



Research Article

## Correlating Spirometry and Forced Oscillatory Technique (FOT) In Patients Presenting with Respiratory Complaints to A Tertiary Care Center in North Maharashtra

Dr Gunavant N Mahajan,<sup>1</sup> Dr Jitendra Surwade <sup>2</sup>

<sup>1</sup>Assistant Professor, Department of Respiratory Medicine, Dr. Ulhas Patil Medical College and Hospital, Jalgaon.

<sup>2</sup>Associate Professor, Department of Community Medicine, Shri Bhausaheb Hire Government Medical College, Dhule, Maharashtra, India

OPEN ACCESS

### Corresponding Author:

**Dr Gunavant N Mahajan**

Assistant Professor,  
Department of Respiratory  
Medicine, Dr. Ulhas Patil  
Medical College and Hospital,  
Jalgaon

*Received:* 19-02-2026

*Accepted:* 20-04-2026

*Published:* 30-04-2026

Copyright© International Journal of  
Medical and Pharmaceutical Research

### ABSTRACT

**Background:** Obstructive lung diseases, particularly Chronic Obstructive Pulmonary Disease (COPD) and asthma, are major contributors to global morbidity and mortality, especially in low- and middle-income countries. Spirometry remains the gold standard for diagnosis; however, its performance is often limited in elderly patients and those unable to perform forced respiratory maneuvers. Forced Oscillation Technique (FOT) has emerged as a promising alternative due to its ease of use and minimal patient cooperation requirements. The study was aimed to study spirometry and FOT in all patients presenting with chronic respiratory symptoms to tertiary care center and attempt to correlate the results of the two with clinical diagnosis.

**Material and Methods:** A cross-sectional study was conducted in the Department of Respiratory Medicine at a tertiary care centre from March 2024 to June 2025. A total of 243 patients with chronic respiratory symptoms were included. All participants underwent clinical evaluation, spirometry, and FOT testing before and after bronchodilator administration. Data were analyzed to assess patterns, bronchodilator response, and concordance between spirometry and FOT findings.

**Results:** The majority of patients (34.16%) were above 60 years. Spirometry revealed a restrictive pattern in 48.56% of patients, obstructive pattern in 31.28%, and normal findings in 20.16%. FOT identified normal findings in 27.16%, small airway obstruction in 23.46%, combined small and large airway obstruction in 20.99%, restriction in 18.11%, and large airway obstruction in 10.29% of patients. Concordance between spirometry and FOT was 60.08% for interpretation and 66.67% for bronchodilator response. FOT showed better correlation with clinical diagnosis in 51% of cases compared to spirometry (26.3%).

**Conclusion:** FOT is a valuable, non-invasive, and patient-friendly modality that demonstrates good concordance with spirometry and superior correlation with clinical diagnosis in a significant proportion of patients.

**Keywords:** Spirometry, Forced Oscillation Technique (FOT), Pulmonary Function Test (PFT), Airway Obstruction, Lung Function Testing.

### INTRODUCTION

Obstructive lung disease is a leading cause of morbidity and mortality globally.<sup>1,2</sup> More specifically, estimates suggest that 90% of deaths due to chronic obstructive pulmonary disease (COPD), which is the primary cause of obstructive lung disease in older adults, occur in lower- and middle-income countries.<sup>3</sup>

As of early 2025, the prevalence of Chronic Obstructive Pulmonary Disease (COPD) in India is estimated to be between 7.4% and 13% among adults, with significantly higher rates in the elderly, males, and those exposed to biomass fuel.<sup>4</sup> It is a major cause of disability and death, driven by pollution, smoking, and indoor air pollution. The Global Initiative for Obstructive Lung Disease (GOLD) guidelines state that the ratio of forced expiratory volume in 1 second (FEV1)/forced vital capacity (FVC) <70% after bronchodilator inhalation is an essential criterion for the diagnosis of COPD.<sup>4</sup>

In addition to COPD, Asthma is another major obstructive airway disease contributing significantly to the global burden of respiratory illness. Asthma is characterized by chronic airway inflammation, variable airflow obstruction, and bronchial hyperresponsiveness, often presenting with symptoms such as wheezing, breathlessness, chest tightness, and cough that vary over time and in intensity. Unlike COPD, airflow limitation in asthma is typically reversible, either spontaneously or with treatment.<sup>5</sup>

