Virtual versus Conventional nasal endoscopy in nasal and paranasal sinuses lesions

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Introduction
Virtual Endoscopy (VE) is a computer-generated simulation of the endoscopic perspective obtained by processing computed tomography (CT) and is one of the applications of virtual reality in medicine. [1]

VE provides a noninvasive, alternative diagnostic technique to conventional nasal endoscopy (CNE); it allows for the exploration of cavities and lumens and has wide applications in medicine, medical education, and surgery. [2] The VE system uses software to render volume data from diverse imaging techniques (e.g., CT) and reconstruct a 3-dimensional (3D) internal anatomical structure of interest. [3]

(VE) is a reformation of axial CT images into a 3D model using sophisticated software. [4] In the present where the medical system is influenced by a paucity of resources and increasing waiting times for diagnostic tests, VE provides a useful diagnostic adjunct for the surgeon, without the need of additional tests. There are no required particular CT specifications over the standard scanner and thus, any patient who can undergo a CT sinus can have a three-dimensional model created. [5,6]

Patients and Methods
This is a prospective randomized comparative study which was conducted in the Otolaryngology Department of Assiut University Hospital (AUH) and department of Otorhinolaryngology of Armed Forced Hospital South Region in Saudi Arabia from March 2012 to July 2016. All patients complained of chronic nasal symptoms as nasal obstruction, nasal discharge, and allergic nasal symptoms.

Approval for this study was obtained from Institutional review board (IRB) of Faculty of Medicine-Assiut University prior to study execution and this was extended to the Saudi part. In addition, all participants received a written consent form. The informed consent was clear and indicated the purpose of the study, and their freedom to participate or withdraw at any time without any obligation. Furthermore, participants’ confidentiality and anonymity were assured by assigning each participant with a code number for the purpose of analysis only. The study was not based on any incentives or rewards for the participants.

The study included 106 patients who presented to the department of the AUH outpatient clinic, aged from (1day-65) years with chronic nasal symptoms. Patients with evidence of chronic sinusitis, sinonasal polyposis, deviated nasal septum, hypertrophied inferior turbinate, allergic rhino-sinusitis, and sinonasal masses with no previous imaging (CT or MRI) on paranasal sinuses were included in this study.
Patients with common cold, and influenza, also patients with headache or facial pain not related to sinus origin, or history of facial trauma were excluded.

The evaluation of the patients involved:
- Detailed history taking.
- Local Nasal examination including anterior and posterior rhinoscopies.
- A detailed Conventional Nasal Endoscopic examination
- Radiological examination: MSCT scan on paranasal sinuses (PNS).
- Virtual Endoscopy of nose and Para nasal sinuses of all patients

Conventional Nasal Endoscopy of nose and Para nasal sinuses.
All patients included in the study were examined by Conventional Nasal Endoscope (CNE) in ENT department. Seventy-six patients afford examination under local anesthesia in the ENT outpatient clinic using xylocaine 2% spray in addition to nasal vasoconstrictor spray xylometazoline 0.1%, while thirty patients went to surgery so examination by rigid nasal endoscope was done under general anesthesia in Operative Theatre (OR) where nasal cavities were decongested using cotton pledges soaked in 4% lignocaine with 1:10,000 adrenaline.

Technique of nasal endoscopy used
Using a rigid nasal endoscope (0° optics, OD 4mm, Karl Storz, Tuttingen, FRG.)

Diagnostic Nasal Endoscopy: It consists basically of three passes:

1st Pass
The endoscopy began with the (4.0 mm, 0-degree) telescope passed along the floor of the nose while the septum, inferior meatus, inferior turbinate, and nasopharynx were inspected.

The scope was advanced into the nasopharynx. The ipsilateral Eustachian tube and the fossa of Rosenmueller, were examined.

2nd Pass
The scope was passed along the floor up to the posterior choana. It was then moved upward medial to the middle turbinate along the roof of the posterior choana and the anterior surface of the sphenoid. The superior turbinate and meatus were seen. The sphenoidal recess was visualized.

