ORİJİNAL ARAŞTIRMA ORIGINAL RESEARCH

DOI: 10.5336/ophthal.2022-91508

Effect of Calcium and Phosphorus Metabolism on Static and Dynamic Pupillary Responses: Prospective Cross-Sectional Study

Kalsiyum ve Fosfor Metabolizmasının Statik ve Dinamik Pupil Yanıtları Üzerine Etkisi: Prospektif Kesitsel Araştırma

Tuğçe HOROZOĞLU CERAN[a], Mehmet Ali ŞEKEROĞLU[a], Ali Mert KOÇER[b], Çağatay Emir ÖNDER[c], Şerife Mehlika KUŞKONMAZ[d]

[a]Clinic of Ophthalmology, Ulucanlar Eye Training and Research Hospital, Ankara, Türkiye
[b]Clinic of Ophthalmology, Arnavutköy State Hospital, İstanbul, Türkiye
[c]Clinic of Internal Medicine, Niğde Ömer Halisdemir University Training and Research Hospital, Niğde, Türkiye
[d]Clinic of Endocrinology and Metabolic Diseases, Ankara Training and Research Hospital, Ankara, Türkiye

ABSTRACT Objective: To investigate the effects of serum calcium and phosphorus levels on static and dynamic pupillometry measurements in patients with postoperative hypoparathyroidism. **Material and Methods:** Pupillometry measurements were undertaken by using an automatic pupillometry to detect high photopic, low photopic, mesopic, scotopic pupil diameters with amplitude, latency, duration and velocity of pupil contraction and dilatation. Duration of hypoparathyroidism and serum parathyroid hormone (PTH), calcium and phosphorus levels were recorded. **Results:** This study included 46 female patients with postoperative hypoparathyroidism and 61 healthy female participants. There were no significant differences between the pupil diameters at different light intensities between the study groups (p>0.05 for all). Among the dynamic pupillometric measurements, pupil contraction amplitude was significantly higher in patients with postoperative hypoparathyroidism when compared to that of healthy controls (1.85±0.04 mm vs 1.72±0.03 mm respectively, p=0.018). There was no significant correlation between the duration of hypoparathyroidism, serum calcium, phosphorus, and PTH levels with static and dynamic pupillometry values (p>0.05 for all), with an exception of a positive correlation between the serum calcium level and amplitude of contraction (r=0.322, p=0.029). **Conclusion:** Pupil diameters at different light intensities were not affected in patients with postoperative hypoparathyroidism, but pupil contraction amplitude was higher than in healthy individuals.

Keywords: Calcium; hypoparathyroidism; parathyroid hormone; phosphorus; pupil disorders

ÖZET Amaç: Bu çalışmanın amacı, postoperatif hipoparatiroidili hastalarda serum kalsiyum ve fosfor düzeylerinin statik ve dinamik pupil yanıtları üzerindeki etkilerini değerlendirmektir. **Gereç ve Yöntemler:** Yüksek fotopik, düşük fotopik, mezopik ve skotopik ortamlardaki pupil çapını, pupil kontraksiyonu ve dilatasyonunun amplitüdünü, latansını, süresini ve hızını tespit etmek için otomatik bir kantitatif pupillometri sistemi kullanılarak pupillometri ölçümleri yapıldı. İstatistiksel analiz için hastaların sağ gözlerinden alınan veriler kullanıldı. Hipoparatiroidizm süresi ile serum paratiroid hormon, kalsiyum ve fosfor düzeylerinin bu verilere etkisi araştırıldı. **Bulgular:** Çalışmaya postoperatif hipoparatiroidili 46 kadın hasta ve 61 sağlıklı kadın kontrol grubu dâhil edildi. İki grup arasında farklı ışık yoğunluklarında pupil çapları arasında istatistiksel olarak anlamlı bir farklılık izlenmedi (tümü için p>0,05). Dinamik pupillometrik ölçümlerden olan pupilla kontraksiyon amplitüdü istatistiksel olarak anlamlı olarak postoperatif hipoparatiroidili hastalarda sağlıklı katılımcı grubuna göre yüksek bulundu (sırasıyla 1,85±0,04 mm'ye karşı 1,72±0,03 mm, p=0,018). Hipoparatiroidizm süresi, serum kalsiyum, fosfor ve paratiroid hormon düzeyleri ile statik ve dinamik pupillometri yanıtları arasında istatistiksel olarak anlamlı bir ilişki yoktu (tümü için p>0,05). İstisna olarak serum kalsiyum düzeyi ve kontraksiyon amplitüdü arasında pozitif korelasyon tespit edildi (r=0,322, p=0,029). **Sonuç:** Postoperatif hipoparatiroidili hastalarda farklı ışık şiddetlerinde pupil çaplarında farklılık tespit edilmezken, pupil kontraksiyon amplitüdü sağlıklı bireylere göre daha yüksek bulundu.