Both COPD and asthma frequently present with chronic respiratory symptoms, making early and accurate diagnosis essential for appropriate management. Spirometry is the primary diagnostic investigation in the respiratory department, but some patients are unable to perform spirometry maneuvers. Routine PFTs are particularly challenging for older patients, those with poor motor coordination, deficits in cognition, and respiratory problems, especially when it comes to the evaluation of FVC.<sup>6</sup>

An oscillatory method for the measurement of the respiratory system (Zrs) mechanics was first described by DuBois *et al.*<sup>7</sup> in 1956. However, due to the greater appeal of body plethysmography and the technical difficulties associated with oscillometry, the latter was not widely accepted. Recent advances in microprocessor technology have addressed many of these earlier limitations, leading to the increased use of forced oscillation techniques (FOT) in clinical pulmonary laboratories. FOT is an advanced modality with better sensitivity and is easy to perform. It is particularly advocated for children and the elderly who are unable to perform spirometry.<sup>8</sup>

Therefore, the study was aimed to study spirometry and FOT in all patients presenting with chronic respiratory symptoms to tertiary care center "Shri Ganesh Hospital" Jalgaon in North Maharashtra and attempt to correlate the results of the two with clinical diagnosis.

#### OBJECTIVE:

1. To study spirometry and FOT in all patients with chronic respiratory complaints.
2. To assess the use of FOT as an alternative to, or in conjunction with, spirometry to categorize chronic respiratory disorders.

#### MATERIAL AND METHODS:

The present cross-sectional study was undertaken to study spirometry and FOT findings in patients presenting with chronic respiratory symptoms in a tertiary care centre. The study was conducted in Department of Respiratory Medicine during the period from March 2024 to June 2025. A total sample size of 243 patients with chronic respiratory symptoms were included in the study population. The study was conducted after taking ethical clearance from the institute and informed consent from the patients.

All patients involved in this study were subjected to clinical evaluation, spirometry (Easy on PC, NDD Medical Technologies), and FOT (Antlia, iCALTECH Innovation Pvt. Ltd.). Both pre- and post-bronchodilator spirometry and FOT were done in the sequence: FOT, spirometry, bronchodilator (salbutamol with ipratropium) 2 puffs, wait 20 minutes, then post-bronchodilator FOT and finally spirometry. At least two acceptable manoeuvres were obtained as per standard guidelines. Other investigations, such as blood tests and chest X-ray, were performed as required. Clinical diagnosis is compared with spirometry and FOT results. Pre and post bronchodilator results were compared and concordance and discordance in diagnosis and post bronchodilator results were plotted. The data of all cases was collected in a specially designed proforma in this study and later transformed to master chart, and subjected to analysis.

#### RESULTS:

**Table no 1: Distribution according to demographic profile among patients:**

Demographic profile	No. of Patients (243)	Percentage
Age group (years)	≤10	05
	11-20	15
	21-30	29
	31-40	36
	41-50	33
	51-60	42
	>60	83
Gender	Male	117
	Female	126

Table 1 shows the age-wise distribution of patients. The majority of patients (34.16%) were in the >60 years age group, with mean age of 49.62 ± 19.70 years. Among 243 patients, females were 126 (51.85%) while males were 117 (48.15%) (Table 1)

**Table no 2: Distribution according to spirometry result among patients:**

Spirometry result	No. of Patients	Percentage
Restrictive	118	48.56
Obstructive	76	31.28
Normal	49	20.16
Total	243	100

Among 243 participants, restrictive pattern was the most common finding, observed in 118 patients (48.56%), followed by obstructive pattern in 76 patients (31.28%). Normal spirometry was seen in 49 patients (20.16%). (Table 2)

**Table no 3: Distribution according to FOT result among patients:**

FOT result	No. of Patients	Percentage
Restriction	44	18.11
Large airway Obstruction	25	10.29
Small airway Obstruction	57	23.46
Small + Large airway Obstruction	51	20.99
Normal	66	27.16
Total	243	100