3rd Pass
The third pass was made to examine the contents of the middle meatus. The middle meatus can be entered by gently retracting the middle turbinate medially with the Fryer’s elevator. This may be difficult if the middle turbinate was rigid and may give rise to pain.

Radiological assessment of the nose and Paranasal sinuses (MSCT):
MSCT Scan PNS was done in all cases included in the study. Scanning was done using a 64-channel Multi-detector CT scanner (Toshiba, Japan) scanner with patient in supine position with head extension. The images were obtained in Axial plane with reconstruction in Sagittal and Coronal images using the raw data.

Images were reconstructed at 1-mm intervals, with a 2-mm slice overlap, and reconstruction in coronal plane perpendicular to the axial plan, both soft tissue and bone windows were obtained. Intravenous contrast was used in some indicated cases.

Virtual Endoscopy of nose and paranasal sinuses
All patients underwent Virtual Endoscopy (VE) of the nose and Paranasal sinuses (PNS). The MSCT data were downloaded to dedicated workstation running software for 3-dimensional rendering (Workstation, Vitrea software: VITAL IMAGE Medical Systems).

After a VE image was created, its color and light were adjusted by using editing functions. The interior of the nasal cavity was dynamically demonstrated using the fly function.

Flight path:
The 3D model provides the surgeon's ability to navigate through the created structure. The navigation tool allows the operator to "fly through" or "sail through" the 3D anatomy, traveling in any direction or any position in the nasal cavity and paranasal sinuses.

Final interpretations were made on the basis of combined evaluation of axial and coronal MSCT images and Virtual Endoscopy reconstruction. The result of CNE was compared with the findings of VE images by an expert otorhinologist (the 4th author "ENT specialist") and radiologist (the 3rd author "Professor of radiology") working together.

Comparison done between the three modalities examinations regarding these items:

1- Nasal Cavity:
   A-Nasal septum.
   B-Nasal floor.
   C-Turbinates & Meati:
      i-inferior turbinate
      ii-middle turbinate
      iii-superior turbinate
      iv-inferior meatus
      v-middle meatus
      vi-superior meatus.
      vii-supreme turbinate (if present)
   D-Ostiomeatal complex:
      i-uncinated process
      ii-infundibulum
      iii-maxillary ostium
   E-Recess:
      i-Frontoethmoidal Recess.
      ii-Sphenoid-ethmoidal Recess.

2-Sinus pneumatization:
   A-frontal sinus
   B-maxillary sinus
   C-ethmoidal sinus
   d-sphenoidal sinus

3-Choanae

4-Nasopharynx
The visualization of these structures through the VE and CNE was classified with scores: quoted from previous study [7].
- Score 2. Structures could be clearly displayed, i.e., the structures were seen in their entirety, with sharp, well-defined margins.
- Score 1. Structures could be partly visualized or had blurred margins and were not easily recognized.
- Score 0. Structures could not be seen.

Statistical Analysis
The data from case record forms were tabulated in a Microsoft Excel spreadsheet. Statistical Analysis was done
Table 1: Demographic Distribution of the patients in the study

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Age</td>
<td>34.21 ± 9.1</td>
<td>25.24 ± 19.1</td>
<td>29.89 ± 15.4</td>
</tr>
<tr>
<td>Median Age</td>
<td>34 (16 – 65 y)</td>
<td>30 (1day – 57 y)</td>
<td>33 (1day-65 y)</td>
</tr>
<tr>
<td>Percentage</td>
<td>56 (52.8%)</td>
<td>50 (47.2%)</td>
<td>100%</td>
</tr>
</tbody>
</table>

Symptoms of the patients

Regarding to the presenting symptom of the patients included in the study, nasal obstruction was the commonest symptom in 95 (89.6%) followed by nasal discharge in 80 patients (75.5%), sneezing in 60 patients (56.6%) & nasal itching in 55 patients (51.8%) & altered sense of smell in 40 patients (37.7%). Other less common symptoms include headache in 24 patients (22.6%) and epistaxis in 15 patients (14.1%).

