Relation Between GD Ration and Diplopia[1]

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Abstract

Eye movements' restriction problems are always associated by diplopia. Researchers in Ophthalmology made many trials to evaluate such problems. Most of those trials were limited. We have used our developed equipment which is connected to a computer via a dedicated software to carry out both specialised tests: Forced Duction Test (FDT) and Force Generation Test (FGT).

We investigated the performance of our equipment in both normal subjects and patients; this led us to new ratio, called GD ratio, which we define as the percentage of FGT/FDT.

The GD ratio showed a range of mean value of 1.15 for normal subjects, with 95% confidence range between 1.1-1.22. While patients with eye movement restriction showed a drop on this ratio.

A case study was demonstrated to show the coincidence between our findings and other diagnostic tools, but also provide more detailed clinical evaluation for treatment strategy.

We have found out that a new parameter could be used in Ophthalmology to diagnose patients with Diplopia.

[1] For the paper in Arabic see pages (203-204).

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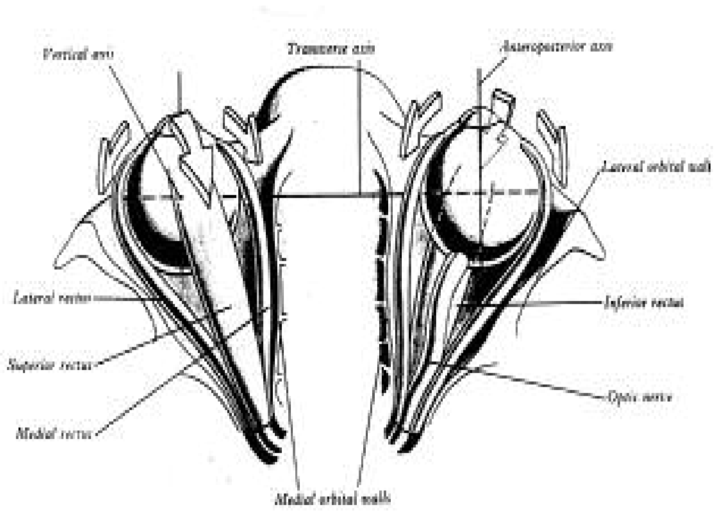
Introduction:

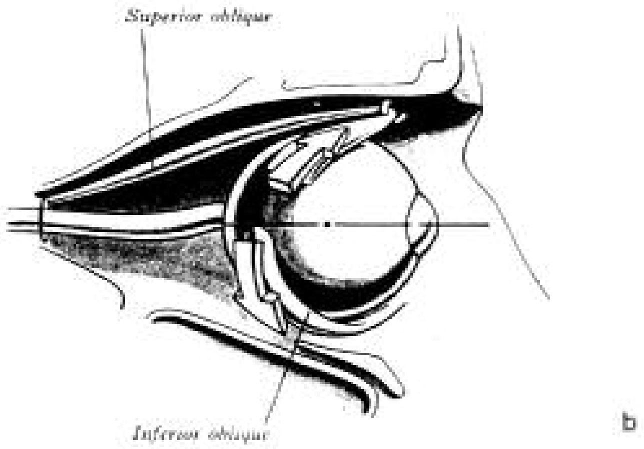
Eye movement is always governed by three sets of extra ocular muscles [1], the horizontal recti (the medial and lateral ones), the vertical recti (Superior and inferior), and the Oblique muscles (Superior and inferior).



Fig(1)- Shows Medial and Lateral Rectus muscles, with Superior and Inferior Rectus.

Usually this movement is a kind of rotation rather than linear displacement.

Horizontal movement is thought to be due to Horizontal recti muscles while vertical one is due to the other two groups of muscles[2], while torsion movement is governed by the Oblique muscles.



Fig(2)- Shows Oblique Muscles.

The muscles have to achieve such a movement usually by overcoming the resistance of the eyeball mass with the viscous surroundings tissues.

The normal case if a subject following a moving target is by saccadic eye movement which reflects the equal innervations delivered to the pair of muscles to both eyes responsible for such a task.

The tests specialized to measure the resistance of the eyeball with its viscous surroundings is Forced Duction Test (FDT), which is by measuring the resistance to passive rotation of the globe while the patient is relaxed and providing neither assistance nor resistance to the forced movement created by the examiner.

While the other test for examining the innervations power of such muscles is the forced generation test which measures the forces created by restraining the tested eye from movement while the contra lateral eye follows a target.