According to Forced Oscillation Technique (FOT) out of 243 participants, normal FOT findings were observed in 66 patients (27.16%) followed by small airway obstruction in 57 patients (23.46%), combined small and large airway obstruction in 51 patients (20.99%) Restriction was noted in 44 patients (18.11%), while large airway obstruction alone was observed in 25 patients (10.29%). (Table 3)

**Table no 4: Distribution according to bronchodilator response among patients:**

Response	Spirometry		FOT	
	No. of Patients	Percentage	No. of Patients	Percentage
Reversible	75	30.86	88	36.21
Partially reversible	39	16.05	31	12.76
No significant change	103	42.39	89	36.63
Worsen	26	10.70	35	14.40
Total	243	100	243	100

In spirometry, 75 patients (30.86%) showed a reversible response, 39 (16.05%) were partially reversible, 103 (42.39%) showed no significant change, and 26 (10.70%) showed worsening. In FOT assessment, 88 patients (36.21%) demonstrated a reversible response, 31 (12.76%) were partially reversible, 89 (36.63%) showed no significant change, and 35 (14.40%) showed worsening. (Table 4)

**Table no 5: Distribution according to Concordance/Discordance among results of Spirometry and FOT:**

Test		No. of Patients (n=243)	Percentage
Interpretation	Concordance	149	60.08
	Discordance	97	39.92
Bronchodilator response	Concordance	162	66.67
	Discordance	81	33.33

Among 243 patients. for test interpretation, 149 patients (60.08%) showed concordant results, while 97 patients (39.92%) showed discordant findings. For bronchodilator response, 162 patients (66.67%) showed concordance between the two tests, whereas 81 patients (33.33%) showed discordance. (Table 5)

**Figure 1: Showing comparison of Spirometry and FOT with clinical diagnosis:**

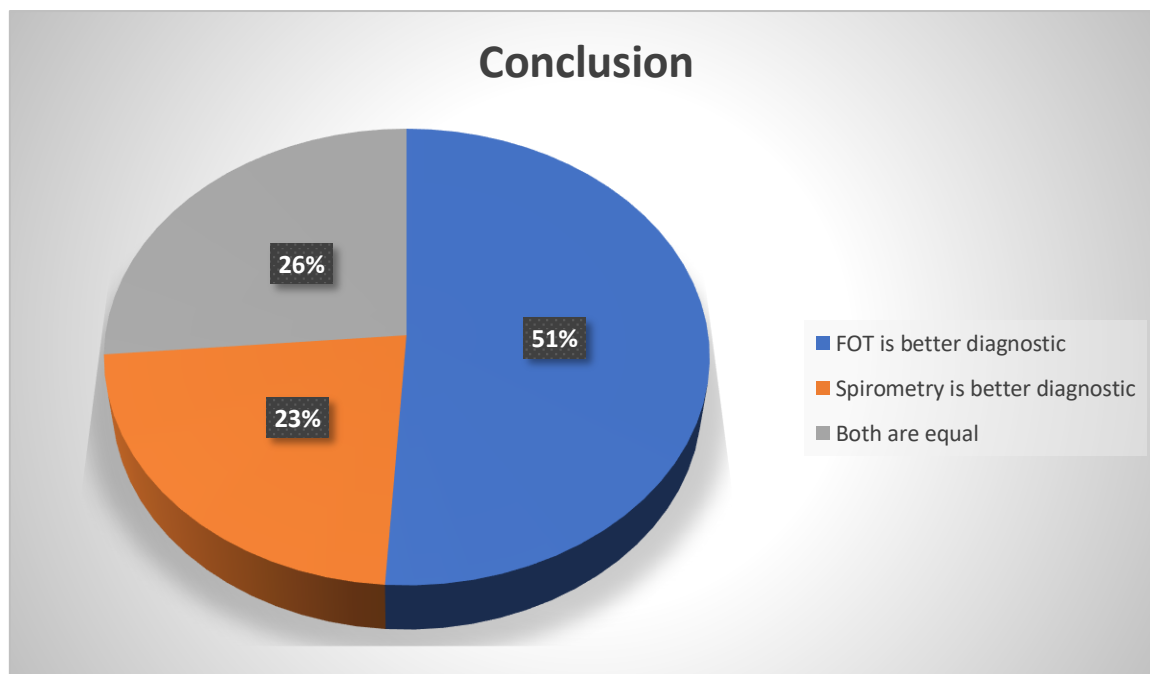


Figure 1 shows that FOT better correlated with clinical diagnosis in 51%, spirometry in 23%, and both were concordant in 26%.