Level of an agreement between the (CNE) and (VE) in visualizing anatomical structure of nose and PNS. (Table. (2) (Fig.1).

1-Nasal septum
As regard visualization of nasal septum in all patients in the study there was good agreement between VE and CNE with (p-value<0.001) and Kappa* = 0.628

2- Inferior turinate
As regard visualization of inferior turbinate in all patients in the study there was moderate agreement between VE and CNE with (p-value <0.001 and Kappa* = 0.594).

3-Middle turbinate & middle meatus
As regard visualization of middle turbinate and middle meatus in all patients in the study there was moderate agreement between VE and CNE with (p-value <0.001 and Kappa* = 0.496) Kappa* = 0.341 respectively.

4-Inferior meatus
As regard visualization of inferior meatus in all patients in the study there was good agreement between VE and CNE with (p-value <0.001 and Kappa* = 0.753).

6-The choanae
As regard visualization of the choanae in all patients in the study there was almost perfect (strong) agreement between VE and CNE with (p-value <0.001 and Kappa* = 0.850)

7-The nasopharynx
As regard visualization of the nasopharynx in all patients in the study there was weak agreement between VE and CNE with (p-value <0.001 and Kappa* = 0.488).

8-The maxillary sinus ostium
As regard visualization of the maxillary sinus in all patients in the study there was moderate agreement between VE and CNE with (p-value <0.001 and Kappa* = 0.401).

9-The sphenoid sinus
As regard visualization of the sphenoid sinus in all patients in the study there was no agreement between VE and CNE with (p-value <0.001 and Kappa* = 0).

The ability of the three diagnostic modality (VE & CNE and MSCT) used in the study in detecting nasal and PNS lesions. (Table 3, Fig. 2).

Choanal atresia
MSCT could detect 7 patients (100%) of choanal atresia out of total 7 patients confirmed by surgery while VE could detect 5 cases (71.4%) of choanal atresia out of 7 patients but CNE could detect only 2 cases (28.6%), and it was statistically significant (p-value <0.001).

Sinonasal polyposis
MSCT could detect 23 patients (95.8%) of sinonasal polyposis out of total 24 cases confirmed by surgery while CNE could detect 22 cases (91.7%) but VE could detect 9 cases (37.5%), and it was statistically significant (p-value <0.01).

Allergic fungal rhinosinusitis
MSCT could detect 11 cases (68.8%) of allergic fungal rhinosinusitis out of 16 cases confirmed by surgery while CNE could detect 8 cases (50.0%) but VE could detect 6 cases (37.5%), and it was statistically significant (p-value = 0.011). Ethmoidal mucocelle.

MSCT could detect 3 cases (100%) of ethmoidal mucocelle out of total 3 patients confirmed by surgery while VE could detect 1 patient (33.3%) and CNE could detect 1 patient (33.3%), and it was statistically insignificant.

Antrochoanal polyp
MSCT could detect 2 patients (66.7%) of antrochoanal polyp out of total 3 patients confirmed by surgery while VE could detect 1 patient (33.3%) and CNE could detect also 1 patient (33.3%), and it was statistically insignificant.

Preseptal cellulitis
MSCT could detect 2 patients (100%) of preseptal cellulitis out of total 2 patients while VE couldn’t detect any patient also CNE could not detect any patient.

Deviated nasal septum
MSCT could detect 14 patients (100%) of deviated nasal septum out of total 14 patients confirmed by surgery while
VE could detect 12 patients (85.7%) and CNE could detect 10 patients (71.4%), and it was statistically significant (p-value = 0.021).

**Hypertrophied inferior turbinate**
MSCT could detect 12 patients (100%) of hypertrophied inferior turbinate out of total 12 patients confirmed by surgery and VE could detect 12 patients (100%) while CNE could detect 10 patients (83.3%), and it was statistically insignificant.

