005	0.003	0.002	0.001	0.009	0.005	0.003	0.001
4	0.004	0.002	0.001	0.001	0.010	0.000	0.008	0.001	0.005	0.004	0.004	0.001
5	0.021	0.008	0.105	0.002	0.004	0.003	0.002	0.000	0.006	0.006	0.006	0.002
MEAN	0.012	0.007	0.042	0.002	0.006	0.002	0.004	0.001	0.005	0.004	0.004	0.002

Table 17: Values of precision of all study subjects at all groups at T_8

Patient	GROUP A				GROUP B				GROUP C			
	Group 2	Group 3	Group 4	Group 5	Group 2	Group 3	Group 4	Group 5	Group 2	Group 3	Group 4	Group 5
1	0.009	0.002	0.001	0.001	0.000	0.000	0.000	0.000	0.004	0.003	0.002	0.001
2	0.008	0.002	0.001	0.001	0.008	0.000	0.004	0.001	0.002	0.003	0.004	0.003
3	0.008	0.011	0.011	0.001	0.005	0.003	0.002	0.000	0.008	0.005	0.003	0.001
4	0.003	0.005	0.004	0.002	0.007	0.005	0.002	0.001	0.004	0.004	0.004	0.001
5	0.004	0.008	0.007	0.001	0.012	0.010	0.009	0.004	0.005	0.005	0.004	0.002
MEAN	0.006	0.006	0.005	0.001	0.006	0.004	0.003	0.001	0.005	0.004	0.003	0.002

Table 18: Values of precision of all study subjects at all groups at T_9

Patient	GROUP A				GROUP B				GROUP C			
	Group 2	Group 3	Group 4	Group 5	Group 2	Group 3	Group 4	Group 5	Group 2	Group 3	Group 4	Group 5
1	0.023	0.002	0.004	0.001	0.006	0.003	0.004	0.003	0.004	0.002	0.001	0.001
2	0.005	0.004	0.002	0.001	0.009	0.006	0.004	0.002	0.002	0.003	0.002	0.002
3	0.006	0.001	0.004	0.003	0.010	0.006	0.009	0.002	0.002	0.003	0.003	0.001
4	0.007	0.004	0.004	0.000	0.006	0.004	0.004	0.004	0.007	0.006	0.003	0.001
5	0.105	0.014	0.102	0.001	0.001	0.002	0.001	0.012	0.003	0.002	0.002	0.001
MEAN	0.029	0.005	0.023	0.001	0.006	0.004	0.004	0.005	0.004	0.003	0.002	0.001

