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Research Article

A COMPARATIVE STUDY OF TENELIGLIPTIN VERSUS HYDROXYCHLOROQUINE AS ADD-ON THERAPY IN UNCONTROLLED TYPE-II DIABETES MELLITUS PATIENTS

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ABSTRACT

Objectives: This study aimed to compare the efficacy and safety of teneligliptin versus hydroxychloroquine (HCQ) as an add-on therapy in uncontrolled type 2 diabetes mellitus (T2DM) patients. To measure the safety and efficacy of teneligliptin and HCQ as add-on therapy in uncontrolled T2DM patients. To compare the safety and efficacy of teneligliptin and HCQ during the study. To assess the glycemic control in patients of T2DM before treatment and after treatment.

Methods: This randomized, observational, and prospective study enrolled 124 uncontrolled T2DM patients who were inadequately controlled on metformin and glimepiride therapy. Patients were randomly assigned to receive either teneligliptin (20 mg/day) or HCQ (400 mg/d ay) as add-on therapy for weeks 4, 12, and 24 weeks. The primary outcome was the change in glycated hemoglobin (HbA1c) from baseline to week 24.

Results: Both teneligliptin and HCQ significantly reduced HbA1c levels from baseline, with a greater reduction observed in the teneligliptin group ($p<0.001$). In addition, the teneligliptin group demonstrated improved fasting blood sugar and post-prandial glucose levels in comparison to HCQ.

Conclusion: This study suggests that teneligliptin is a more effective and tolerable add-on therapy compared to HCQ in uncontrolled T2DM patients, highlighting its potential as a valuable treatment option for improving glycemic control.

Keywords: Type 2 diabetes mellitus, Teneligliptin, Hydroxychloroquine, Glycated hemoglobin reduction, Insulin resistance, Hyperglycemia, Efficacy, Safety.

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INTRODUCTION

Diabetes mellitus is a chronic, metabolic disease characterized by elevated levels of blood glucose, which over time causes both microvascular and macrovascular complications [1].

Around 90% of all diabetes cases are of type 2 diabetes (T2D), making it the most frequent variety on a global scale. Rapid socioeconomic growth, demographic transitions, and a greater genetic susceptibility among the Indian population have contributed to a significant rise in the incidence of diabetes during the last 40 years in India [2,3].

Diabetic incidence and prevalence are both affected by age. Example: 1.7% of people aged 20–39 have diabetes, according to both self-reports and official diagnoses, compared to 15.8% of those aged 65 and over. Between 2003 and 2004, the prevalence of diabetes in those over the age of 65 rose by 62%, according to one research. Furthermore, there is a significant ethnic gap in the incidence of T2D [4].

T2D mellitus (T2DM) requires both pharmaceutical and non-pharmacological treatments, including regular exercise, a healthy diet, and a reduction in body fat. The American Diabetes Association (ADA) reports that glycated hemoglobin (HbA1c) reductions ranging from 0.7% to 1.0% are familiar with adding additional classes of oral hypoglycemic medications to beginning treatment [5,6].

Many TD2 patients fail to reach the 7.0% HbA1c goal, even when treated with metformin and sulfonylurea (SU) in combination [7]. First- or second-line medications in the treatment of diabetes should include dipeptidyl peptidase 4 (DPP-4) inhibitors, according to 2016 guidelines from the ADA, American Association of Clinical Endocrinologists, and American College of Endocrinology [8].

Evidence suggests that hydroxychloroquine (HCQ) may mitigate the dangers of diabetes and dyslipidemia on cardiovascular health. There has been new evidence that HCQ may help people with diabetes control their blood sugar and cholesterol levels. There has been new evidence that HCQ may help people with diabetes control their blood sugar and cholesterol levels. A patient with T2D who was on HCQ fell into a hypoglycemia coma in one instance [9].

HCQ showed superior glycemic control than SU in a cross-sectional study evaluating risk factors for cardiovascular disease. Researchers found that HCQ users were less likely to have diabetes compared to non-users in an observational analysis of 4,905 people with rheumatoid arthritis [10,11].

Among the gliptin compounds covered in depth in this publication is teneligliptin, a DPP-4 inhibitor. Anagliptin, vildagliptin, saxagliptin, and sitagliptin are examples of peptidomimetic inhibitors, whereas alogliptin and linagliptin are non-peptidomimetic inhibitors. This study provides a concise overview of the established chromatographic and spectrophotometric methods for determining teneligliptin. Metformin was found to be the most frequent combination with teneligliptin [12].

