ICare^{TM} Tonometry: Reliability and Validity in Diabetic Patients

Purpose

Reliability and validity of ICare^{TM} tonometer was evaluated for its accuracy on IOP measurements in diabetic patients and controls. Central and peripheral corneal pressures, within and between groups were compared.

Methods

This is a prospective study conducted from March 2015 to June 2015 in a tertiary hospital. Group 1 included central and peripheral IOP measurements in diabetics, Group 2 included central and peripheral IOP measurements in controls, Group 3 composed of central IOP measurements in diabetics and controls, and Group 4 was peripheral IOP measurements in diabetics and controls. Statistical analysis was performed by MedCalc software.

Results

Sixty eyes of 60 participants constituting 30 diabetics and 30 controls were recruited. Mean age in diabetics and controls was 52.63 (+/- 11.87) and 41.7 (+/- 16.53) years. Male to female ratio was 18 (60%) and 12 (40%) in diabetic group while 12 (40%) and 18 (60%) in control group. Mean central and peripheral IOP in diabetics was 15.20 (+/- 3.15) and 14.10 (+/- 3.95) mm of Hg. Mean central and peripheral IOP In controls was 13.97 (+/-2.70) and 13.73 (+/- 3.16) mm of Hg. Pearson coefficient (r) of -0.28, -0.19, 0.12 and 0.22 was found respectively for groups. Paired sample t test showed t values of 1.74, 0.45, -1.06 and -0.28 obtained respectively. Statistical significance was considered when p <0.05. Reliability of ICare^{TM} tonometer was performed by calculating Cronbach's alpha and intraclass correlation coefficient. Calculated Cronbach's alpha was 0.44, 0.32, 0.22 and 0.37 respectively. Intraclass correlation coefficient of -0.27, -0.19, 0.12 and 0.22 as single measures were found respectively. ICare^{TM} tonometer validity was determined by ROC curve and accuracy was calculated by AUC difference that revealed 0.23, 0.06, 0.14 and 0.35 respectively. Limits of agreement were evaluated by Bland-Altman difference plots.

Conclusion: ICare^{TM} tonometry reliably measured ocular pressures in all groups with

comparable values. Diabetic central pressures were negatively correlated with controls. Central and peripheral pressures showed slightly higher values in diabetics compared to controls.

1. INTRODUCTION

Diabetes mellitus is considered as a risk factor for glaucoma therefore it is essential to identify and diagnose in its early stages by intraocular pressure (IOP) measurements.[1] Goldmann applanation tonometer provides accurate pressure values however its use is restricted in some circumstances due to patient incompatibility and postural abnormalities.[2]

Newly introduced ICare™ tonometer (Finland Oy, Espoo, Finland) is popular for its rapidity and ease of acquaintance of intraocular pressure (IOP) values in unanesthetized corneas. It is used not only to diagnose and follow up glaucoma patients but also used as domiciliary tonometer. When tested against Goldmann applanation tonometer (GAT) in normal 42 healthy subjects it yielded small statistical insignificant positive bias.[3] IOP readings obtained by ICare™ tonometer in 178 primary open angle glaucoma patients were comparable to GAT values.[4] Previous study of ICare™ tonometer in assessing influence of measuring position of probe in 40 normal subjects showed good correlation between central and peripheral pressures.[5]

The present study investigated reliability and validity of ICare™ tonometer in diabetic patients and normal subjects in addition to evaluation of central and peripheral corneal pressures.

2. MATERIALS AND METHODS

This was a prospective and comparative study on intraocular pressure measurements recorded by ICare™ tonometer (Figure 1) in thirty diabetic and thirty non-diabetic participants. Patients attending outpatient ophthalmology department with known history of diabetes mellitus were recruited along with normal subjects. Verbal consent was obtained from study subjects as ICare™ tonometry is noninvasive method after giving instructions regarding measurement procedure.

2

Figure 1 Showing measurement of peripheral corneal rebound properties by ICare[TM] tonometer

Corneal pathological lesions, previous ocular inflammations and surgeries, and diabetic retinopathy changes were excluded that might interfere with pressure measurements. Primary open angle glaucoma was excluded from current study as this investigation focuses on evaluating central and peripheral IOP in diabetics and controls. Suspicion regarding IOP rise in diabetics facilitates early glaucoma diagnosis because diabetes mellitus is a risk factor for glaucoma development in addition to slightly pachymetric increase in corneal thickness probably due to diabetic status leading to falsely high readings which has to be confirmed by phasing and visual field recordings.

This paper evaluates central and peripheral corneal pressure measurements by ICare[TM] tonometer so that a normative data of intraocular pressures shall be deduced between normal subjects and diabetic patients. Reasons for conducting this study on diabetic patients are to find out existence of pressure variation in diabetics compared to controls as glaucoma incidence is more common in diabetics than in normal population. Another reason is to draw conclusion regarding whether actual measured IOP is normal to diabetic patients as IOP ranges from 9 mm to 21 mm of Hg. Furthermore IOP was compared with normal subjects to study existence of differences or similarities within and between groups.