Any problem related to eye movement's restriction is caused either [3]:

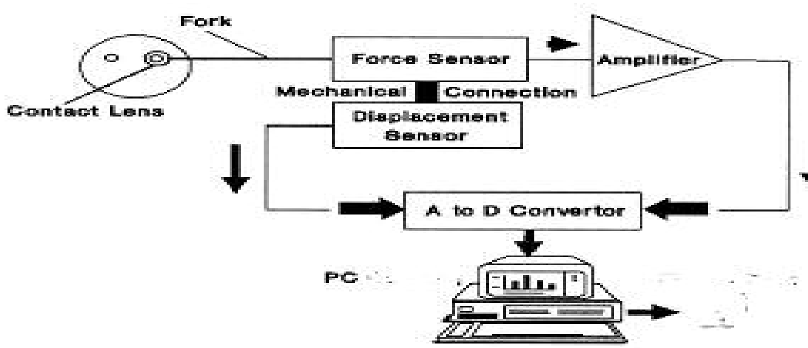
1- Orbital fracture which could cause muscle entrapment..
2- Nerve Palsy.
3- Muscle bruising which could be resolve without any interferences.

Many gadgets were developed to carry out such as test, the most common method was based on grasping the globe close to the corner with a pair of forceps and rotate the eye ball in the required direction, while for force generation test, the tested eye is maintained stationary by forceps while the other eye follows a target. Usually both eyes move in harmony and the force generated by the restrained eye reflects the power of the extraocular muscle for the direction of the gaze tested, in both cases the estimation of the forces generated is entirely subjective and based on the tester's clinical impression.

Load-sensing forceps designed to produce more objective and quantified measurements have been described [4]. The eye is grasped at the limbus using these forceps and pulled in the required direction; the eye displacement is measured using a linear ruler, although a later version incorporated an ultrasonic displacement transducer [5]. A similar device incorporating a self-closing clip at the jaws of the forceps has been developed [6]. Both the load and displacement have been measured by mounting a strain gauged force transducing forceps on a linear track [7]. Later improvement led to a system for manual movement of the eye which incorporated both force and linear displacement transducers. The device was coupled to a suction cup contact lens via a surgical silk suture.

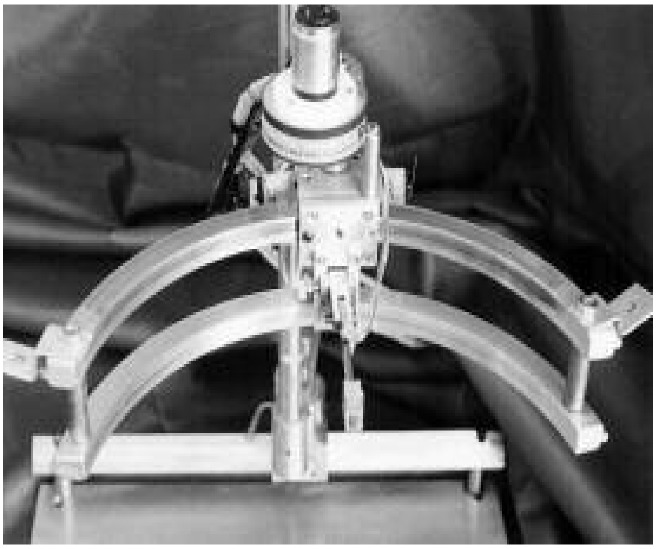
The Developed Equipment:

We have developed a system to carry out such tests the device were composed of:



Fig(3)- The developed System components.

- Force transducer mounted on a carriage traveling along a circular track driven by DC motor.
- The force transducer and potentiometer (driven by the motor) outputs were transferred to an A/D converter and a PC Pentium (3 800 MHz).
-Special software to carry out both tests recording, displaying , retrieving.
- the coupling between the eye ball and the force transducer was done by using a specially designed hard contact lens with a rod [8,9,10], vacuum was applied so the lens would consist one object with eye ball during the test .



Fig(4)- The developed System carriage carrying the force transducer and the potentiometer.

Test Protocol:
Patient bio data is taken and documented on both hard copy and the PC's software.
Following the administration of a local anaesthesia in the eye to be examined, patient is instructed to rest his/her chin on the chinrest of the examination table where equipment is mounted.