#### DISCUSSION:

The present cross-sectional study was conducted to study correlation between spirometry and forced oscillatory technique (FOT) findings in patients presenting with respiratory complaints at tertiary care center. A total of 243 patients presenting to OPD with chronic respiratory complaints were studied.

In the present study, mean age of patients was  $49.62 \pm 19.70$  years with females were 126 (51.85%) (Table 1)

Similar findings seen Mehta et al<sup>9</sup> study where among 100 participants mean age of the cohort was  $48 \pm 17$  years with 50% patients were female. Priyanka Singh et al<sup>10</sup> in a study observed amongst 100 patients, there were 47% ( $n = 47/100$ ) males and mean age of patients was 54.12 years (ranging from 18 to 83 years). Almeida et al<sup>11</sup> observed most patients were female (65.8%) with median age 42.

In the study, among 243 participants, spirometry findings showed restrictive pattern was the most common finding and normal spirometry was seen in 49 patients (20.16%). (Table 2) while normal FOT findings were observed in 66 patients (27.16%) and most common morbidity of small airway obstruction in 23.46% (Table 3)

A similar observation was reported by Agarwal et al.<sup>12</sup> who found a higher prevalence of restrictive lung patterns among symptomatic individuals. In contrast, Jindal et al.<sup>13</sup> (INSEARCH study) reported a higher burden of obstructive airway diseases in the Indian population. Buist et al.<sup>14</sup> (BOLD study) reported a notable proportion of symptomatic individuals with normal spirometry, comparable to the 20.16% observed in the present study, suggesting the presence of early or undetected airway disease.

Among 243 patients, Forced Oscillation Technique detected a higher proportion of reversible airway obstruction (36.21%) compared to Spirometry (30.86%), indicating greater sensitivity of FOT in identifying bronchodilator response. Overall, moderate concordance was observed between the two modalities (60.1% for interpretation and 66.7% for bronchodilation), with spirometry tending to miss small airway obstruction and occasionally misclassify it as a restrictive pattern. FOT better correlated with clinical diagnosis in 51%, spirometry in 23%, and both were concordant in 26%. (Table 4 & 5)

F Zerah et al<sup>15</sup> observed the use of FOT can be considered as an alternative to forced expiration for detecting bronchodilatation in asthmatics and patients with COPD.

The study by Al-Mutairi et al.<sup>16</sup> reported that the sensitivity of IOS for asthma was 31.3%, while the sensitivity of conventional pulmonary function tests was 19.6%. They found that the sensitivity of IOS in COPD was 38.95%, while the sensitivity of conventional pulmonary function tests was 47.4%. When it came to identifying healthy individuals, IOS's sensitivity of 45.8% outperformed PFT's (28.8%). IOS and conventional PFT have 80.5% and 86.2% specificity, respectively, in identifying healthy individuals.<sup>16</sup> This suggested that when diagnosing mild COPD and assessing modest

airway alterations following bronchodilator and bronchoprovocation challenges, IOS resistance measurements can be helpful.<sup>17</sup>

Mandilwar S. et al<sup>18</sup> in a recent investigation reported that oscillometry outperformed spirometry in both diagnosing asthma and assessing response to treatment over a three-month period. Conversely, another study by Houle M.C. et al<sup>19</sup> involving military personnel found that spirometry was more effective than oscillometry in diagnosing obstructive lung disease. Such variability may stem from heterogeneity in device types and the lack of universally accepted abnormal threshold values for oscillometric parameters. The use of oscillometry for bronchodilator and bronchoprovocation testing in asthma is an area of investigation. According to current technical standards, a significant bronchodilator response (BDR) is considered by a 40% decrease in R5, a 50% increase in X5, and an 80% decrease in the area under the reactance curve (Ax) in both adults and children.<sup>20</sup>

A study by Rathod et al.<sup>21</sup> demonstrated that although asthma typically presents with obstructive patterns, spirometry may be normal in early or mild disease. Similarly, Song et al.<sup>22</sup> highlighted that while Spirometry remains the gold standard for diagnosing Chronic Obstructive Pulmonary Disease, it may fail to detect early or small airway dysfunction, necessitating additional diagnostic modalities. Park et al.<sup>23</sup> demonstrated that impulse oscillometry (FOT) is effective in identifying small airway disease even when spirometry results are normal.