IOP was measured by consultants and research scholars who were trained in ICare[TM] tonometry. With the device held perpendicularly, care was taken to click the ICare[TM] when the probe was at central cornea and just within temporal/nasal limbus for measuring central and peripheral corneal pressures respectively. [6] Reasons for testing central versus peripheral IOP is that central and peripheral pressure varies greatly as the corneal thickness gradually increases towards its periphery.

64 Accurate (when ICare^TM displays without hyphen and non flickering P on display screen) central and
65 peripheral IOP measurements were recorded. Single beep is associated with pressure recording where
66 as dual beep indicated errata and prolonged brief beep means end of the final measurements. ICare^TM
67 automatically records average of five readings and sixth reading will be the average value. A statistical
68 analysis was performed by MedCalc software. Although efficacy and reliability of rebound tonometer is
69 extensively studied to the best of authors' knowledge there are no articles on reliability and validity of
70 ICare^TM tonometer investigated in diabetic patients in addition to comparison of central and peripheral
71 corneal pressures.

72

73 Specificity of a test or device is the ability to correctly identify true negatives that is, those without disease
74 and sensitivity of a test or device is the ability to correctly diagnose true positives that is, those with
75 disease. Receiver operating characteristic (ROC) curve analysis helps in calculating specificity and
76 sensitivity rate of a test or device through calculations of area under the curve (AUC) that provides test
77 accuracy which ranges from 0 to 1. AUC of 1 implies perfect 100% accuracy and 0.6 onwards it is graded
78 as fair, good, excellent and high accuracy.

79

80 ## 3. RESULTS

81
82 Total of 60 eyes of sixty participants consisting of 30 known diabetic patients and 30 normal subjects
83 were studied. Uniocular pressure measurements were considered for convenience of statistical analysis.
84 Mean age in diabetic group was 52.63 years (+/- 11.87) ranging from 30-75 years with 18 males (60%)
85 and 12 (40%) females. Mean age in control group was 41.7 years (+/- 16.53) ranging from 18-70 years
86 with 12 (40%) males and 18 (60%) females. Statistical significance was considered when p value was at
87 or less than 0.05.

88

89 Mean central and peripheral corneal pressure in diabetic group was 15.20 (+/- 3.15) and 14.10 (+/- 3.95)
90 mm of Hg. Mean central and peripheral corneal pressure in controls was 13.97 (+/- 2.70) and 13.73 (+/-
91 3.16) mm of Hg as shown in Table 1. Mean difference (MD), standard error of the Mean, Pearson
92 correlation coefficient (r), confident intervals at 95%, t values, degree of freedom (DF), and p values in
93 diabetic and controls is shown in Table 2.

94

95 Cronbach's alpha was calculated as it is an index and measure of reliability of internal consistency of
96 close relatedness of recorded pressures shown in Table 3.[5] Intraclass correlation coefficient (ICC) was
97 calculated as it is a measure of reliability of pressure measurements shown in Table 4 and graphically
98 represented in Figures 2, 3, 7 and 8.[6]

99

100 ROC curve analysis was performed as it is a fundamental tool for determining validity in terms of its
101 diagnostic test ability to discriminate diseased cases from normal cases through sensitivity and specificity

4

102 rates. The area under the ROC curve (AUC) was calculated to find out accuracy of how well a given
103 pressures could be distinguished between diabetic and control groups. AUC with sensitivity and
104 specificity rates, AUC difference, z values and *p* values are shown in Table 5 and 6. ROC curves are
105 shown in Figures 4, 5, 9 and 10.

106

107 Validity of ICare[TM] was analyzed by Bland Altman plots (1986 and 1999) or difference plots to compare
108 two measurement techniques in terms of limits of agreement (LoA). In this graphical method, difference
109 between two measurement techniques are plotted against the average of two methods shown in Figures
110 6a, 6b, 11a and 11b. Horizontal lines are drawn at mean difference and limit of agreement, which are
111 defined as mean difference +/- 1.96 times the standard deviation of the difference. [7-9]

112

113 **Z-score** was calculated that indicated how many standard deviations of pressure varied from the mean
114 pressure. A 'z' score which is greater than zero represents pressure greater than mean pressure. A **z**-
115 score equal to 0 represents pressures equal to mean pressures. A **z**-score equal to 1 represents pressure
116 that is 1 standard deviation greater than mean pressure; a **z**-score equal to 2 means 2 standard
117 deviations of pressures greater than mean pressures.

118

119 **DISCUSSION**

120

121 This study investigated intraocular pressure measurements recorded by ICare[TM] tonometer for its
122 reliability and validity in 30 diabetic patients and 30 normal subjects in addition to evaluation of central
123 and peripheral corneal pressures. Statistical analysis was performed within and between groups. IOP
124 measurements were normally distributed according to Gaussian standard curve.