Anahtar Kelimeler: Kalsiyum; hipoparatiroidi; paratiroid hormonu; fosfor; pupil bozuklukları

Correspondence: Tuğçe HOROZOĞLU CERAN
Clinic of Ophthalmology, Ulucanlar Eye Training and Research Hospital, Ankara, Türkiye
E-mail: tugcehorozoglu00@gmail.com

Peer review under responsibility of Turkiye Klinikleri Journal of Ophthalmology.

Received: 24 May 2022 ***Received in revised form:*** 13 Jan 2023 ***Accepted:*** 17 Jan 2023 ***Available online:*** 24 Jan 2023

Regulation of plasma calcium levels is necessary for the maintenance of normal function of cells. Parathyroid hormone (PTH) tightly controls the level of serum calcium and phosphorus. Abnormal function or structure of the parathyroid glands can cause imbalance of the serum calcium levels. Main causes of hypocalcemia are insufficient PTH or vitamin D production and PTH resistance.[1] In hypoparathyroidism, serum calcium decreases while serum phosphorus level increases. Hypoparathyroidism often occurs due to damage or excision during thyroidectomy surgery.[2]

A common point of hypocalcemia is increased neuromuscular disturbance such as muscle stiffness.[3,4] An imbalance of serum calcium and phosphorus levels may alter the muscular function. The effects of the disease vary according to the calcium level and the duration of hypoparathyroidism. Although the effect of PTH on bone and kidney functions is well known, it also has effects on other structures (ocular, cardiovascular and neurological). There are studies examining the effects of hypoparathyroidism papilledema development.[5] It has also been reported in publications that hypoparathyroidism causes cataract.[6] But there is no study in the literature about the effect of PTH, calcium and phosphorus status on pupillary contraction. Based on these data, we hypothesized that pupillary muscle functions may be affected by serum calcium and phosphorus levels.

The autonomic nervous system affects all systems, especially the eye. Pupillary sphincter and dilatator muscles are also controlled by this autonomous system. Parasympathetic and sympathetic nerve functions are in balance. Therefore, pupillometry measurements can give us quantitative information about autonomic nervous system functions. In other studies, significant differences were found in pupillometry values in patients with autonomic nervous system disorders.[7] Pupillometry values were also found to differ in Parkinson's patients.[8] The use of pupillometry to evaluate the development of neuropathy in patients with diabetes mellitus was also investigated.[9] It may be possible to predict autonomic nervous system problems by evaluating pupillary muscle functions.

This study aimed to evaluate the effects of serum calcium and phosphorus situations on static and dynamic pupillary responses in cases with postoperative hypoparathyroidism by comparing the data of healthy participants.

MATERIAL AND METHODS

This prospective cross-sectional study was conducted between January 2019 and July 2019. The study protocol (date: February 20, 2020; no: E-19-142) was confirmed by Ankara Training and Research Hospital Clinical Research Ethics Committee. The study was carried out in agreement with the Declaration of Helsinki. The attenders were informed about the study and written informed consent was obtained from everyone.