The higher proportion of restrictive patterns on spirometry in the present study is due to the fact that most of pure small airway obstruction on FOT are wrongly labelled as restriction due to airway trapping. If we compare with FOT results which show restriction in only 18.11% patients. Also, some of mild small +large airway obstruction cases may be missed on spirometry and counted in restriction. This underscores the need to include both spirometry and FOT in investigation to properly characterise the pathophysiological mechanism. Additionally, the presence of normal spirometry in a considerable number of symptomatic patients highlights the limitations of spirometry alone.

The strength of the study is the study is coming from peripheral center from district level far from metro cities. Here we have assessed patients, his pre-test clinical diagnosis and post- test treatment response, so reaffirming the diagnosis. Here FOT is done in all patients and not only elderly and children. It identified even mild cases which would have been missed if only spirometry is done. It differentiates between small and large airway obstruction. It found out that many of the small airway obstruction were wrongly labelled as restrictive pattern on spirometry due to air trapping. This study also cautions that even though FOT is better than spirometry in obstructive diseases, spirometry correlate better with clinical diagnosis in 23% of the cases, hence both spirometry and FOT are complementary and together provide better diagnosis than single test alone.

Additionally, significant correlation of oscillometric indices with all daily symptoms of patients with respiratory diseases is detected, even for normal spirometric findings, which is exceptionally important in clinical practice. Thus, great sensitivity is achieved in detecting underlying pathology, and a different perspective is offered in approaching therapeutic interventions, as far as individualized care is concerned for patients' relief and improvement of their quality of life. Of great importance is also the fact that oscillometry is proved much friendlier to the subject than the conventional lung function tests, as it is a much simpler, more obvious, shorter method, requiring significantly less effort.

However, some of the lesser disadvantages of FOT are the standardization and the necessity for supplementary testing. There is a lack of standardized protocols for FOT measurements, leading to variability in results across different settings and devices.

The study was limited by being conducted at a single centre, which restricts the generalizability of its findings. Additionally, a detailed correlation between reactance, impedance, and the severity of airway obstruction was not performed.

## CONCLUSION:

The study concludes that, Spirometry and the Forced Oscillation Technique (FOT) are generally moderately correlated, but they provide complementary information for better diagnosis. FOT is more sensitive in obstructive airway diseases. It differentiates small as well as large airway obstruction. It is also more sensitive in judging bronchodilator response. It is better but complementary to spirometry and can't totally replace spirometry, reinforcing the use of both tests to gain a complete picture of a patient's respiratory health.

## REFERENCES:

1. Halpin DMG, Celli BR, Criner GJ, Frith P, López Varela MV, Salvi S, et al. The GOLD Summit on chronic obstructive pulmonary disease in low- and middle-income countries. *Int J Tuberc Lung Dis.* 2019;23(11):1131–41.
2. GBD 2019 Chronic Respiratory Diseases Collaborators. Global burden of chronic respiratory diseases and risk factors, 1990-2019: an update from the Global Burden of Disease Study 2019. *E Clinical Medicine.* 2023; 59:101936.
3. WHO. Chronic obstructive pulmonary disease (COPD), Fact sheet. Geneva: WHO; 2017.