Despite the availability of multiple treatment options for T2DM, a significant number of patients continue to experience inadequate glycemic control. This study addresses the gap in knowledge regarding effective add-on therapies for patients who are already on standard antidiabetic medications but have uncontrolled diabetes.

Teneligliptin and HCQ are both potential candidates for improving glycemic control in T2DM, but there is limited direct comparison in clinical trials. Understanding their comparative. Effectiveness can provide clinicians with evidence-based guidance on selecting the most suitable add-on therapy.

Improving glycemic control in T2DM not only reduces the risk of complications but also enhances the quality of life for patients. By evaluating outcomes such as HbA1c reduction, fasting plasma glucose levels, and patient-reported outcomes, the study aims to directly impact patient care and outcomes. The study aims to provide practical insights into the real-world application of these medications as add-on therapies. This can influence clinical practice guidelines and help optimize treatment strategies for managing T2DM.

METHODS

The study was carried out at S.N. Medical College and Hospital, Agra (U.P.), by the Department of Pharmacology and Therapeutics in collaboration with the Department of Medicine at S.N. Medical College and Hospital, Agra (U.P.).

Study design

It is an observational and prospective study conducted to analyze the effect of teneligliptin and HCQ as add-on therapy for the treatment of uncontrolled T2DM patients who are already on metformin and glimepiride.

Inclusion criteria

- All patients with newly diagnosed T2DM who were not managed well with oral hypoglycemic medications such as metformin and glimepiride
- Fasting blood sugar (FBS) level >126 mg/dL
- Post-prandial glucose (PPG) level >200 mg/dL
- HbA1c >7%
- The age group is 30–50 years and attended the medicine outpatient department, at S.N. Medical College, Agra.

Exclusion criteria

- Patients were on insulin therapy or T1DM
- Patients who have had hyperosmolar hyperglycemic non-ketotic syndrome or diabetic ketoacidosis during the last 6 months, as well as patients suffering from renal or liver disease
- Patients with macular edema, retinopathy of any grade, or both
- Patients of age <30 years and >50 years
- Patients with a history of peripheral vascular disease/gangrene
- Patients with a recent (<1 year) cardiovascular event, that is, myocardial infarction/acute coronary syndrome, stroke, or has undergone surgery
- Pregnant females or those planning to become pregnant
- Patients with hypersensitivity to teneligliptin or HCQ.

Sample size calculation

In the case of a qualitative study, the sample size will be calculated using the OpenEpi online sample size calculator. A total of 124 patients as per inclusion and exclusion criteria randomly selected suffering from uncontrolled T2DM patients who are already on metformin and glimepiride.

Study duration

- The study duration was conducted for a period of 1 year (May 2023–April 2024)
- The Institutional Ethical Committee meeting was conducted in the S. N. Medical College, and clearance was given for the above research work.

Patients were divided randomly into two separate groups

- Group-1 (n=62) comprised of patients taking Metformin(1000mg) and Glimepiride(2mg) per day, received Teneligliptin (20mg).
- Group-2 (n=62) comprised of patients taking Metformin (1000mg) and Glimepiride(2mg) per day, received Hydroxychloroquine(400mg).
- In both groups, follow-up was done at 1, 3, and 6 months.

Follow-up and evaluation

At the first visit as well as at the 4, 12, and 24-week follow-up appointments, data were obtained from the patient for:

- Evaluation of efficacy
- Evaluation of safety
- Assessment of glycemic control.

Evaluation of efficacy was done by

- FBS levels
- Post-prandial blood glucose levels
- HbA1c levels
- Serum triglycerides
- Serum high-density lipoprotein (HDL).

Evaluation of safety was done by

- Adverse drug events reported
- Number of hypoglycemic events
- Clinical evaluation.

Assessment of glycemic control was done by

1. FBS levels
2. Post-prandial blood glucose levels
3. HbA1c levels.

Statistical analysis

After completing the study, data were analyzed using appropriate statistical methods. Student's t-test was employed for analyzing continuous variables, allowing for comparisons between two groups. Single-factor analysis of variance was utilized to compare multiple groups across different time periods. The study outcomes are reported as percentages, along with corresponding p-values for intergroup comparisons.

RESULTS

In our study, a total of 124 individuals with uncontrolled T2DM were treated with conventional therapy; 62 of these patients received teneligliptin treatment, whereas another 62 received HCQ treatment.