The patients with surgically induced hypoparathyroidism and who were followed at least 1 year after thyroidectomy surgery were included in the study. The study was carried out in collaboration with the ophthalmology and endocrinology departments. Blood tests and eye examinations were performed within the same day. The patients and control groups in the study were all age-matched female participants, since it is well known that hyperparathyroidism is much more common in women following thyroidectomy surgery. All patients were using elemental calcium, activated vitamin D and levothyroxine. The records of the patients' age, gender, follow-up period, calcium levels, phosphorus levels, PTH levels, surgical procedure and thyroid gland pathology results were obtained from the endocrinology department, where they were followed. The patients who have any other systemic diseases other than hypoparathyroidism were not included in this study. Additionally, all patients had normal serum thyroid-stimulating hormone levels.

After blood tests were performed in the endocrinology department, the patients' eye examinations and automated pupillometry measurements were performed in Ulucanlar Eye Training and Research Hospital. All participants were evaluated with a detailed ophthalmologic examination including slit-lamp biomicroscope, best-corrected visual acuity, intraocular pressure measurement, and fundus ex-

amination. Participants with conditions such as previous history of ocular or orbital surgery, cataract, any ocular disorders, a history of orbital surgery, iris, or pupillary abnormalities (anisocoria, coloboma, anterior/posterior synechia and sphincter rupture) were excluded from the study. Patients who had undergone iris surgery or laser therapy were not included in the study. Also, those who used drugs such as cyclopentolate, tropicamide, brimonidine, apraclonidine, pilocarpine and narcotic-derived drugs and alpha-blockers were barred.

Subjective analysis of pupils which can be affected by many factors such as physician's experience, intensity of light stimulus and room illumination. Repeatable objective measurements of pupils can be done by using automated pupillometric devices, which can perform both static and dynamic measurements under standardized lightning conditions. In this study, an automatic quantitative pupillometry system (MonPack One, France) was used. The device takes measurements with infrared light at a wavelength of 880 nm and imaging is provided by a 940 nm high resolution camera. The accuracy of the measurements is controlled with a precision of 0.1 mm. Measurements were taken from each patient at the same time by the same technician on different days. Automatic pupillometry device takes measurements binocularly. Static data obtained from the device provide information about pupillary diameter, while dynamic data provide information about pupillary movements. The fixation stability was checked during the measurements. Static pupillary measurements are taken in 4 different illuminated environments: Static pupillometry measures were acquired under scotopic, mesopic, low photopic, and high photopic situations (respectively 0.1 cd/m^2, 1 cd/m^2, 10 cd/m^2, 100 cd/m^2). After the dark adaptation for 10 minutes, dynamic measures were attained for 1.5 minutes. The participant was examined using white light flashes with an ON time of 200 milliseconds and an OFF time of 3300 milliseconds. Total luminance of white light flashes was 100 cd/m^2 and total intensity white light flashes were 20 lux. Thirty images per second were acquired from both eyes. Amplitude, latency, duration, and velocity of pupil contraction with latency, duration and velocity of pupil dilatation were recorded. Only the data from right eyes of the participants were included in the study.

STATISTICAL ANALYSIS

SPSS version 23.0 (IBM, New York, USA) was used for statistical analysis. Kolmogorov-Smirnov/Shapiro-Wilk tests were used to check whether the variables were normally distributed. Student's t-test were used in the analysis of the data determined to be parametric. Mann-Whitney U test were used in the analysis of the data determined to be non-parametric. Pearson correlation test was used to detect any correlation. The statistical significance was determined as $p<0.05$.