4. Halder P, Khaiwal R, Goel S, Kumar N, Sarkar M, Soni M, Nongkynrih B, Prabhakar MC, Mamgai A, Rathor S. Burden of chronic obstructive pulmonary disease among Indian adults: systematic review and meta-analysis. *BMC Pulm Med.* 2026 Feb 7;26(1):112.
5. Cukic V, Lovre V, Dragisic D, Ustamujic A. Asthma and Chronic Obstructive Pulmonary Disease (COPD) - Differences and Similarities. *Mater Sociomed.* 2012;24(2):100-5.
6. Haynes JM. Basic spirometry testing and interpretation for the primary care provider. *Can J Respir Ther.* 2018 Winter;54(4):10.29390/cjrt-2018-017.
7. Dubois AB, Brody AW, Lewis DH, Burgess BF Jr. Oscillation mechanics of lungs and chest in man. *J Appl Physiol* 1956;8:587-94.
8. King GG, Bates J, Berger KI, Calverley P, de Melo PL, Dellacà RL, et al. Technical standards for respiratory oscillometry. *Eur Respir J* 2020; 55:1900753
9. Mehta AA, Ashok A, Vazhoor V, Mathai P. A Study to Assess the Utility of Forced Oscillometry in the Diagnosis of Obstructive Airway Disease and its Correlation with Spirometry. *Pulmon.* 2023 Sep 1;25(3):80-6.
10. Singh P, Saxena P, Ahuja NB, Chopra M, Yadav A, Tiwari S. Spirometry parameters versus forced oscillometry parameters in obstructive airway disease - Is there a correlation? *Lung India.* 2023 May-Jun;40(3):291-294.
11. Almeida PC, Aljehani M, Martin MJ, Harrison TW. Comparison of forced oscillation technique (FOT) with spirometry measures in acute asthma. *European Respiratory Journal* 2023 62(suppl 67): OA754.
12. Agarwal R, Aggarwal AN, Gupta D, Jindal SK. Pattern of respiratory diseases in North India: Experience from a tertiary care center. *Lung India.* 2009;26(3):77-82.
13. Jindal SK, Aggarwal AN, Gupta D, Agarwal R, Kumar R, Kaur T, et al. Indian study on epidemiology of asthma, respiratory symptoms and chronic bronchitis (INSEARCH). *Int J Tuberc Lung Dis.* 2012;16(9):1270-7.
14. Buist AS, McBurnie MA, Vollmer WM, Gillespie S, Burney P, Mannino DM, et al. International variation in the prevalence of COPD (BOLD study): A population-based prevalence study. *Lancet.* 2007;370(9589):741-50.
15. Zerah F, Lorino AM, Lorino H, Harf A, Macquin-Mavier I. Forced oscillation technique vs spirometry to assess bronchodilatation in patients with asthma and COPD. *Chest.* 1995 Jul 1;108(1):41-7.
16. Al-Mutairi SS, Sharma PN, Al-Alawi A, Al-Deen JS. Impulse oscillometry: an alternative modality to the conventional pulmonary function test to categorise obstructive pulmonary disorders. *Clinical and experimental medicine.* 2007 Jun;7(2):56-64.
17. Kanda S, Fujimoto K, Komatsu Y, Yasuo M, Hanaoka M, Kubo K. Evaluation of respiratory impedance in asthma and COPD by an impulse oscillation system. *Internal medicine.* 2010;49(1):23-30.
18. Mandilwar S., Thorve S.M., Gupta V., Prabhudesai P. Role of impulse oscillometry in diagnosis and follow-up in bronchial asthma. *Lung India.* 2023; 40:24-32.
19. Houle M.C., Cavacece C.T., Gonzales M.A., Anderson J.T., Hunninghake J.C., Holley A.B., Morris M.J. Correlation of Impulse Oscillometry with Spirometry in Deployed Military Personnel with Airway Obstruction. *Mil. Med.* 2023;188((Suppl. S6)):400-406.
20. Oostveen E., MacLeod D., Lorino H., Farré R., Hantos Z., Desager K., Marchal F. The forced oscillation technique in clinical practice: Methodology, recommendations and future developments. *Eur. Respir. J.* 2003; 22:1026-1041.
21. Rathod K, Sharma S, Patel J, Mehta R. Role of spirometry in early detection of asthma and its limitations in mild disease. *J Asthma.* 2024;61(2):215-22.
22. Song WJ, Kang MG, Chang YS. Diagnostic utility and limitations of spirometry in chronic obstructive pulmonary disease. *J Clin Med.* 2024;13(1):112.
23. Park JH, Lee SY, Kim HJ, et al. Impulse oscillometry for detection of small airway dysfunction in symptomatic patients with normal spirometry. *Sci Rep.* 2024;14:12345.