Table 1 and Fig. 1 display the demographic information together with the blood test results for two patient groups: One using teneligliptin and the other taking HCQ. The mean, standard deviation, and p-value for each test are shown in the table.

Table 1 and Fig. 1 display the age distributions of the individuals in each group. Teneligliptin patients had an average age of 39.8 years and a standard deviation of 5.96. Members of the HCQ group had an average age of 38.12 years and a standard deviation of 6.67. A p=0.141 indicates that the age distributions of the two groups are not significantly different from one another.

Those in each group's body mass index (BMI) were shown in Table 1 and Fig. 1. Patients using teneligliptin had a mean BMI of 22.90 kg/m^2 and a standard deviation of 1.8 kg/m^2. Individuals in the HCQ group had a mean BMI of 25.29 kg/m^2 and a standard deviation of 3.2 kg/m^2. A statistically significant difference in BMI exists between the two groups since the $p<0.0001$.

There is no statistically significant difference between the separate groups using teneligliptin and HCQ in terms of HbA1C and Hb levels in the blood which is shown in Table 1 and Fig. 1.

Each group' FBS levels are shown in the third row in Table 1 and Fig. 2. Teneligliptin patients had an average FBS of 196.54 mg/dL and a

Table 1: Patient characteristics at the beginning of the study

Characteristic	Teneligliptin group (n=62)	HCQ group (n=62)	p-value
Age (years)	39.8±5.96	38.12±6.67	0.141
BMI (kg/m^2)	22.90±1.82	25.29±3.25*	<0.0001
FBS (mg/dL)	196.54±20.38	193.30±21.50	0.390
PPG (mg/dL)	225.20±14.38	222.74±14.81	0.349
HbA1c (%)	9.30±1.71	8.87±1.58	0.148
Hb (g/dL)	10.54±1.12	10.45±1.14	0.658
TLC (/cmm)	7150.45±1101.02	7083.74±944.22	0.717
Monocytes (%)	4.33±1.05	4.64±1.18	0.124
Eosinophils (%)	3.48±0.50	3.41±0.49	0.432
Lymphocytes (%)	30.17±1.86	30.62±1.90	0.185
Platelets count (×109/l)	328.32±19.16	303.93±21.98*	<0.0001
S. Bilirubin (mg/dL)	0.38±0.12	0.30±0.12*	0.0003
SGOT (U/L)	24.93±2.86	22.54±1.69*	<0.0001
SGPT (U/L)	24.51±3.16	24.79±3.45	0.638
S. Albumin (g/dL)	3.85±0.76	3.98±0.81	0.358
Alk_Phosp (IU/L)	180.95±12.31	179.72±11.69	0.569
B.urea (mg/dL)	17.96±1.49	17.77±1.49	0.479
S. Creatinine (mg/dL)	0.79±0.45	0.81±0.26	0.762

HCQ: Hydroxychloroquine, BMI: body mass index, FBS: Fasting blood sugar, PPG: Post-prandial glucose, HbA1c: Glycated hemoglobin, Hb: Hemoglobin, TLC: total leukocyte count, SGOT: Serum glutamic oxaloacetic transaminase, SGPT: Serum glutamate pyruvate transaminase

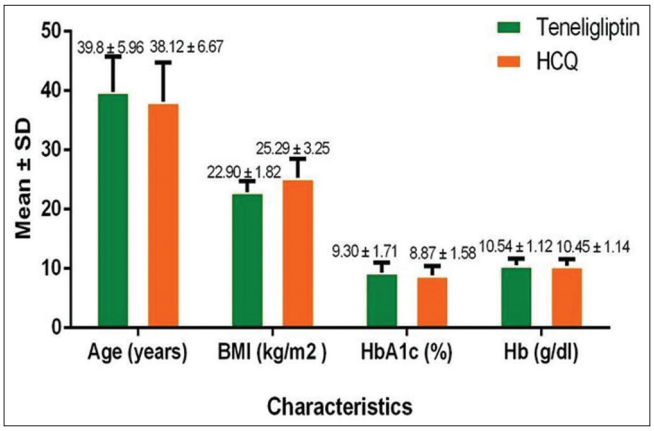

Fig. 1: Patient characteristics at the beginning of the study based on age, body mass index, glycated hemoglobin, and hemoglobin