RESULTS

One hundred and seven female participants were included in the study, 61 were healthy control group with a mean age of 46.0±1.0 (28-72) years and 46 were the ones with postoperative hypoparathyroidism with a mean age of 47.4±1.0 (29-78) years. There was no statistically significant difference in age between the groups (p=0.514). Of the 46 patients, 42 had a history of total thyroidectomy and 4 had a subtotal thyroidectomy with a mean duration of 8 (1-22) years before recruitment for the study. The pathology results of the thyroid tissue samples of all those who had subtotal thyroidectomy was benign; however, of the 42 total thyroidectomy cases, 9 were malignant. The mean serum calcium levels of patients with hypoparathyroidism were 8.95±0.82 (6.91-10.51) mg/dL, the mean serum phosphorus levels were 4.25±0.68 (2.92-5.88) mg/dL. The mean serum PTH levels of patients with hypoparathyroidism were 16.36±8.75 (5-38.90) pg/mL. The mean serum calcium levels of healthy control group were 9.15±0.72 (7.82-10.82) mg/dL, the mean serum phosphorus levels were 4.02±0.64 (2.51-5.02) mg/dL. The mean serum PTH levels of healthy control group were 34.78±7.66 (18.16-59.22) pg/mL.

Static and dynamic pupillometry measurements of the participants are shown in Table 1. There were no significant differences between the pupil diameters at different light intensities among the groups (p>0.05 for all). Among the dynamic pupillometric measurements, amplitude of contraction was signifi-

TABLE 1: Comparison of the static and dynamic pupillometric parameters.

	Hypoparathyroidism (n=46) $\bar{X}$±SD (minimum-maximum)	Control (n=61) $\bar{X}$±SD (minimum-maximum)	p value
High photopic pupil diameter, mm	2.89±0.07 (0.40-3.70)	2.84±0.09 (0.40-4.00)	0.689
Low photopic pupil diameter, mm	3.42±0.07 (2.60-4.80)	3.55±0.06 (2.40-4.40)	0.165
Mesopic pupil diameter, mm	4.65±0.11 (2.90-7.00)	4.63±0.10 (3.40-6.90)	0.902
Scotopic pupil diameter, mm	6.13±0.11 (3.70-7.60)	6.20±0.09 (4.60-8.30)	0.635
Resting diameter, mm	5.46±0.10 (3.60-6.70)	5.43±0.10 (4.20-7.30)	0.876
Amplitude of contraction, mm	1.85±0.04 (1.10-2.30)	1.72±0.03 (1.00-2.20)	0.018
Latency of contraction, ms	277.61±6.77 (110.00-328.00)	258.92±6.51 (128.00-319.00)	0.052
Duration of contraction, ms	605.43±13.19 (213.00-908.00)	594.69±10.06 (424.00-811.00)	0.511
Velocity of contraction, mm/s	5.89±0.11 (4.30-7.30)	5.64±0.10 (3.77-7.98)	0.112
Latency of dilatation, ms	883.04±12.64 (466.00-1063.00)	842.13±15.67 (515.00-1059.00)	0.056
Duration of dilatation, ms	1600.70±12.65 (1437.00-2034.00)	1624.34±10.54 (1303.00-1831.00)	0.153
Velocity of dilatation, mm/s	2.13±0.08 (1.41-3.95)	2.21±0.13 (1.29-7.75)	0.612

SD: Standard deviation; bold values indicate p<0.05

cantly higher in patients with postoperative hypoparathyroidism when compared with that of healthy control group (1.85±0.04 mm vs 1.72±0.03 mm respectively, p=0.018). There were no significant correlations between the duration of hypoparathyroidism, serum phosphorus, calcium and PTH levels with static and dynamic pupillometry responses (p>0.05 for all), except for the serum calcium level and amplitude of contraction which were positively correlated (r=0.322, p=0.029) (Table 2) (Figure 1).