After administration a topical anaesthesia (Benoxinate- Minims, Smith and Nephew) into the eye to be tested. The intraocular pressure is measured using a tonometer. Then examiner fits the sterile suction cup contact lens on the eye of the subject then by creating a vacuum (down to 70-80 mmHg) the contact lens consist one object with the examined eye.
The contact len's rod is rested on the force transducer's fork.
To perform FDT subject is instructed neither assist nor resist the movement of the carriage carrying both the Force transducer and the Potentiometer (angle measuring device). The carriage is driven to certain limit while the software mounted on the PC is capturing both the force versus the angle in both ways ascending and descending, the tests is performed three time on sequence, patients hold a button in which he/she can stop the test in case he/she is not happy with the test procedure.
Examiner could watch the results in real time on the computer's screen.
FGT performed while carriage is steady, and patient is instructed to follow a moving target on a screen with his free eye, the results of the forces generated of the restrained eye is plotted against the moving target angle of rotation.
All results and patients bio data are saved in a data file where they can be retrieved for further analysis.
The entire test protocol for both tests on one eye should be completed within ten minutes. After removal of the contact lens, the intraocular pressure is once again measured. Informed consent was obtained from all subjects.

Results:

32 subjects were examined in different age normal from 16 – 65 years, males and females.
The FDT results showed that significant forces are required to rotate the eye even when the muscle being stretched is relaxed, the force required to overcome this passive resistance and move the eyeball is produced by the antagonistic muscle, and its value has been measured at specific rotations of either 30° (superior and inferior rectus) or 35° (lateral and medial rectus) by the FGT.
In the normal subjects the value obtained from the FGT was invariably the eye to the angle used for the FGT. This presumably reflects the ability of the normal eye muscle to produce the eye movement required to maintain binocular vision.

We will define the GD ration which is the ratio of FGT/FDT; normal subjects demonstrated GD ratio mean value of 1.15 with 95% confidence range between 1.1-1.22 [12].

All examined 12 patients with the blow out fracture and 8 cases of dysthyroid groups and the majority of patients with strabismus (10 cases) showed a marked reduction in the GD ratio see table (1).

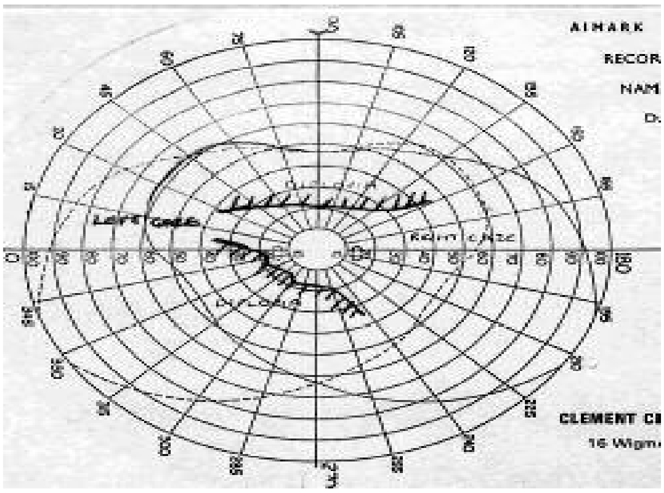
	Mean GD Ratio	**GD Range**
Normal subjects	1.15	1.1 – 1.22
Trauma	0.59	0.47 – 0.79
Palsy	0.31	0.14 – 0.5
Thyroid	0.56	0.45 – 0.72
Strabismus	0.82	0.67 – 1.04

Table (1) FGT/FDT ratio (GD ratio) for the different patients group including normal subjects. The FGT/FDT for the last group represents those patients still suffering from squint and diplopia after surgery.

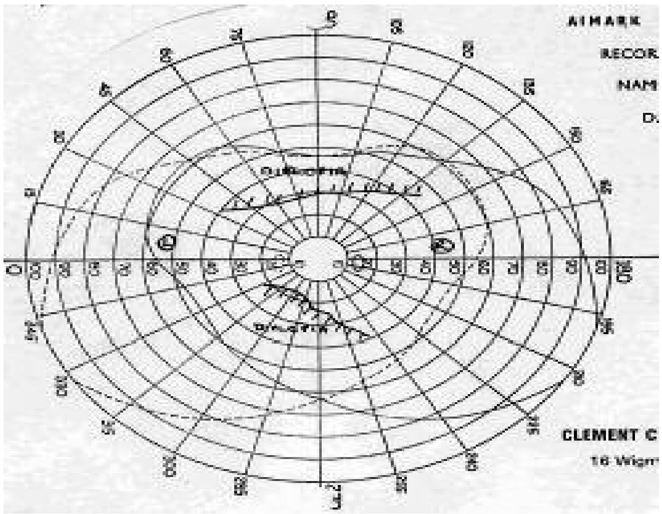
There is functional association between the GD ratio and the occurrence of diplopia, with all patients showing diplopia having a ratio of less than one.