125

126 Mean age in diabetic group was 52.63 (+/- 11.87) years (range 30 -75) and mean age in control group
127 was 41.7 (+/- 16.53) years (range 18-70) in contrast to the previous study that showed mean age of 45.9
128 (+/- 19.8) years ranging from 18-85 years.[10] Another study reported mean age of 21.5 years (+/- 3.2) that
129 included 42 normal study subjects and reported limits of agreement of +/- 5.11 mm Hg. [1]

130

131 Yamshita et al study showed a least bias for peripheral corneal pressures than central corneal pressures
132 however ICare[TM] temporal pressures values were closest to Goldman applanation values in 102 normal
133 eyes. Muttuvelu et al reported significant greater reading of central corneal pressures with peripheral
134 corneal pressure in 40 normal subjects similar to the present study's results. [11]

135

136 **Within group analysis**

137

Evaluation of central and peripheral corneal pressures in diabetics (Group 1) and controls (group 2) were statistically first analyzed followed by reliability and validity assessment of ICare[TM] tonometric pressure measurements.

Descriptive statistical analysis in diabetic group showed a slight increment in the central pressure compared to peripheral pressure (p 0.35, p 0.005) probably to glycosylated hemoglobin levels and hyperglycemic status and which have been correlated with higher IOP levels.[12] Central and peripheral IOP did not deviate substantially in control group as calculated mean pressures were similar (p 0.04, p 0.03) (Table 1)

Table 1 showing descriptive statistics of pressures in DM and CT

N=60	Mean	SD	SEM	95% CI for mean	P value
Group 1	15.20	+/- 3.15	0.57	14.03 to 16.37	0.35
Group 2	14.10	+/- 3.95	0.72	12.63 to 15.58	0.005
Group 3	13.97	+/- 2.70	0.49	12.96 to14.97	0.04
Group 4	13.73	+/- 3.16	0.58	12.55 to 14.91	0.03

cIOP: central intraocular pressure; pIOP: peripheral intraocular pressure

Mean pressures reported in this present study were similar in contrast to Muttuvelu et al study that showed greater significant central ICare[TM] corneal pressures than peripheral corneal pressures in normal subjects probably as cornea gradually thickens towards periphery therefore higher pressures are likely to be expected.

In group 1 and 2, central and peripheral IOP showed inverse relation as the Pearson correlation coefficient was -0.28 and -0.19 with poor correlation (p 0.30, p 0.78). (Table 2)

Table 2 showing paired sample t test within and in between groups

N=60	MD	SE of MD	r	95% CI	T value	DF	P value
Group 1	-1.10	1.04	-0.28	-3.23 to 1.03	-1.06	29	0.30
Group 2	0.23	0.83	-0.19	-1.92 to 1.46	-0.28	29	0.78
Group 3	1.23	0.71	0.12	-2.68 to 0.23	1.74	29	0.09
Group 4	0.37	0.82	0.22	-2.04 to 1.31	0.45	29	0.66

Alpha coefficient ranges in value from 0 to 1 and may be used to describe the reliability of pressures. Higher the score, more reliable the generated scale is. Accepted and reported Cronbach's alpha which is an index of reliability of 0.7 however low values of 0.44 and 0.32 were calculated in the present study respectively in group 1 and 2. (Table 3)

165   Table 3 Internal consistency measurement of relatedness within and in between groups

N=60	Group 1	Group 2	Group 3	Group 4
Cronbach's alpha	0.44	0.32	0.22	0.37
95% lower confidence limit	-0.05	-0.27	-0.45	-0.18

166

167   The Rankin paper discussed intraclass correlation coefficient (ICC) for a reliability assessment using
168   average and single measurements. Intraclass correlation coefficient provides a scalar measure of
169   agreement or concordance between groups. Value 1 represents perfect agreement and 0 as no
170   agreement at al. Group 1 showed strong agreement when average measurement of -0.75 was
171   considered compared to group 2 where ICC for average measurement showed fair agreement by -0.45. [13]
172   (Table 4)
173   Table 4 showing intraclass correlation coefficient within and in between groups

N=60	ICC Single measures	95% confidence interval	ICC Average measures	95% confidence interval
Group 1	-0.27	-0.57 to 0.09	-0.75	-2.67 to 0.17
Group 2	-0.19	-0.51 to 0.18	-0.45	-2.14 to 0.31
Group 3	0.12	-0.24 to 0.46	0.22	-0.65 to -.063
Group 4	0.22	-0.15 to 0.53	0.36	-0.35 to 0.69

174

175   Figure 2 shows box and whiskers plots that revealed increased width of the box for central corneal
176   pressures than peripheral corneal pressures and also revealed increased range of values for peripheral
177   corneal pressures than central corneal pressures in diabetic patients implying acceptable measure of
178   reliability of ICare™ tonometry as for as central pressures were considered. Slight increase in the
179   peripheral corneal pressure noted in group 2 compared to central corneal pressures with a fair agreement
180   of ICare™ tonometry when control pressures were considered. Therefore ICare™ pressures in diabetics
181   showed strong reliability compared to control pressures that showed a fair amount of agreement or
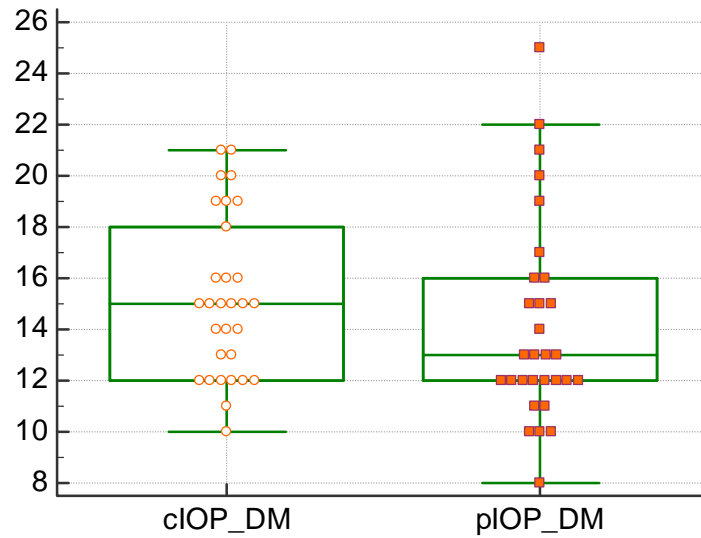182   reliability (Figure 3)