DISCUSSION

To the best of our knowledge, this is the first study investigating the effect of postoperative hypoparathyroidism on static and dynamic pupillary responses. In this pilot study, we aimed to investigate the effects of calcium and phosphorus levels on pupillometric responses of patients with surgically induced hypoparathyroidism. Automated quantitative static and dynamic pupillometry was performed to compare the pupillary responses of the patients with postoperative hypoparathyroidism and healthy controls; and it was also aimed to determine the correlation between pupillometric properties with serum calcium, phosphorus and PTH levels, and the duration of the hypoparathyroidism. Since the autonomic nervous system may be affected by age, attention was paid to ensure that there was no statistically significant age difference between the groups. It was determined that there was no significant difference in pupil diameters between healthy individuals and patients with postoperative hypoparathyroidism at different light intensities. It would be a potential area of research to examine if the static pupillary measurements under different illumination conditions of the patients with severe hypocalcemia during initial diagnosis of hypoparathyroidism are affected or not.

In the treatment of hypoparathyroidism, it is important to prevent soft tissue calcification that the mathematical product of calcium level and phosphate level is below the value determined in the guidelines. In case of imbalance, calcification (calcium and phosphate accumulation) occurs in soft tissues, especially in the basal ganglia.[10] The basal ganglia is a subcortical nucleus that regulates our functions and behavior. It is known that the basal ganglia play a role in the pathophysiology of many movement disorders such as parkinsonism, chorea, ballism and dystonia. Basal ganglia are also responsible for autonomic pathways such as postural reflex and stretch reflex. As a matter of fact, the significant difference in the pupillometry study performed in parkinsonism, which we emphasized above, suggests the relationship between basal ganglia and pupillary muscle functions and therefore the autonomic nervous system.

Among the dynamic pupillometric measurements, pupil contraction amplitude was significantly

TABLE 2: Correlations between the clinical/laboratory findings and static/dynamic pupillometric values of patients with hypoparathyroidism.

	Serum calcium	Serum phosphorus	Serum PTH	Hypoparathyroidism duration
High photopic pupil diameter, mm	r=-0.004	r=0.127	r=-0.107	r=0.021
	p=0.979	p=0.402	p=0.478	p=0.889
Low photopic pupil diameter, mm	r=0.179	r=-0.034	r=0.022	r=-0.233
	p=0.234	p=0.822	p=0.883	p=0.119
Mesopic pupil diameter, mm	r=0.109	r=0.038	r=0.031	r=-0.275
	p=0.47	p=0.802	p=0.839	p=0.064
Scotopic pupil diameter, mm	r=0.134	r=0.089	r=-0.062	r=-0.156
	p=0.375	p=0.554	p=0.684	p=0.301
Resting diameter, mm	r=0.059	r=0.091	r=0.014	r=-0.106
	p=0.698	p=0.546	p=0.927	p=0.484
Amplitude of contraction, mm	r=0.322	r=0.005	r=-0.119	r=-0.140
	p=0.029	p=0.972	p=0.430	p=0.354
Latency of contraction, ms	r=0.087	r=-0.263	r=0.030	r=-0.228
	p=0.567	p=0.078	p=0.845	p=0.128
Duration of contraction, ms	r=0.154	r=0.164	r=0.000	r=0.058
	p=0.308	p=0.276	p=0.997	p=0.702
Velocity of contraction, mm/s	r=0.170	r=-0.067	r=0.003	r=0.086
	p=0.260	p=0.658	p=0.987	p=0.569
Latency of dilatation, ms	r=0.207	r=0.030	r=0.016	r=-0.062
	p=0.168	p=0.841	p=0.914	p=0.684
Duration of dilatation, ms	r=-0.045	r=-0.053	r=-0.087	r=0.012
	p=0.768	p=0.725	p=0.566	p=0.934
Velocity of dilatation, mm/s	r=-0.035	r=0.024	r=0.179	r=0.225
	p=0.815	p=0.874	p=0.235	p=0.133

PTH: Parathyroid hormone; bold values indicate statistically significant correlations.