**Chronic rhino-sinusitis**
MSCT could detect 18 patients (100%) of chronic rhino-sinusitis out of total 18 patients while VE could detect 12 patients (66.7%) and CNE could detect 10 patients (55.6%), and it was statistically significant (p-value = 0.039).

**Post ESS nasal synachae**
MSCT could detect only 2 patients of post FESS nasal adhesion out of total 6 patients confirmed by surgery also VE could detect only 2 patients (33.3%) while CNE could detect the 6 patients (100%), and it was statistically insignificant.

**Rhinolith**
MSCT could detect the only 1 patient diagnosed as rhinolith confirmed by surgery while VE and CNE couldn’t detect this patient.

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**Table 2: Showing Level of agreement between the conventional nasal endoscope and Virtual Endoscopy in visualizing anatomical structure of nose and PNS**

<table>
<thead>
<tr>
<th>Anatomical structure</th>
<th>VE</th>
<th>P-value*</th>
<th>Kappa**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>visualized</td>
<td>Non-visualized</td>
<td></td>
</tr>
<tr>
<td>Septum</td>
<td>visualized</td>
<td>86 (84.4%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Non-visualized</td>
<td>8 (7.8%)</td>
<td>8 (7.8%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>visualized</td>
<td>98 (96%)</td>
<td>0 (0%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Inferior Turbinate</td>
<td>Non-visualized</td>
<td>2 (2.0%)</td>
<td>2 (2.0%)</td>
</tr>
<tr>
<td>visualized</td>
<td>88 (88.2%)</td>
<td>0 (0%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Middle Turbinate</td>
<td>Non-visualized</td>
<td>12 (9.8%)</td>
<td>2 (2.0%)</td>
</tr>
<tr>
<td>visualized</td>
<td>42 (41.2%)</td>
<td>0 (0%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Inferior Meatus</td>
<td>Non-visualized</td>
<td>56 (54.9%)</td>
<td>4 (3.9%)</td>
</tr>
<tr>
<td>visualized</td>
<td>66 (64.7%)</td>
<td>0 (0%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Middle Meatus</td>
<td>Non-visualized</td>
<td>30 (29.4%)</td>
<td>6 (5.9%)</td>
</tr>
<tr>
<td>visualized</td>
<td>72 (70.6%)</td>
<td>0 (0%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Choanae</td>
<td>Non-visualized</td>
<td>10 (9.8%)</td>
<td>20 (19.8%)</td>
</tr>
<tr>
<td>visualized</td>
<td>70 (69.6%)</td>
<td>0 (0%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Nasopharynx</td>
<td>Non-visualized</td>
<td>26 (25.5%)</td>
<td>4 (3.9%)</td>
</tr>
<tr>
<td>visualized</td>
<td>18 (17.7%)</td>
<td>0 (0%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Max.Sinus stium</td>
<td>Non-visualized</td>
<td>30 (29.4%)</td>
<td>54 (52.9%)</td>
</tr>
<tr>
<td>visualized</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0.000</td>
</tr>
<tr>
<td>Sphenoid Sinus</td>
<td>Non-visualized</td>
<td>80 (78.4%)</td>
<td>22 (21.6%)</td>
</tr>
</tbody>
</table>
Fig 1: Bar Chart of Level of agreement between the conventional nasal endoscope and Virtual Endoscopy in visualizing anatomical structure of nose and PNS.
Table 3: Distribution of the diseases in our study detected by the three diagnostic modalities