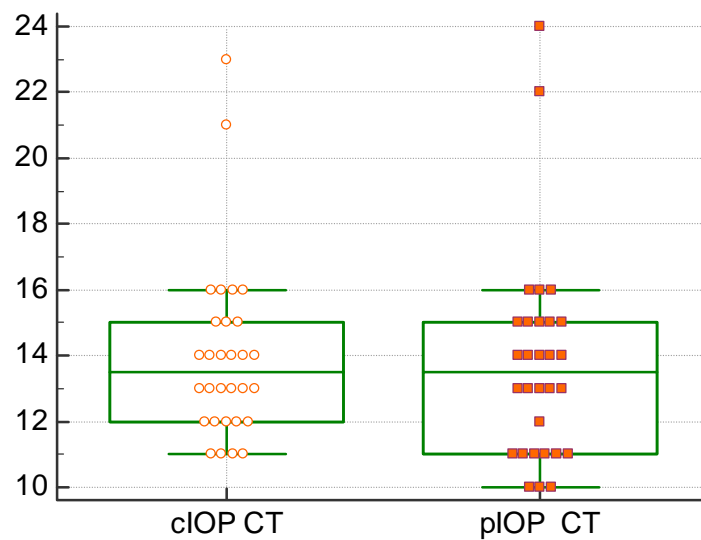Figure 2 Intraclass correlation coefficient of central and peripheral IOP in DM patients

Figure 3 Intraclass correlation coefficient of central and peripheral IOP in CT

ICare[TM] tonometric pressure measurements were validated when ROC curve and area under the curve was calculated separately for pressure values in both groups with hundred percent sensitivity and specificity. (Table 5) ROC curve analysis helps in determining accuracy on certain preset cutoff points hence at a cut off value of IOP at or less than 21 mm of Hg, ICare[TM] tonometric performance in identifying accurately true positives and negatives with statistically significance was validated resulting in perfect values as shown in Table 5.

194 However when ROC curves were compared, pair wise differed in analysis in both groups. AUC

195 differences were narrow for group 1 and 2 (0.23, 0.06) suggesting that ICare[TM] pressures

196 showed a fair amount of validity. Group 1 showed z value of +/- 0.77 mm of Hg of standard

197 deviation between central and peripheral corneal pressures compared to controls that showed a

198 'z' value of 0.13 mm of Hg almost similar measurements between central and peripheral corneal

199 pressures with 0.05 AUC difference. (Table 6)

200   Table 5 showing ROC curve analysis of central and peripheral IOP in DM and CT

N=60	AUC	SE	95% CI	P value	Sensitivity	Specificity
Group 1	1.00	0.00	1.00 to 1.00	<0.0001	100%	100%
Group 2	1.00	0.00	1.00 to 1.00	<0.0001	100%	100%
Group 3	1.00	0.00	1.00 to 1.00	<0.0001	100%	100%
Group 4	1.00	0.00	1.00 to 1.00	<0.0001	100%	100%

201

202   Table 6 showing pair wise comparison of ROC curve analysis of IOP in DM and CT

N=60	AUC difference	SE	95% CI	Z statistics	P value
Group 1	0.23 0.64, 0.86	0.29	-0.34 to 0.80	0.77	0.44
Group 2	0.06 0.67, 0.62	0.43	-0.80 to 0.91	0.13	0.90
Group 3	0.15 0.87, 0.72	0.26	-0.36 to 0.67	0.58	0.56
Group 4	0.35 0.98, 0.64	0.23	-0.09 to 0.79	1.55	0.12

203
204

205 ROC curve for group 1 revealed peripheral corneal pressures curve moving to the left corner of graph

206 compared to central pressures and in group 2 ROC curve plotting showed almost overlap of these curves

207 for central and peripheral corneal pressures suggesting that pressures are equivalent however showed