Figure 1: Bar graph depicting value of trueness at T_1

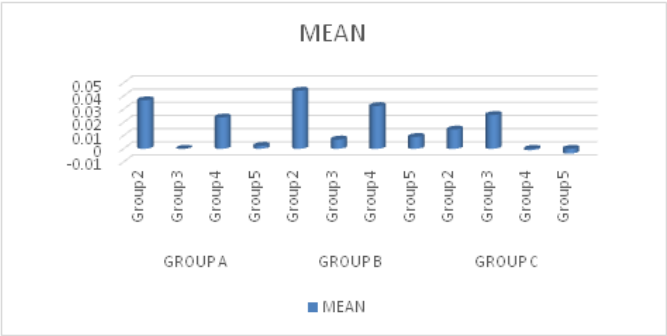

Figure 2: Bar graph depicting value of trueness at T_2

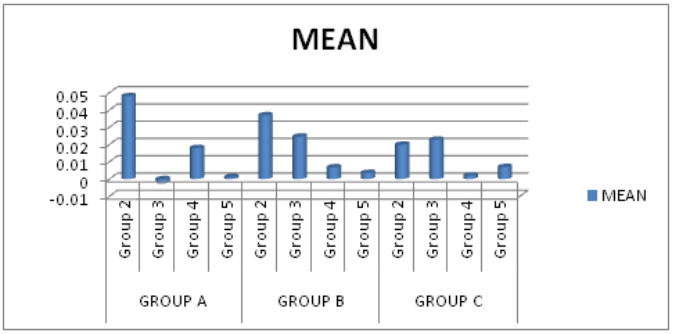

Figure 3: Bar graph depicting value of trueness at T_3

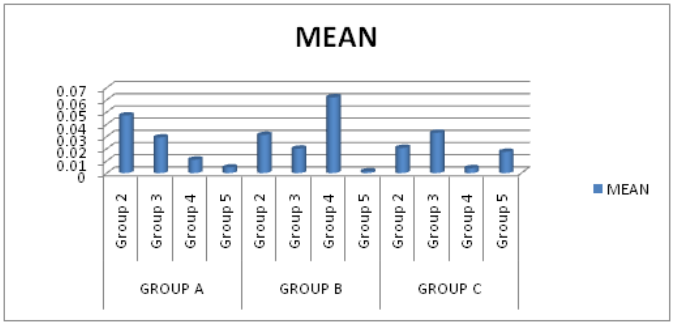

Figure 4: Bar graph depicting value of trueness at T_4

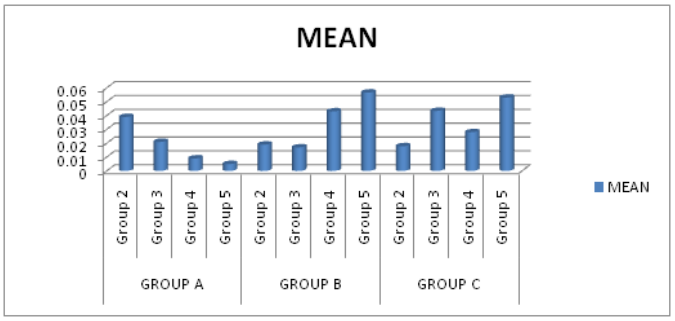

Figure 5: Bar graph depicting value of trueness at T_5

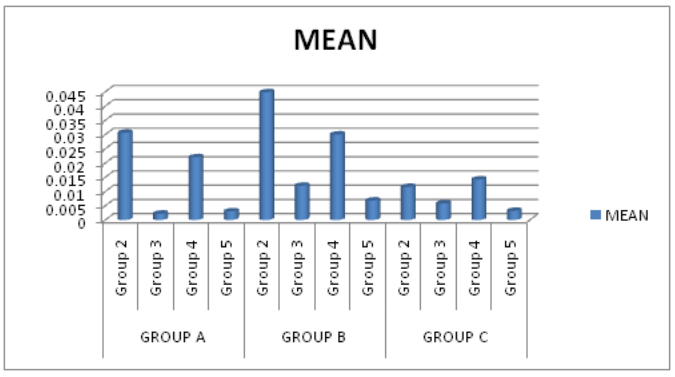

Figure 6: Bar graph depicting value of trueness at T_6

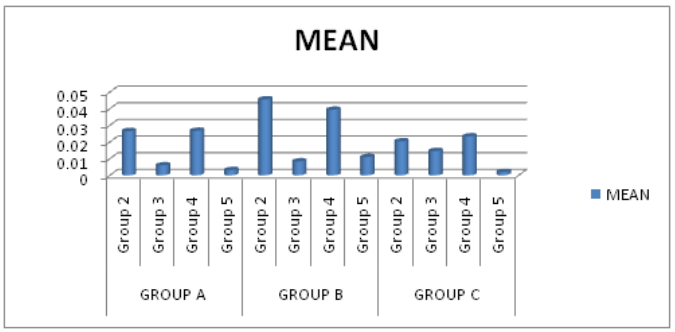