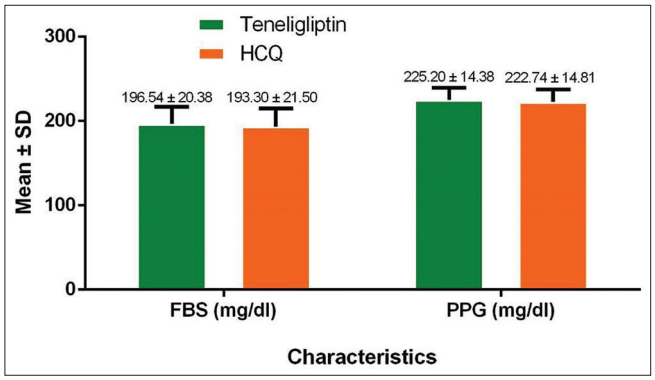

Fig. 2: Patient characteristics at the beginning of the study based on fasting blood sugar, post-prandial glucose

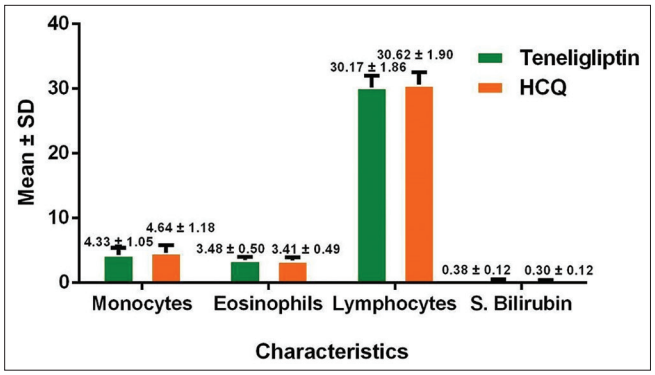

Fig. 3: Patient characteristics at the beginning of the study based on monocytes, eosinophils, lymphocytes, and serum bilirubin

standard deviation of 20.38 mg/dL. Individuals in the HCQ group had an average FBS of 193.30 mg/dL and a standard deviation of 21.50 mg/dL. Since the p-value is just 0.39, we may rule out any statistical significance between the two groups concerning FBS.

Table 1 and Fig. 3 display the blood test results for each distinct group. In each group, there is no statistically significant variation in the levels of monocytes, eosinophils, lymphocytes, or serum bilirubin.

Fig. 4, Table 1, and Fig. 5 show the results of each group's blood test. Where in the platelet count and serum glutamic oxaloacetic transaminase (SGOT) blood report displayed statistically significant differences with a p<0.0001.

The changes in three important variables are visually presented in Table 2, Figs. 6-8 – FBS, PPG, and HbA1c – in group-1 of 62 participants who received teneligliptin treatment. It tracks these variables at four time points: Baseline, 30 days, 90 days, and 180 days.

Key Findings from the Table: From baseline to 180 days, FBS decreased by 39.48% (p<0.001), PPG decreased by 35.57% (p<0.001), and HbA1c decreased by 31.72% (p<0.001)." The three variables showed continuous and substantial decreases throughout the 180 days. The level of triglyceride decreased by 10.54% and HDL increased by 7.41% from baseline to 180 days (p<0.001).

Table 3, Figs. 9 and 10 outline the changes in three key glucose-related variables within the HCQ group-2 over 180 days: Key Findings: FBS – Exhibited a substantial decrease of 34.94% from baseline to 180 days (p<0.001). PPG – demonstrated a significant reduction of 33.83% over the 180 days (p<0.001). The level of triglyceride decreased by 13.96% and HDL increased by 10.4% from baseline to 180 days (p<0.001). From baseline to 180 days, HbA1c decreased by 14.99% (p<0.001) (Fig. 8).

The following Fig. 11 compares the adverse effect profiles of two groups of patients who took different medications for 180 days. Teneligliptin

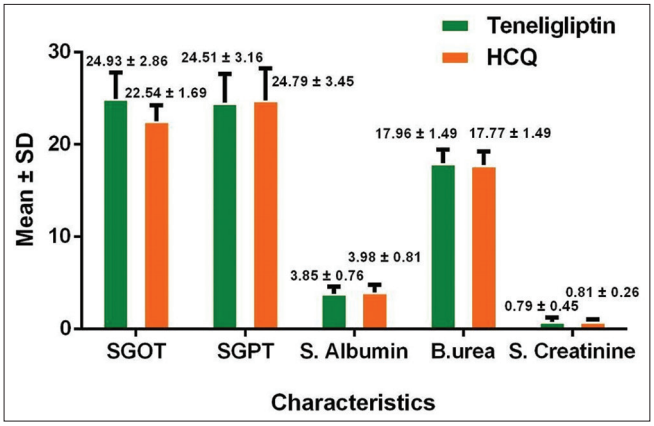

Fig. 4: Patient characteristics at the beginning of the study based on serum glutamic oxaloacetic transaminase, serum glutamate pyruvate transaminase, serum albumin, blood urea, serum creatinine