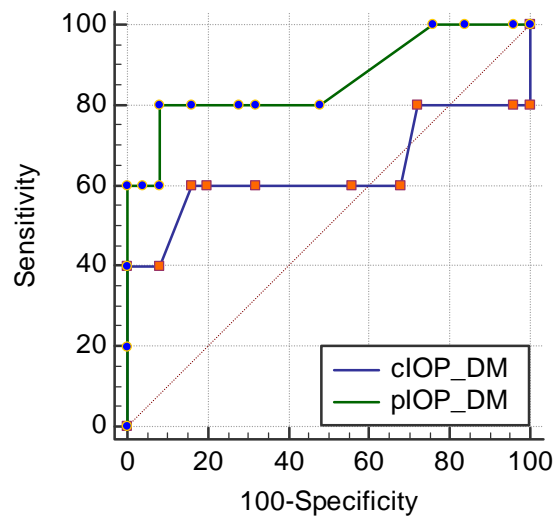208 poor validity for ICare[TM] pressures. (Figure 4 and 5)

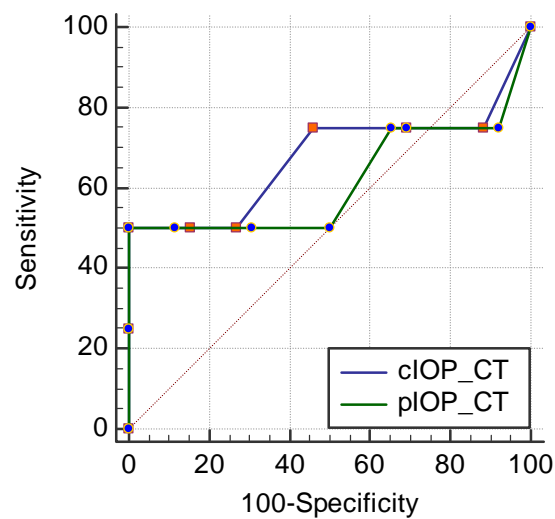Figure 4 Comparison of ROC curves of central and peripheral IOP in DM patients

Figure 5 Comparison of ROC curves of central and peripheral IOP in CT

All the data points fell within 95% limits of agreement (except 1 point outside LoA) of +/- 1.96 standard deviation of bland-Altman difference plots with a positive bias of 1.1 mm of Hg (95% CI of 12.3 to -10.1 mm of Hg) in group 1 suggesting very good agreement of ICare[TM] pressures. (Figure 6a) Similarly for group 2, showed positive bias of 0.2 mm of Hg with 95% confident intervals of 9.1 to -8.6 mm of Hg and all data points (except 2 points) fell within limits of agreement implying good agreement of ICare[TM] tonometric pressures. (Figure 6b)

222
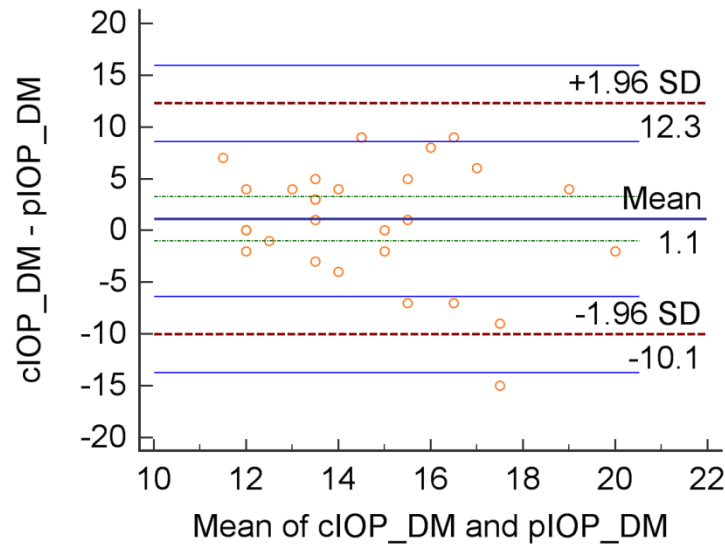
223   Figure 6a Bland Altman analysis of difference plots showing limits of agreement between central and

224   peripheral IOP in DM patients [95% CI: -10.1 to 12.3 (N=60)]

225
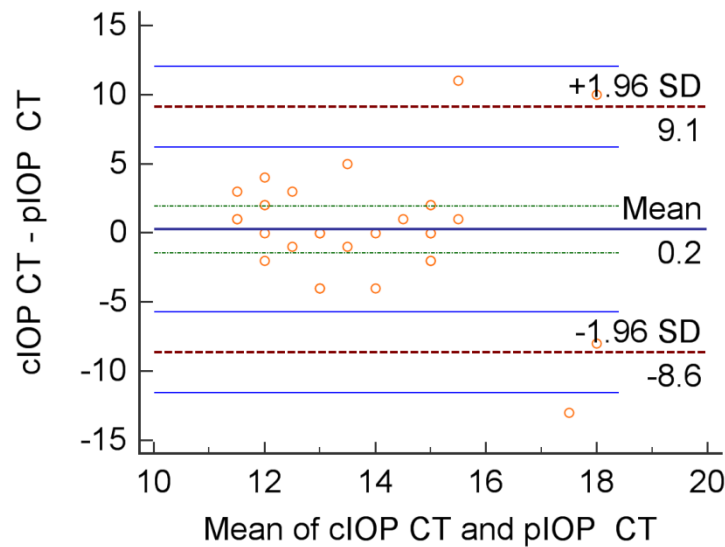
226   Figure 6b Bland Altman difference plots showing limits of agreement between central and peripheral IOP

227   in CT [95% CI: -8.6 to 9.1 (N=60)]

228

Between group analysis

230

231   Central IOP in diabetic and control groups (Group 3) and peripheral IOP (Group 4) were statistically

232   evaluated for their association and correlation. Paired sample t test in group 3 and 4 showed low positive

233   correlation (r 0.12, r 0.22) (Table 2) Pearson's correlation coefficient is an inappropriate measure of

234 reliability because the strength of linear association, and not agreement, is measured (it is possible to
235 have a high degree of correlation when agreement is poor. [13]

236

237 A paired t-test assesses whether there is any evidence that two sets of measurements agree on average.
238 However, it is the difference between within-subjects scores that is of interest (taking the mean score of
239 all subjects has potential to provide misleading estimates).