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>No.</th>
<th>VE</th>
<th>CNE</th>
<th>MS-CT</th>
<th>P-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Congenital choanal atresia</td>
<td>7</td>
<td>5 (71.4%)</td>
<td>2 (28.6%)</td>
<td>7 (100%)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Bilateral nasal polyposis</td>
<td>24</td>
<td>9 (37.5%)</td>
<td>22 (91.7%)</td>
<td>23 (95.8%)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Allergic fungal sinusitis</td>
<td>16</td>
<td>6 (37.5%)</td>
<td>8 (50.0%)</td>
<td>11 (68.8%)</td>
<td>=0.011</td>
</tr>
<tr>
<td>Ethmoidal mucocele</td>
<td>3</td>
<td>1 (33.3%)</td>
<td>1 (33.3%)</td>
<td>3 (100%)</td>
<td>=0.051</td>
</tr>
<tr>
<td>Antrochoanal polyp</td>
<td>3</td>
<td>1 (33.3%)</td>
<td>2 (66.7%)</td>
<td>2 (66.7%)</td>
<td>=0.081</td>
</tr>
<tr>
<td>Preseptal cellulitis</td>
<td>2</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>2 (100%)</td>
<td>-----</td>
</tr>
<tr>
<td>Deviated nasal septum</td>
<td>14</td>
<td>12 (85.7%)</td>
<td>10 (71.4%)</td>
<td>14 (100%)</td>
<td>=0.021</td>
</tr>
<tr>
<td>Hypertrophied inf. turbinate</td>
<td>12</td>
<td>12 (100%)</td>
<td>11 (91.7%)</td>
<td>12 (100%)</td>
<td>=0.154</td>
</tr>
<tr>
<td>Rhinolith</td>
<td>1</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>1 (100%)</td>
<td>---</td>
</tr>
<tr>
<td>Chronic rhinosinusitis</td>
<td>18</td>
<td>12 (66.7%)</td>
<td>10 (55.6%)</td>
<td>18 (100%)</td>
<td>=0.039</td>
</tr>
<tr>
<td>Post ESS nasal synachae</td>
<td>6</td>
<td>2 (33.3%)</td>
<td>6 (100%)</td>
<td>2 (33.3%)</td>
<td>=0.051</td>
</tr>
</tbody>
</table>

*Z-test was used to compare the proportion difference

Fig 2: Bar chart showing distribution of the diseases in the study detected by the three diagnostic modalities.
Case presentation

1st case Bilateral Congenital Choanal atresia (Figs. 3a,b,c,d)

Fig 3a: VE image shows the choanal atresia.

Fig 3b: CNE image shows the choanal atresia.

Fig 3c: axial CT scan on PNS.

Fig 3d: Choanogram axial CT scan on PNS.

2nd case Bilateral Sinonasal polyposis (Figs. 4a,b,c)

Fig 4a: Endoscopic view of nasal polyposis.

Fig 4b: VE image of nasal polyposis.
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Fig. 4c: Coronal CT scan on PNS shows nasal polypsis.

5th case: Rhinolith (Figs. 5a,b,c)

Fig 5a: Coronal CT scan on PNS showing radio-opaque shadow rhinolith in right nasal fossa.

Fig 5b: VE image shows bulging in nasal floor.

Fig 5c: Shows the size of rhinolith after removal.

Discussion

This study included 106 patients, 56 patients were males (53%) and 50 patients were females (47%). The age of patients in this present study was ranged from (1 day-60 years) with median of 33 years and mean age of the patients was (29.89 ± 15.4 years).

The commonest symptom in this study was nasal obstruction in 95 (89.6%) followed by, nasal discharge in 80 patients (75.5%).

Therefore, in the present study, VE could demonstrate clearly inferior, middle turbinate in 98%, 98.1% slightly better than CNE in which visualization of same structures was 96.2%, 86.8% respectively and these findings were corresponding to the study done by Di Rienzo et, al., 2003 [10] in which they found also VE could visualize inferior, middle turbinate in 100 (100%), 91 (91%), while CNE could visualize same structure in 100 (100%), 81 (81%), and this may be attributed to that anatomical structures were demonstrated clearly in MSCT so when VE was done easily reformatteed the data from MSCT and all MSCT cut views (coronal, axial and sagittal) guided us to detect these anatomical structure.