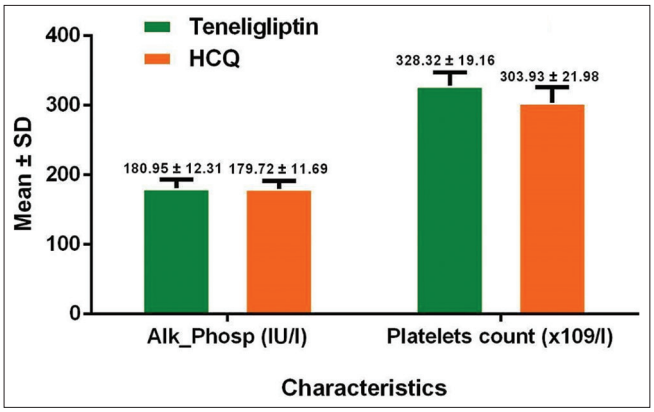

Fig. 5: Patient characteristics at the beginning of the study based on alkaline phosphatase and platelet count

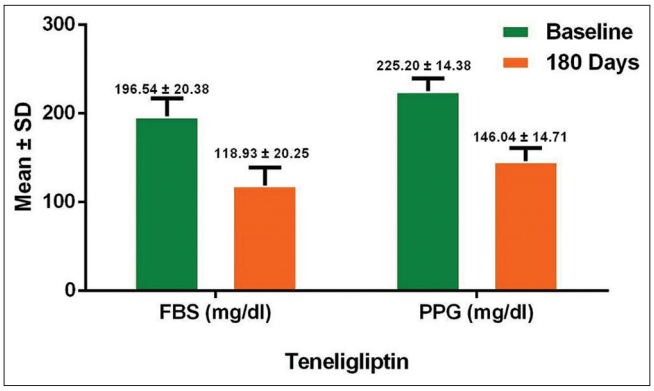

Fig. 6: Changes in variables in the teneligliptin group-1 based on fasting blood sugar, post-prandial glucose

was administered to group-1 whereas HCQ was given to group-2. Percentages of patients in each group who encountered each side effect are shown in the table. Tiredness was the most prevalent side effect in the HCQ group-2, affecting 41.18% of participants. Bloating was the most prevalent side effect in the teneligliptin group-1, affecting 33.33% of participants. An adverse effect, such as headache, occurred in both groups. Overall, the teneligliptin group-1 had a higher percentage of patients who experienced any adverse effect, compared to the HCQ group-2.

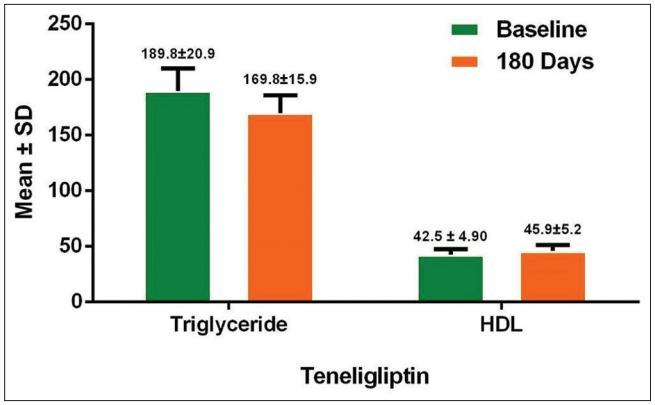

Fig. 7: Changes in variables in the teneligliptin group-1 based on triglyceride, high-density lipoprotein

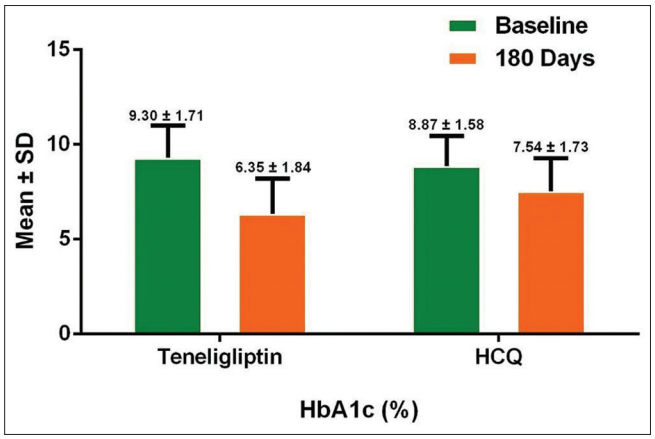

Fig. 8: Changes in variables in the teneligliptin and hydroxychloroquine based on glycated hemoglobin