240

241 Cronbach's alpha which is a tool for assessing reliability found to be not acceptable as the values were
242 0.22 and 0.37 of group 3 and 4 with narrow 95% confident intervals (-0.45 to -0.18). (Table 3) ICC found
243 to be for average measurements were 0.22 and 0.36 that indicated poor acceptability of ICare[TM]
244 pressures in group 3 and 4. (Table 4)

245

246 Intraclass correlation coefficient of central pressures in diabetics spread over a wide range where as
247 narrow range was plotted in box and whisker plots. (Figure 7) When compared of the peripheral IOP in
248 group 4 they seem to correlate however with the median pIOP found to be at the beginning of
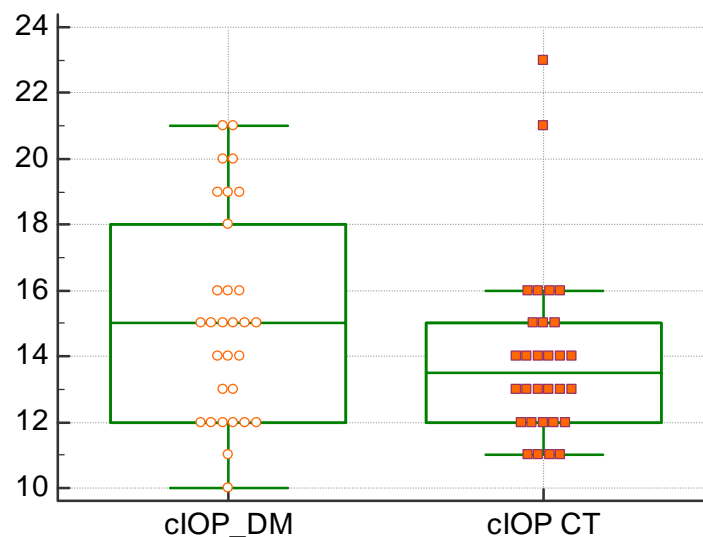249 measurements in diabetic patients compared to controls. (Figure 8)

250
251   Figure 7 Showing intraclass correlation coefficient of central IOP in DM and CT
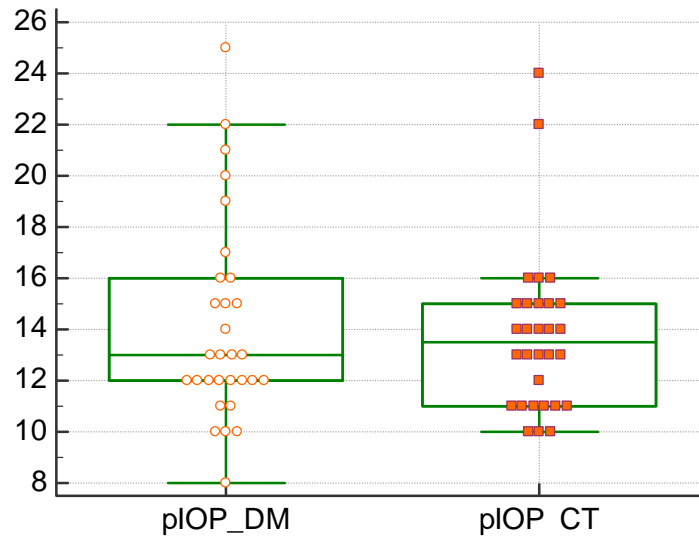
252

Figure 8 Showing intraclass correlation coefficient of peripheral IOP in DM and CT

254

ROC curve analysis showed AUC difference of +/- 1.55 mm Hg and 0.35 in group 3 and 4 with z value of 1.55 mm of Hg standard deviation in group 4. (Table 6) ROC graph revealed curve shift towards the left corner of the graph suggesting acceptable validification of ICare^{TM} pressures at the same time depicting good accuracy of central corneal pressures in controls than central corneal pressures in diabetics. (Figure 9) ROC drawing revealed peripheral IOP curve in diabetics shifting completely to the left corner of the graph indicating high accuracy compared to peripheral corneal pressure curve in controls. (Figure 10)
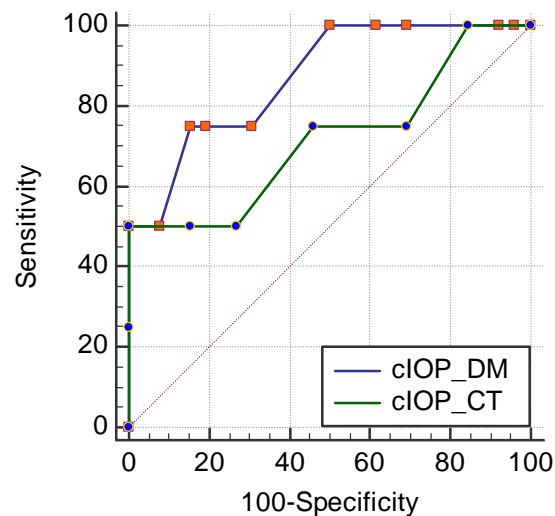