Another study done by Anand et al., in 2011 [5] found that VE could clearly visualize inferior and middle turbinate in 22 (91.7%), 16 (66.7%), respectively while CNE could visualize same structure in 23 (95.8%), 18 (85.7%) and our results regarding to these same structure were better than their study may be attributed to our number of patients (n=106) more than their study group (n=25).

From data of the present study VE could visualize maxillary, and sphenoid sinuses in 62.8%, 39.2% respectively better than findings of CNE in which couldn't visualize any of these structures 0 percentage, and these findings were statistically significant and corresponding to the study done by Di Rienzo et, al., 2003 [10] in which they found also VE could visualize maxillary, and sphenoid sinuses in 80 (80%), 83 (83%) respectively while CNE couldn't visualize any of these structures (0 %), and regarding to our VE's results which less than study of Di Rienzo et, al., 2003 [10] may be attributed to our study included variable obstructive sinonasal disease than their study so VE couldn't detect some anatomical structures, but regarding to the ability of VE to detect the anatomical detail paranasal sinuses was better than CNE which cannot see the sinuses from inside.
From data of the present VE could visualize the choanae, nasopharynx in 80.4%, 96.2%, respectively better than the findings of CNE in which could visualize same structures in 71.7%, 69.8% and these findings were statistically significant and corresponding to the results of the study done by Di Rienzo et al., 2003 [10] in which they found VE could visualize the choanae, nasopharynx in 100 (100%), 100 (100%), respectively while CNE could visualize same structures in 100 (100%), 100 (100%), and this may be attributed to the ability of VE to go beyond the obstructive lesion as polyps, masses and secretions and the ability to enter the nasal cavity from posterior to anterior guided by MSCT cut views via the nasopharynx or posterior choana.

In the present study we found good agreement between VE and CNE in visualization of nasal septum, inferior turbinate, the choanae, inferior meatus statistically significant with (p-value<0.001) and Kappa* value=0.62, 0.594, 0.850, 0.753 respectively), and that means we can depend on VE in demonstrating these structures as CNE.

We found weak agreement between VE and CNE in visualization of middle meatus, middle turbinate, the nasopharynx, maxillary sinus; statistically significant with Kappa* value=0.341, 0.496, 0.488, 0.401 respectively, and that means VE was better than CNE in visualization theses structure which cannot be accessible by CNE.

We found was no agreement between VE and CNE in visualization of sphenoid sinus with (p-value <0.001 and Kappa*=0), and that means VE was better than CNE in visualization theses structure which cannot be accessible by CNE.

Regarding to the ability of detecting nasal and paranasal lesion by three diagnostic modalities MSCT, VE and CNE.

According to our results we found that MSCT could detect 7 patients (100%) of choanal atresia out of total 7 patients confirmed by surgery, and that showed that MSCT still the gold standard of nasal and paranasal diseases especially in congenital disease, and that was better than VE in which it could detect 5 cases (71.4%) of choanal atresia but very difficult with CNE to use it in such cases and this may be due to narrow nasal passages in such young infants.

According to our results MSCT could detect 23 patients (95.8%) of sinonasal polyposis slightly the same findings of CNE in which it could detect 22 cases (91.7%) better than the results of VE because CNE can differentiate easily between the coloration of different tissue and secretions which inaccessibility for the VE, so VE could detect only 9 cases (37.5%), and these findings were better than the results from previous study was done by Han et al., 2000 [7] in which CNE could detect polyps in 6 patients (nasal cavities) 6 out of 18 (33.3%).

Also in previous study done by Chavan et al., 2018, [11] they found that MSCT could detect nasal polyposis in 11 out of 50 patients (22%) while CNE could detect nasal polyposis in 14 out of 50 (28%) with excellent agreement between both modalities (kappa value =0.84).