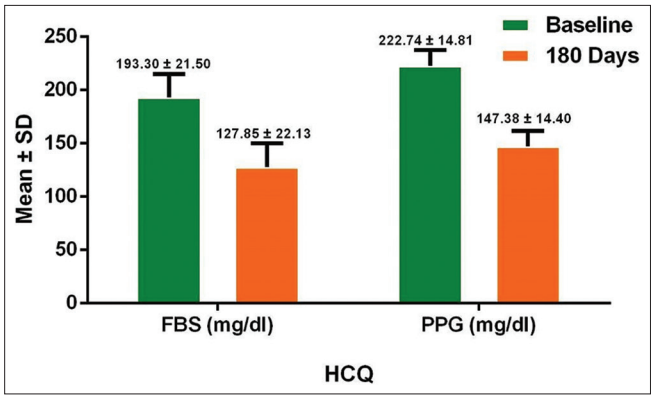

Fig. 9: Changes in variables in the hydroxychloroquine group-2 based on fasting blood sugar, post-prandial glucose

In our study, there were no significant changes observed in the hematological profile, liver function indicators (including serum bilirubin, serum glutamate pyruvate transaminase [SGPT], alkaline phosphatase, and serum albumin), or kidney function indicators (such as blood urea and serum creatinine levels).

DISCUSSION

Microvascular and macrovascular problems are both increased in patients with T2D. There is evidence that systemic inflammation significantly increases the risk of atherosclerosis [13]. Glycemic

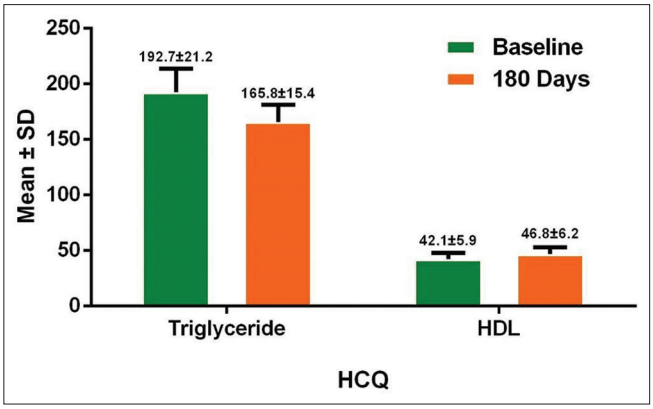

Fig. 10: Changes in variables in the hydroxychloroquine group-2 based on triglyceride, high-density lipoprotein

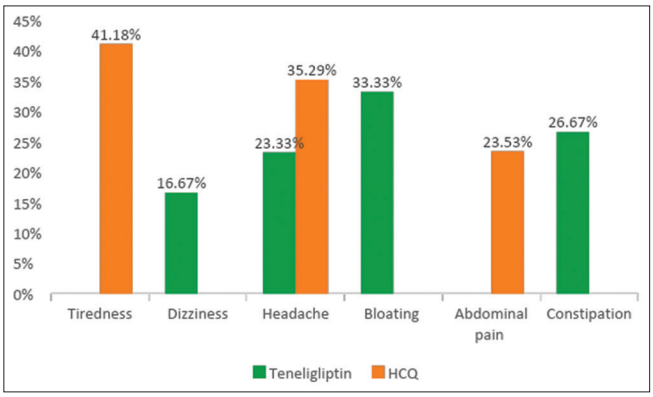

Fig. 11: Comparison of the adverse effect profile of patients in both groups over 180 days of treatment

Table 2: Changes in variables in the teneligliptin group (n=62)

Parameters	Baseline	30 Days	90 Days	180 Days	% Change	p Value
FBS (mg/dl)	196.54 ± 20.38	134.38 ± 20.16$	123.38 ± 20.16$	118.93 ± 20.25$	39.48	< 0.001
PPG (mg/dl)	225.20 ± 14.38	172.74 ± 14.81$	150.74 ± 14.81$	146.04 ± 14.71$	35.57	< 0.001
HbA1c (%)	9.30 ± 1.71	7.30 ± 1.71	6.30 ± 1.71	6.35 ± 1.84	31.72	< 0.001
Triglyceride (mg/dl)	189.8±20.9	181.8±19.7	175.2±21.5	169.8±15.9	10.54	< 0.001
HDL (mg/dl)	42.5 ± 4.90	43.4±5.4	44.5±4.6	45.9±5.2	7.41	< 0.001
ANOVA fallowed by Tukey's multiple comparisons test, Baseline vs 30, 90, 180 Days – $ - Significant at p - < 0.001.						