261

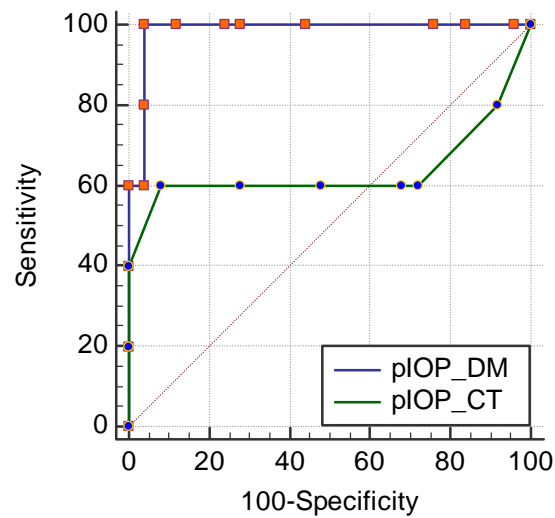Figure 9 Comparison of ROC curves of central IOP in DM and CT

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Figure 10 Comparison of ROC curves of peripheral IOP in DM and CT

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266

267 Acceptable and good Limits of agreements found in group 3 as more than 95% of data points fell within

268 dotted horizontal lines (except one data point) with a mean positive bias of 1.2 mm of Hg. (Figure 11a).

269 Peripheral IOP between diabetics and controls showed good agreement as 95% of data points fell within

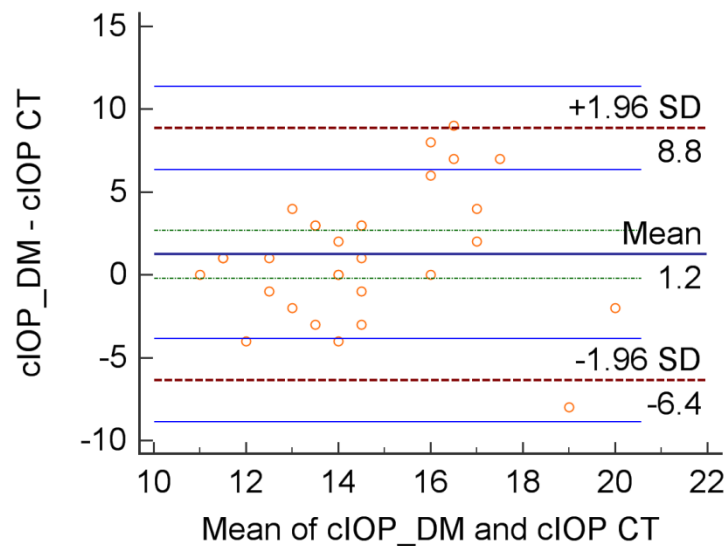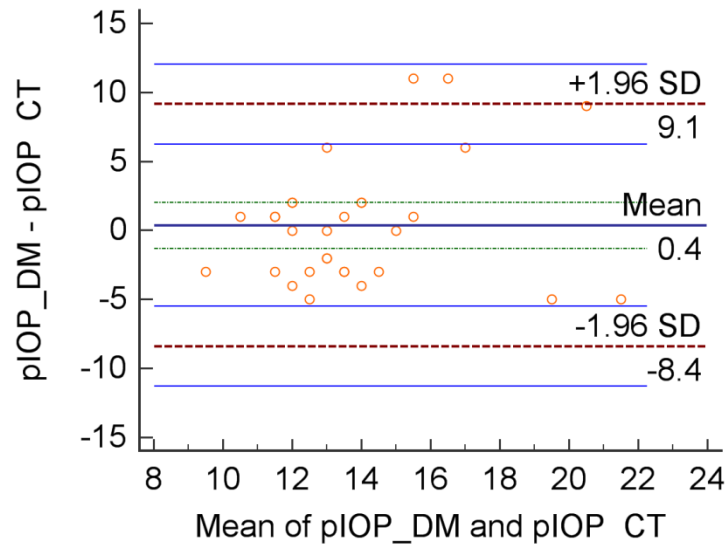270 limits of agreement. (Figure 11b)

271

272 Figure 11a Bland Altman difference plots showing limits of agreement between central IOP in DM and
273 CT [95% CI: -6.4 to 8.8 (N=60)]

274

Figure 11b Bland Altman difference plots showing limits of agreement between peripheral IOP in DM and CT [95% CI: -8.4 to 9.1 (N=60)]

