UNIVERSIDADE DE BRASÍLIA
FACULDADE DE AGRONOMIA E MEDICINA VETERINÁRIA

CORRELAÇÃO ENTRE PARÂMETROS OFTÁLMICOS E CRANIOMORFOMÉTRICOS EM CÃES SHIH TZU

PAULO HENRIQUE SAMPAIO DA SILVA

DISSERTAÇÃO DE MESTRADO EM CIÊNCIAS ANIMAIS

BRASÍLIA/DF
FEVEREIRO DE 2024

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Dissertação de mestrado submetida ao programa de pós-graduação em Ciências Animais, como parte dos requisitos necesários à obtenção do grau de Mestre em Ciências Animais

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1. Oftalmologia 2. Shih tzu 3. craniometria 4. Superfície ocular

EPÍGRAFE

“So…yes, I think it’s possible to ordinary people to choose to be…extraordinary”

Elon Musk

DEDICATÓRIA

Dedico este trabalho a todos os Médicos Veterinários que buscam na ciência esperança para tratar de seus pacientes.

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RESUMO

Objetivou-se avaliar a correlação entre parâmetros oftálmicos e parâmetros cranianos, bem como índices craniométricos, e sua associação entre os índices morfométricos. A raça Shih Tzu foi escolhida em virtude de sua popularidade vigente e seu papel na síndrome ocular do braquicefélico. Uma série de testes oftálmicos e craniométricos foi realizada para cada cão: fissura palpebral (FP); fissura palpebral relativa (FPR); sensação tátil da córnea (STC); altura do menisco lacrimal (AML); comprimento do focinho (ML); comprimento do neurocrânio (NL); comprimento do crânio (CL); largura do crânio (SW); índice cefálico (IC); índice craniano (ICr); razão craniofacial (RCF) em 36 cães da raça Shih Tzu, totalizando 72 olhos. Sua idade também foi considerada como objetivo de correlação das variáveis oftálmicas.   Para as correlações, foi realizada corrleação de pearosn a nível de significância de 5%. A mediana da FP foi de 30 milímetros (mm) (IC 95% 28,00:31); 26,63 (IC 95% 24,16:29,55) para FPR; 3,00 (IC 95% 1,50:4,50) para STC e 0,67 (IC 95% 0,50:1,08) para AMH. Para os parâmetros craniométricos, ML apresentou média de 26,09 ± 7,38 mm; NL de 112,2 ± 15,89 m; 138,3 ± 18.47 mm CL; 156,3 ± 14,28 mm para SW; 1,41 ± para IC; 1,13 ± 0,14 para ICr, e 0,23 ± 0,07 para RCF . As correlações entre parâmetros craniométricos e oftálmicos variaram de fracas a moderadas. Uma associação positiva e significativa foi encontrada entre STC e comprimento do focinho (r = 0,41, P = 0,01), FP e FPR (r = 0,37, P = 0,002), FP e AML (r = 0,23, P = 0,04), e também FP e RCF (r = -0,39, P = 0,02). As correlações entre índices e parâmetros morfométricos foram moderadas a fortes, com uma associação significativa entre FPR e NL (r = -0,86, P < 0,001), FPR e SW (r = -0,37, P = 0,02), CI (r = 0,71, P < 0,001), e ICr (r = 0,73, P < 0,001). A Houve correlação significativa entre L e B-C (r = 0,45, P = 0,005), assim como IC e Icr (r = 0,86, P < 0,001), e também entre RCF e IC (r = 0,36, P < 0,001). A variável CL se correlacionou de forma significativa (P < 0.05) com as variáveis FPR (r = - 0.86), A-B (r = 0,53); NL (r = 0,92); SW (r = 0,47); IC (r = - 0,71) e Icr (r = - 0.78). A idade esteve associada com STC (r = -0,44, P = 0,007) e FPR (r = 0,42, P = 0,01). Observou-se que, nos cães Shih Tzu, a sensibilidade corneana está associada com o comprimento do focinho e a idade, e o grau de braquicefalia está associado com a largura palpebral e também à AML. Os índices craniométricos se correlacionam de maneira significativa entre si e com as medidas morfométricas. Este estudo sugere novas ferramentas para a abordagem da síndrome ocular do braquicefálico na raça Shih Tzu.