Figure 7: Bar graph depicting value of trueness at T_7

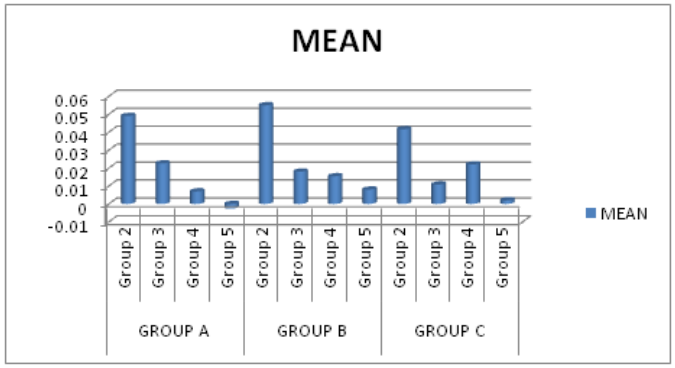

Figure 8.Bar graph depicting value of trueness at T_8

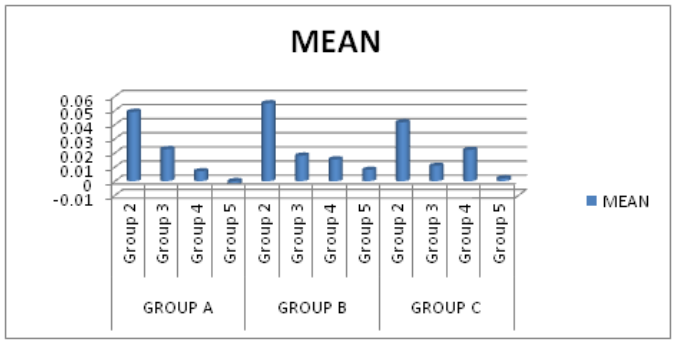

Figure 9: Bar graph depicting value of trueness at T_9

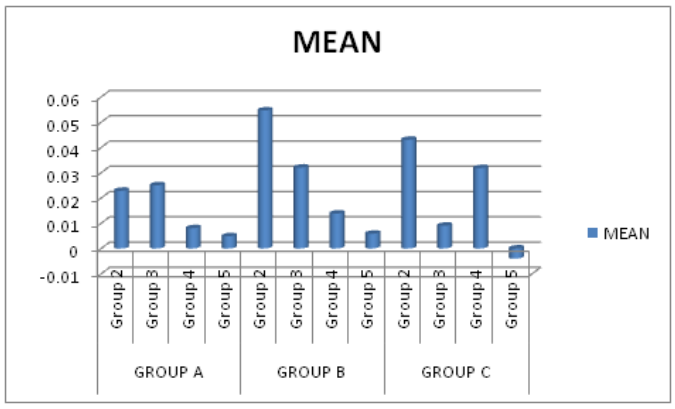

Figure 10: Bar graph depicting value of precision at T_1

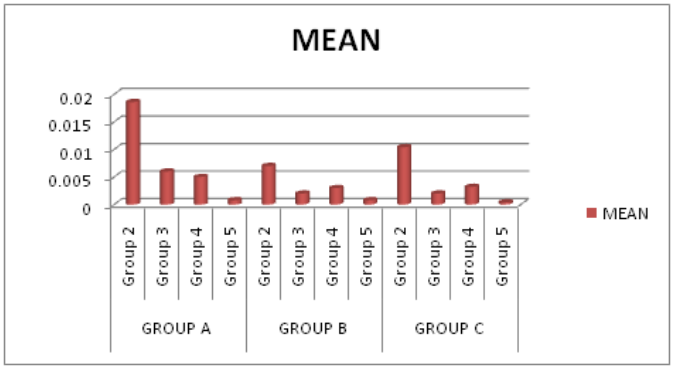

Figure 11: Bar graph depicting value of precision at T_2

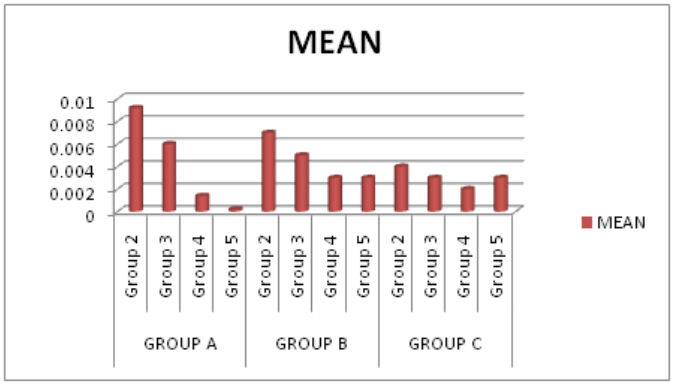

Figure 12: Bar graph depicting value of precision at T_3