Table 3: Changes in variables in the HCQ group (n=62)

Parameters	Baseline	30 Days	90 Days	180 Days	% Change	p Value
FBS (mg/dl)	193.30 ± 21.50	143.30 ± 21.50$	132.30 ± 21.50$	127.85 ± 22.13$	34.94	< 0.001
PPG (mg/dl)	222.74 ± 14.81	174.08 ± 14.56$	152. 08 ± 14.56$	147.38 ± 14.40$	33.83	< 0.001
HbA1c (%)	8.87 ± 1.58	7.87 ± 1.58	7.24 ± 1.67	7.54 ± 1.73	14.99	< 0.001
Triglyceride (mg/dl)	192.7±21.2	185.7±19.8	178.5±19.4	165.8±15.4	13.96	< 0.001
HDL (mg/dl)	42.1±5.9	43.9±6.4	45.6±4.6	46.8±6.2	10.4	< 0.001
ANOVA fallowed by Tukey's multiple comparisons test, Baseline vs 30, 90, 180 Days – $ - Significant at p - < 0.001.						

management, defined as keeping HbA1c level around 6–7% to reduce the occurrence of microvascular and macrovascular problems without putting patients at risk of hypoglycemia [14], is the main objective of therapy. It is possible to use insulin, SU, thiazolidinediones (TZDs), gliptins, glucagon-like peptide-1 analogs, or gliflozins as second-line drugs if first-line treatment fails to manage diabetes. However, there are several reasons why these conventional agents may not be used extensively. The slow but steady loss of beta-cell function is unaffected by biguanides and TZDs, which only enhance insulin resistance. TZDs raise the danger of heart failure and fracture, whereas SUs may become less effective over time. Therefore, in alternative treatments in patients with diabetes mellitus, HCQ decreases inflammatory indicators [2,3].

Patients with T2D who are not well controlled for blood sugar levels when taking metformin and SU were the subjects of this research, which aimed to evaluate the safety and effectiveness of adding 400 mg of HCQ once daily (OD) to their treatment regimen. Clinically significant decreases in HbA1C, FBS, and PPG were seen with teneligliptin treatment as compared to HCQ.

Our study reveals a 39.48% decrease in FBS with teneligliptin and 34.94% decrease with HCQ from baseline to 180 days. This suggests that teneligliptin achieved a superior reduction in FBS levels compared to HCQ in our study.

Our study reveals a 35.57% decrease in PPG with teneligliptin and 33.83% decrease with HCQ from baseline to 180 days. This suggests that teneligliptin achieved a superior reduction in PPG levels compared to HCQ in our study.

Our study indicates a 31.72% decrease in HbA1c with teneligliptin and a 14.99% decrease with HCQ from baseline to 180 days. This demonstrates that teneligliptin achieved better glycemic control than HCQ in our study.

Similar findings were seen in a multicentric study conducted by Kumar *et al*. from August 2017 to March 2018. Which compared the efficacy and safety of Teneligliptin (20 mg/day) with HCQ (400 mg/day). Results from 500 individuals showed that after 24 weeks, there were substantial decreases in HbA1c levels (−1.1±0.17%; p=0.000), FBG levels (−29.87±8.9 mg/dL), and PPBG levels (−56.89±9.2 mg/dL). Significantly, after transitioning from teneligliptin to HCQ, 52% of patients reached HbA1c levels below 7%, proving the efficacy of the medication [15].

Our study reveals a 10.54% decrease in triglycerides with teneligliptin and 13.96% decrease with HCQ from baseline to 180 days. This suggests that HCQ achieved a superior reduction in triglyceride levels compared to teneligliptin in our study.

Our study reveals a 7.41% increase in HDL levels with teneligliptin and a 10.4% increase with HCQ from baseline to 180 days. This suggests that HCQ showed better improvement in HDL levels compared to teneligliptin in our study.