Only limited information was obtained on the extent of diplopia.

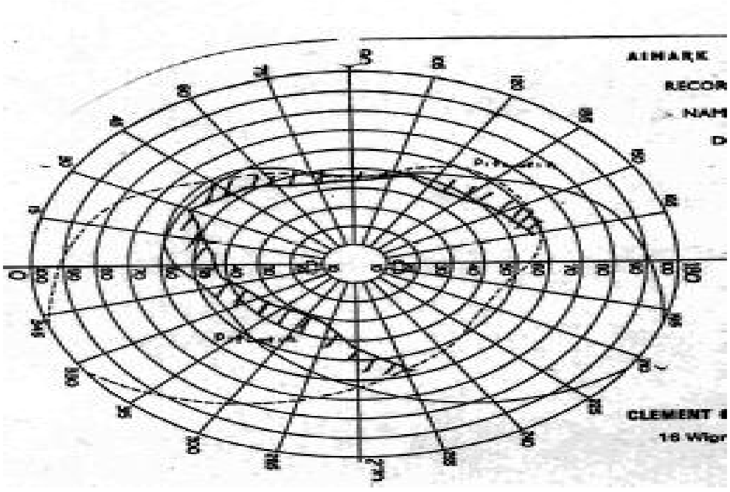
We randomly picked a case for patient 2, who had muscle entrapment which was proven by X-ray, The results of the B.S.V test, were quantified using the method of the Woodruff et al (1987).



Visit A



Visit B

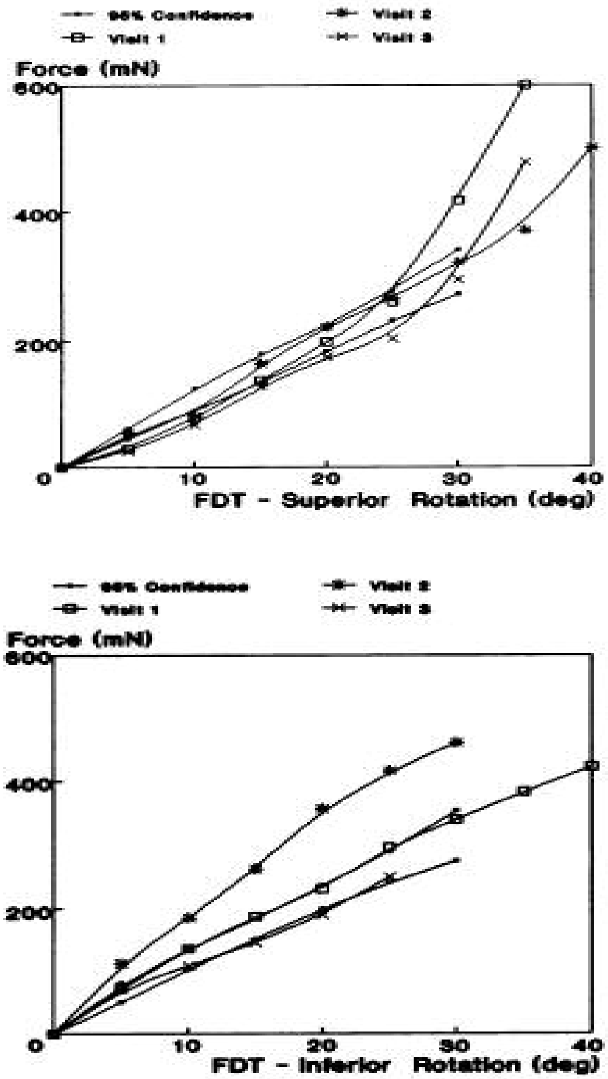


Visit C

Fig(5)- BSV evaluation for the three sequential visit A, B before surgery and C after Surgery

The patient was initially managed conservatively but her fields of binocular single vision fig(5) showed only slight improvement of her field of binocular vision between two visits separated by one week but symptomatic diplopia remained a problem for her.

The FDT was carried out for the affected eye in the superior direction. The forces required to rotate the eye up were significantly higher than the 95% confidence range fig (6) and started rising markedly after 25 of rotation.