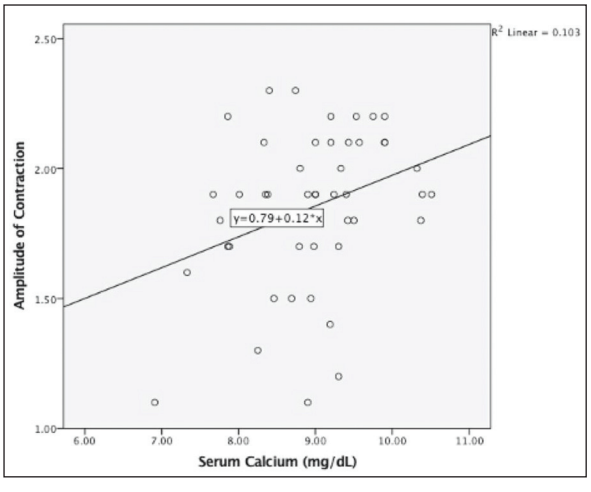

FIGURE 1: Correlation graph between serum calcium levels and amplitude of contraction of patients with hypoparathyroidism.

higher in patients with postoperative hypoparathyroidism than that of healthy controls. It was thought that there is no causal relationship between PTH and pupil contraction amplitude, instead hypoparathyroidism-induced imbalance in calcium levels was responsible for the increase in contraction. The possible relationship between hypocalcemia and increased muscle tone can explain the increase in pupil contraction amplitude. All hypoparathyroid patients in this cohort were under the care of endocrinology department and were using the standard care in postsurgical hypoparathyroidism; activated vitamin D and oral calcium. Thus, they have a stable clinical course and normal serum calcium levels; however, it is well known that the treatment cannot fully substitute the functions of normal serum PTH.[11] Chronic inability of calcium treatment can be a potential explanation to increased amplitude of contraction in our cohort.

There was no statistically significant correlation between the duration of hypoparathyroidism, serum calcium level, serum phosphorus level, and PTH levels and static and dynamic pupillometry responses in the group with hypoparathyroidism, except for the

serum calcium level and amplitude of contraction which were positively correlated.

One strength of this study can be the quantitative data obtained from an automated and reproducible pupillometry system. However, this study has some limitations. First of all, hypothyroidism is another condition which may affect pupillary responses; however, in this study, the patients with abnormal thyroid function tests were excluded to eliminate the effect of hypothyroidism. Additionally, we demonstrated a direct correlation between the levels of serum calcium and amplitude of contraction, which is controversial, and possibly can be attributed to the intake of vitamin D and oral calcium for the treatment of hypoparathyroidism, which can be a confounding factor during interpretation of the results. Thyroid diseases affect women 500% more than males; because of that the small sample size and the inclusion of only female patients are limitations of our study.[12]

CONCLUSION

In conclusion, this study quantitatively demonstrated that pupil diameters at different light intensities were not affected in patients with postoperative hypoparathyroidism, but pupil contraction amplitude was found to be higher when compared to healthy individuals. Although there was no correlation between PTH levels and pupillometry measurements, the existence of a correlation between the amount of calcium and the amplitude of contraction, which is a dynamic measurement, suggested that calcium balance affects autonomic nervous system functions.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Tuğçe Horozoğlu Ceran, Mehmet Ali Şekeroğlu, Ali Mert Koçer;* ***Design:*** *Tuğçe Horozoğlu Ceran, Mehmet Ali Şekeroğlu, Ali Mert Koçer;* ***Control/Supervision:*** *Tuğçe Horozoğlu Ceran, Mehmet Ali Şekeroğlu, Ali Mert Koçer;* ***Data Collection and/or Processing:*** *Tuğçe Horozoğlu Ceran, Mehmet Ali Şekeroğlu, Ali Mert Koçer, Çağatay Emir Önder, Şerife Mehlika Kuşkonmaz;* ***Analysis and/or Interpretation:*** *Tuğçe Horozoğlu Ceran, Mehmet Ali Şekeroğlu, Ali Mert Koçer, Çağatay Emir Önder, Şerife Mehlika Kuşkonmaz;* ***Literature Review:*** *Tuğçe Horozoğlu Ceran, Mehmet Ali Şekeroğlu, Ali Mert Koçer, Çağatay Emir Önder, Şerife Mehlika Kuşkonmaz;* ***Writing the Article:*** *Tuğçe Horozoğlu Ceran, Mehmet Ali Şekeroğlu, Ali Mert Koçer, Çağatay Emir Önder, Şerife Mehlika Kuşkonmaz;* ***Critical Review:*** *Tuğçe Horozoğlu Ceran, Mehmet Ali Şekeroğlu, Ali Mert Koçer, Çağatay Emir Önder, Şerife Mehlika Kuşkonmaz;* ***References and Fundings:*** *Tuğçe Horozoğlu Ceran, Mehmet Ali Şekeroğlu, Ali Mert Koçer, Çağatay Emir Önder, Şerife Mehlika Kuşkonmaz;* ***Materials:****Tuğçe Horozoğlu Ceran, Mehmet Ali Şekeroğlu, Ali Mert Koçer, Çağatay Emir Önder, Şerife Mehlika Kuşkonmaz.*