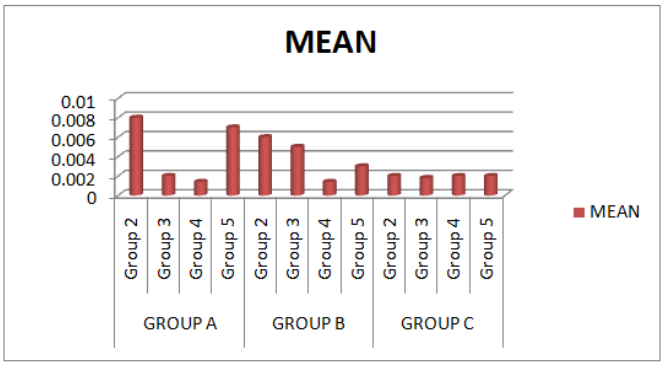

Figure 13: Bar graph depicting value of precision at T_4

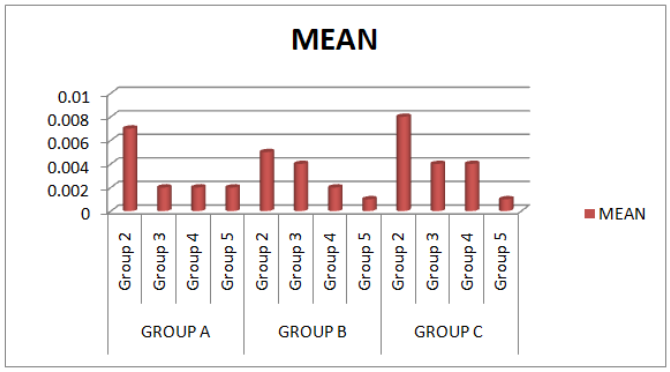

Figure 14: Bar graph depicting value of precision at T_5

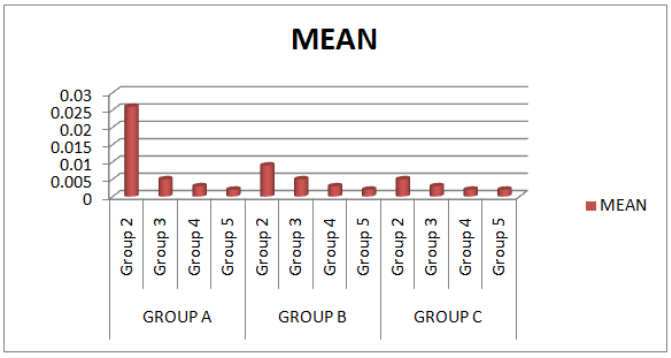

Figure 15: Bar graph depicting value of precision at T_6

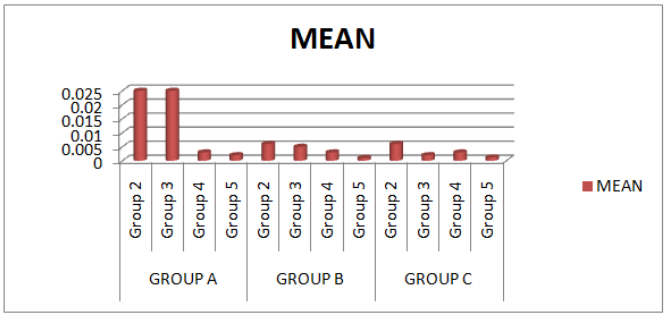

Figure 16: Bar graph depicting value of precision at T_7

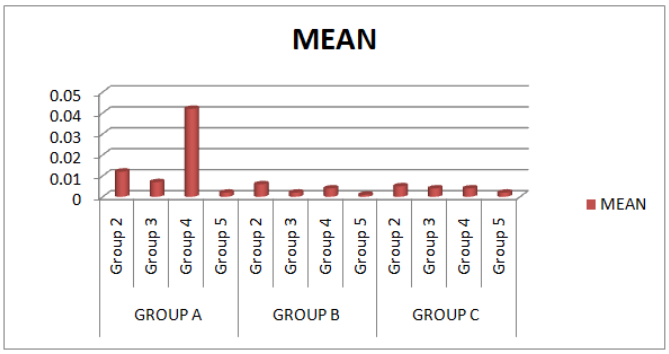

Figure 17: Bar graph depicting value of precision at T_8

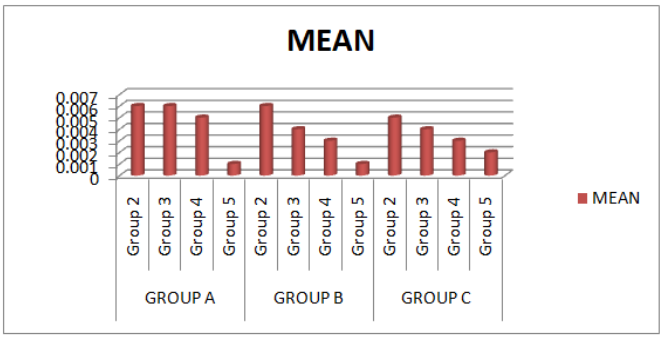

Figure 18: Bar graph depicting value of precision at T_9