According to our results MSCT could detect 11 cases (68.8%) of allergic fungal rhino-sinusitis showed better sensitivity than CNE. CNE could detect 8 cases (50.0%) better than VE which detected 6 cases (37.5%), and these results of MSCT corresponding with previous study that concluded MSCT sensitivity in allergic fungal sinusitis nearly (62-66%). [12,13]

According to our results, MSCT could detect 14 patients (100%) of deviated nasal septum nearly agreement with VE which detected 12 patients (85.7%) better than CNE in which detected 10 patients (71.4%), and these result were better than the study done by Han et al., in 2000 [7] in which they found that VE could display patient’s septal deviation in 7 of 9 patients (77.8%).

In other study done by Chavan et al., 2018, [11] in which they found that MSCT could detect septal deviation in 42 out of 50 patients (84%) while CNE could detect septal deviation in 40 out 50 patients (80%) with excellent agreement between the both modalities (kappa value= 0.86).

According to our results MSCT could diagnose 12 patients (100%) of hypertrophied inferior turbinate; same results of the VE in which could diagnose 12 patients (100%); but better than CNE could detect 10 patients (83.3%); this may be attributes to occlusive disease which prevent introduce the rigid nasal endoscope to evaluate some cases of hypertrophied turbinates. Our findings were better than the results done by Han et al., 2000 [7] in which VE could detect turbinate hypertrophy in 6 out of 36 (16.6%) and that may due to small number of patient in Han et al., study.

In the study done by Zojaji R et al., 2008 [14] they found that hypertrophied inferior turbinate was more evidenced in MSCT scan compared to CNE (86% vs 82%).

According to our results MSCT could diagnose 18 patients (100%) of chronic rhino-sinusitis better than the results of VE could detect 12 patients (66.7%) and better than CNE which could detect 10 patients (55.6%).

Lohiya et al.,2018 [15] in their study found no significant difference in diagnosing chronic rhino-sinusitis by either modality.

In the previous study of Deosthale et al., in 2014 [16], they found that CNE detected chronic rhinosinusitis in 70 patients out of 122 patients (57.4%) while MSCT detected chronic rhinosinusitis in 80 patients out of 122 patients (65.6%).

According to our results MSCT could detect the only 1 patient diagnosed as rhinolith confirmed by surgery while VE and CNE couldn’t detect this patient, and that may be attributed to that MSCT has high sensitivity more than CNE and VE in detecting rhinolith.

**Limitations of the study**

The main limitations of VE are the impossibility of performing biopsy & evaluating nasal mucosa &secretions, and inability to detect color of mucosa (cannot differentiate between erythema and leukoplakia), cannot detect thickness of tissues and cannot differentiate thick secretions from soft tissue structures or differentiating fibrotic tissue from relapses in post-surgery patients. Further studies are needed to overcome this latter limitation. In our experience, VE resulted in a fast, relatively easy, and noninvasive technique that could be integrated into CNE, but we underline the necessity of a careful standard CNE for all patients before performing CT and eventually VE reconstruction. [17]

**Conclusion**

- Multi-Slice Computer Tomography (MSCT) is still the gold standard diagnostic imaging in nasal and paranasal sinuses for assessment either anatomical structures and different pathologic lesions. MSCT is mandatory before all paranasal sinus surgeries not only before FESS.
- Conventional Nasal Endoscopy (CNE) as it is done by the surgeon himself, so the diagnosis and assessment is quick, helps to reduce CT utilization.
• Conventional Nasal Endoscopy (CNE) is complementary to MSCT when combined with it can reach to precise diagnosis of the patients.
• Virtual Endoscopy (VE) is a fast, non-invasive, relatively easy diagnostic tool provided a good simulation of the CNE without need to more radiation exposure but in fact, VE is not an alternative to CNE.
• VE in comparable with CNE has the ability to display structures of the nasal cavity such as septum, turbinates, and middle meatus. and superior to CNE in demonstrating nasal cavity beyond obstructive lesions and can demonstrating inside sinuses cavity.
• VE is considered an advanced simulator tool in teaching and training before Endoscopic Sinus Surgery.

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There are no conflicts of interest

References