Inverse correlation of central IOP measurements found between control and diabetic group suggesting pressure variation in diabetic patients that is lower pressure in controls is associated with higher pressures in diabetic patients. (r= -0.20) There was no correlation seen with peripheral corneal pressures between groups. Negative t values suggested low mean sample pressures. Negative Z score of -1.49 mm Hg for central pressure suggested raw score less than the mean pressure and 1.49 standard deviations away from the mean in diabetic patients were found. *p* values calculated for both one tail and two tails test were not statistically significant although *p* value for central IOP was near 0.05 (p 0.07). There was no correlation observed with central pressures in both groups. Negative Z score suggested units of standard deviation in which raw score is below mean pressures. (Table 6)

ICare™ Validity Tests

Diagnostic validity of ICare™ pressures was determined by calculating sensitivity and specificity rates, positive and negative predictive values from ROC curve analysis. ICare™ accurately measured pressures in all the groups with hundred percent sensitivity and specificity implying its validification in IOP measurements. (Table 5)

However when pair wise comparative ROC curve analysis was performed within and between groups there seems to be reduction in its accuracy and the results were not significantly different as *p* value was more than 0.05. ICare™ measured very good accuracy (AUC of 0.86) for peripheral corneal pressures in diabetics than central corneal pressures (AUC 0.64) in group 1. ICare™ tonometer measured fair amount

300 of accuracy in controls equally for both central and peripheral corneal pressures (AUC 0.67, AUC 0.62).

301 (Table 6)

302

303 ICare[TM] accuracy improved to very good accuracy (AUC 0.87) for central pressures in diabetics than

304 central pressures of controls (AUC 0.72) in group 3 validating the utility of ICare[TM] tonometer. Surprisingly

305 in group 4 ICare[TM] performance showed excellent almost perfect accuracy (AUC 0.98) in measuring

306 peripheral pressures in diabetics compared to peripheral pressures (AUC 0.64) in controls. (Table 6)

307

308 Two false positive each for central IOP in controls and diabetic patients found with specificity rate of 93

309 percent. Upper limit of 95% confidence interval for positive predictive value was 80% and for negative

310 predictive value was 15 percent.

311

312 Three false positive values found for peripheral IOP measurements in controls. Specificity rate of 95%

313 with upper limits of 95% confident interval for positive predictive value was 69% and for negative

314 predictive value was 09% for peripheral pressures in control group. Six false positive values calculated for

315 peripheral IOP in diabetic patients. Specificity of 89% found with upper limit of 95% confident interval for

316 positive predictive value was 48% and negative predictive value of 9% found. Sensitivity is not calculated

317 as the study sample included only non glaucomatous normal patients.

318

319 In younger subjects of 18-30 years range, higher central ICare[TM] pressures recorded similar to the results

320 of Gonza lez meijome study. Negative correlation found between central and peripheral ICare[TM]

321 pressures in control group in contrast to high correlation revealed from Gonza lez meijome study.

322

323 Klein B E reported higher mean pressures in 2366 diabetic patients than 381 non diabetics and

324 suggested careful IOP recordings in diabetics as there is increased risk of glaucoma occurence.[14]

325

326 Krueger reported statistically significant higher IOP and reveled correlation of insulin resistance states,

327 hyperglycemia and glycosylated hemoglobin levels with higher IOP measurements in diabetic patients.

328 This study in addition to hypothesize that glucose mediated corneal stiffening due to collagen cross

329 linking might be responsible for IOP overestimation in diabetic patients.

330

331 Queiros A revealed mean central IOP of 14.9 (+/- 2.8) mm of Hg and peripheral IOP of 14.1 (+/- 2.5) and

332 14.5 (+/- 2.7) mmHg at nasal and temporal corneal locations respectively that included 153 patients, age

333 ranging from 21 to 85 years with mean age of 55.5 (+// 15.2) years. This study showed higher significant

334 correlation between central and peripheral pressure measurements and reported IOP recorded at nasal

335 cornea reveals slightly lower pressures on average and correlated with central pressures. The study

336 concluded with good agreement between both nasal and temporal readings in correlation to central
337 pressures and recommended acceptable and reliable pressure measurements.

338

339 **Limitations**

340

341 All age groups included in this prospective study may not pin point effect of age factor and IOP increase
342 in diabetics. These findings might be correlated with slightly increased corneal thickness by pachymetry,
343 exclusion of which and small sample size were the limitations of the study.

344

345 **4. CONCLUSION**
346
347 In conclusion, central and peripheral corneal pressures were not associated with statistically significant
348 difference between controls and diabetic group. ICare^{TM} tonometer measurements were comparable,
349 reliable and valid in recording IOP in both the groups. While recording pressures in diabetic patients
350 moderately elevated IOP values are expected as revealed from this study. ICare^{TM} tonometric central
351 corneal pressure measurements yielded 95% specificity rates of identifying true negatives in controls as
352 well diabetics where as peripheral corneal pressure recordings in controls revealed 95% specificity rates
353 and slightly lower specificity rates of 89% of identifying true negatives in diabetic group.

354

355 **5. Conflicts of interest statement:** Authors have no financial or proprietary conflicts of interest

356

357 **Consent Disclaimer:**
358 As per international standard or university standard, patient's written consent has been collected
359 and preserved by the author(s).

360

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