Fig(6)- FDT test results for case 2 in both direction Superior and Inferior

The FDT at the superior direction fig(6) at the first visit showed force values falling within the normal 95% confidence range until 25 of rotation .

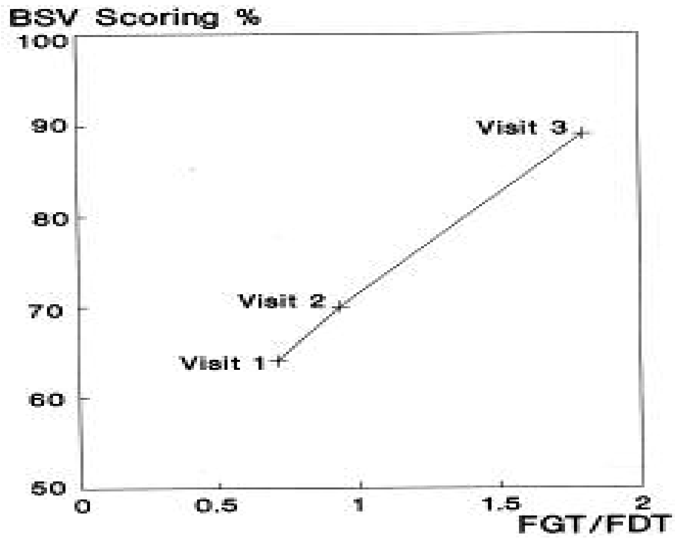
The force then rose to values above the upper normal confidence limit.
At the second visit the forces for the superior direction were within the normal range until 35 and then increased rapidly. The FDT in the inferior direction (second visit) showed forces higher than the 95% confidence limit from the beginning, which suggested buckling of the inferior rectus since muscle were entrapped and swollen after first visit due to oedema. The FGT was normal at 300 mN for both directions.
The results in the superior direction on both visits correspond to the field of binocular single vision in which there was improvement in the field of vision on up gaze. The patient was referred for surgery due to her continuing symptomatology. It is of interest that the increasing force required to depress the eye was not accompanied by any concomitant diminution in the field of B.S.V on down gaze.
Post operatively for the superior FDT showed forces values within the 95% confidence range until 30 of rotation, and higher at 35, while it was within 95% range for the inferior FDT, this coincided with B.S.V. where diplopia was witnessed at the extreme of vertical gaze.
Table(2) lists the results for both FGT and FDT at the same angle (30). It is quite clear that FDT values on both visits were higher than the corresponding FGT values, while the FGT on the Third visit was higher than FDT in both directions especially for the superior one.
The GD ratio (FGT/FDT) results obtained during the 3 sequential visits by the patient are displayed as figure(7), and for this patient there is a strong positive correlation between the two variables (FGT/FDT, BSV Score [13]).

	Forces at 30 deg (mN)			
	Superior		Inferior	
	FGT	FDT	FGT	FDT
1st Visit	300	418	300	339
2nd Visit	300	320	300	461
3rd Visit	540	293	340	290
Normal 95% Confidence limits	248-327	271-341	271-312	275-353

Table (2)- Results of FDT, FGT for case 2 for three visits.

	GD Ratio	
	Superior	Inferior
1st Visit	0.72	0.88
2nd Visit	0.94	0.65
3rd Visit	1.84	1.17

Table (3)- Results of GD ratio for case 2 for three visits.



Fig(7)- GD ratio (FGT/FDT) in the Superior direction in relation To BSV scoring% for case 2

It does appear, however, that unless the FGT is greater than FDT in the antagonist muscle, measured at the same angle, there will be limitation of eye rotation and resulting diplopia.

Discussion and Conclusion:

Although table(1) shows a clear distinction between the different groups in this ratio. But similarity of this ratio between trauma and dysthyroid group could be differentiated by the increase of both FDT and FGT in the

dysthyroid ones. The similarity is related to swallowing of the affected muscles in both cases.
The GD ratio obtained is a good clinical indicative tool for the evaluation of eye problems associated with diplopia. It does describe the sufficiency of the stored power of the innervations required to rotate the eyeball with its muscles and other tissues. When this ratio is equal one or above this means that the eye has an adequate power to be rotated without any problem, the drop in this ration below 1 would means that the stored power is not enough to rotate the eye, which means that double vision is imminent or a must depending on this value.
This is the first time somebody is mentioning such a ratio in the history of the Ophthalmology.

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