REFERENCES

1. Hakami Y, Khan A. Hypoparathyroidism. Front Horm Res. 2019;51:109-26. [Crossref] [PubMed]
2. Almquist M, Ivarsson K, Nordenström E, Bergenfelz A. Mortality in patients with permanent hypoparathyroidism after total thyroidectomy. Br J Surg. 2018;105(10):1313-8. [Crossref] [PubMed]
3. Bilezikian JP, Khan A, Potts JT Jr, Brandi ML, Clarke BL, Shoback D, et al. Hypoparathyroidism in the adult: epidemiology, diagnosis, pathophysiology, target-organ involvement, treatment, and challenges for future research. J Bone Miner Res. 2011;26(10):2317-37. [Crossref] [PubMed] [PMC]
4. Giusti F, Brandi ML. Clinical presentation of hypoparathyroidism. Front Horm Res. 2019;51:139-46. [Crossref] [PubMed]
5. Gradisnik P. Hypoparathyroidism should always be checked in papilledema. J Neurosci Rural Pract. 2017;8(3):329. [Crossref] [PubMed] [PMC]
6. Saha S, Gantyala SP, Aggarwal S, Sreenivas V, Tandon R, Goswami R. Long-term outcome of cataract surgery in patients with idiopathic hypoparathyroidism and its relationship with their calcemic status. J Bone Miner Metab. 2017;35(4):405-11. [Crossref] [PubMed]
7. Bremner F, Smith S. Pupil findings in a consecutive series of 150 patients with generalised autonomic neuropathy. J Neurol Neurosurg Psychiatry. 2006;77(10):1163-8. [Crossref] [PubMed] [PMC]
8. Giza E, Fotiou D, Bostantjopoulou S, Katsarou Z, Karlovasitou A. Pupil light reflex in Parkinson's disease: evaluation with pupillometry. Int J Neurosci. 2011;121(1):37-43. [Crossref] [PubMed]
9. Ferrari GL, Marques JL, Gandhi RA, Heller SR, Schneider FK, Tesfaye S, et al. Using dynamic pupillometry as a simple screening tool to detect autonomic neuropathy in patients with diabetes: a pilot study. Biomed Eng Online. 2010;9:26. [Crossref] [PubMed] [PMC]
10. Bilezikian JP. Hypoparathyroidism. J Clin Endocrinol Metab. 2020;105(6):1722-36. [Crossref] [PubMed] [PMC]
11. Mannstadt M, Bilezikian JP, Thakker RV, Hannan FM, Clarke BL, Rejnmark L, et al. Hypoparathyroidism. Nat Rev Dis Primers. 2017;3:17055. Erratum in: Nat Rev Dis Primers. 2017;3:17080. [Crossref] [PubMed]
12. Castello R, Caputo M. Thyroid diseases and gender. Ital J Gender-Specific Med. 2019;5(3):136-41. [Link]