A multicentric prospective, parallel-group, randomized study of 6 months was conducted by Baidya *et al.* (from October 2017 to March 2018). In the HCQ group, there was a little decrease in body weight and a slight improvement in lipid markers (p<0.001), but there was no change in serum creatinine level. In this research, the glimepiride group had a much higher incidence of confirmed hypoglycemia than the HCQ group [12].

In our study, we observed no changes in the hematological profile. However, we did find a statistically significant change in platelet count, total leukocyte count, and transaminase levels. There were no changes observed in hepatic profile indicators such as serum bilirubin, SGOT, SGPT, alkaline phosphatase, or serum albumin. Similarly, there were no changes noted in renal profile indicators such as blood urea or serum creatinine levels.

Group-1 (teneligliptin) had a statistically significant improvement in BMI compared to group-2 (HCQ) in this research. In a study by

Chakravarti and Nag, 304 individuals with poorly managed T2DM participated in a trial evaluating HCQ as an adjunct therapy. Participants received HCQ at doses of 200 mg, 300 mg, 400 mg OD, or placebo, alongside their existing treatment of glimepiride and metformin. After 12 weeks, significant reductions in HbA1c levels were observed in the HCQ groups (200 mg, 300 mg, and 400 mg OD), compared to a minimal decrease in the placebo group ($p<0.005$). In addition, each HCQ dosing group showed a decrease in body weight, highlighting a beneficial effect on weight loss in this study [16].

In contrast, Kumar *et al*. found no statistically significant weight loss with HCQ (400 mg/day) and teneligliptin (20 mg/day) during 12 weeks in an observational trial done at 2 diabetes centers in Patna City [17]. There was also no discernible change in BMI after 6 months of therapy with HCQ (400 mg/day), according to another multicenter trial carried out in India by Baidya *et al*. [12].

Hypoglycemia was not observed with either HCQ or teneligliptin during the study. On analysis of adverse effects in our study, both the groups had comparable safety profiles. None of the groups had shown any serious/unexpected adverse effects or the need to discontinue the treatment.

The primary goal of this research was to assess the safety and effectiveness of two recently authorized medications for T2D in Indian patients. Compared to HCQ, the results showed that teneligliptin can provide better glycemic control.

Strength of the study

The study's primary strength lies in its specific focus on a well-defined population of patients with uncontrolled T2DM who are already undergoing treatment with metformin and glimepiride.

This precise targeting enables an accurate assessment of the efficacy and safety of the add-on therapies being evaluated. Moreover, by comparing the therapeutic effects of teneligliptin and HCQ, the study contributes valuable comparative insights, potentially informing clinical decision-making processes.

The investigation's clinical relevance is underscored by its focus on addressing a significant medical challenge: Enhancing glycemic control in T2DM patients insufficiently managed by existing standard therapies. Successful outcomes from this research could introduce new therapeutic options, thereby potentially improving health outcomes for patients experiencing difficulties in maintaining optimal blood glucose levels.

In addition, the study's robust methodological approach, which presumably includes comprehensive monitoring of blood glucose levels, HbA1c, and other pertinent biomarkers, is expected to yield detailed and reliable data on the interventions' effectiveness.

CONCLUSION

Regardless of the patient's initial HbA1c level, the results show that teneligliptin and HCQ therapies significantly improve a number of metabolic markers. It is worth mentioning that teneligliptin medication seems to have better results than HCQ in lowering FBS, PPG, and HbA1c levels. HCQ showed improvements in triglyceride levels and HDL increase during the study period.

These findings hold significant implications for clinical practice, suggesting that teneligliptin could be a preferred choice for managing glycemic control and associated metabolic disorders, especially among patients with elevated HbA1c levels. The study underscores the potential of teneligliptin to effectively lower FBS, PPG, and HbA1c levels. Importantly, our study highlights that HCQ, although showing improvements in triglyceride levels and HDL increase, may not be as effective as teneligliptin in achieving comprehensive metabolic control. Health-care providers should consider these efficacy differences when tailoring treatment plans for patients with diabetes or metabolic syndrome. The relative safety profiles of these medications also warrant attention, suggesting the need for further research and long-term trials to confirm and clarify their benefits and risks across diverse patient populations. Continued investigation will be crucial in refining therapeutic strategies and optimizing outcomes in the management of diabetes and related metabolic conditions.

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CONFLICT OF INTEREST

None declared.

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