Palavras-chave: Shih tzu; craniomorfométrico; SOB

ABSTRACT

The objective of this study was to assess the correlation between ophthalmic and cranial parameters, as well as craniometric indices, and their association among morphometric indices. The Shih Tzu breed was chosen due to its current popularity and its role in brachycephalic ocular syndrome. A series of ophthalmic and craniometric tests were conducted for each dog: palpebral width (PW); relative palpebral width (RPW); corneal tactile sensation (CTS); tear meniscus height (TMH); muzzle length (ML); neurocranium length (NL); cranial length (CL); cranial width (CW); cephalic index (CI); skull index (SI); craniofacial ratio (CFR) in 36 Shih Tzu dogs, totaling 72 eyes. Their age was also considered as an objective for correlating ophthalmic variables. For the correlations, Pearson correlation was performed at a significance level of 5%. The median PW was 30 millimeters (mm) (95% CI 28.00:31); 26.63 (95% CI 24.16:29.55) for RPW; 3.00 (95% CI 1.50:4.50) for CTS, and 0.67 (95% CI 0.50:1.08) for TMH. For craniometric parameters, A-B had a mean of 26.09 ± 7.38 mm; B-C of 112.2 ± 15.89 mm; A-C of 138.3 ± 18.47 mm; L of 156.3 ± 14.28 mm; 1.41 ± for CI; 1.13 ± 0.14 for CrI, and 0.23 ± 0.07 for CFR. The correlations between craniometric and ophthalmic parameters ranged from weak to moderate. A positive and significant association was found between CTS and snout length ($r = 0.41$, $P = 0.01$), PW and RPW ($r = 0.37$, $P = 0.002$), PF and TMH ($r = 0.23$, $P = 0.04$), and also PW and CFR ($r = -0.39$, $P = 0.02$). The correlations between indices and morphometric parameters were moderate to strong, with a significant association between RPF and NL ($r = -0.86$, $P < 0.001$), RPW and SW ($r = -0.37$, $P = 0.02$), CI ($r = 0.71$, $P < 0.001$), and SI ($r = 0.73$, $P < 0.001$). There was a significant correlation between L and B-C ($r = 0.45$, $P = 0.005$), as well as CI and SI ($r = 0.86$, $P < 0.001$), and also between CFR and CI ($r = 0.36$, $P < 0.001$). The variable CL correlated significantly ($P < 0.05$) with RPW ($r = -0.86$), ML ($r = 0.53$); NL ($r = 0.92$); SW ($r = 0.47$); CI ($r = -0.71$), and SI ($r = -0.78$). Age was associated with CTS ($r = -0.44$, $P = 0.007$) and RPW ($r = 0.42$, $P = 0.01$). It was observed that in Shih Tzu dogs, corneal sensitivity is associated with ML and age, and the degree of brachycephaly is associated with palpebral width and also TMH. Craniometric indices are significantly correlated with each other and with morphometric measures. This study suggests new tools for approaching brachycephalic ocular syndrome in the Shih Tzu breed.

Keywords: Shih Tzu; craniometric; brachycephalic ocular syndrome.

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LISTA DE ABREVIAÇÕES

BOS – Brachycephalic Ocular Syndrome

BOAS - Brachycephalic Obstructive Airway Syndrome

CBOV – Colégio Brasileiro de Oftalmologistas Veterinários

CFR – Craniofacial Ratio

CL – Cranial Length

CI – Cephalic Index

cm – Centímetros/Centimeters

CTS – Corneal Tactile Sensation

GERVO – Guidelines of Ehtical Research on Veterinary Ophthalmology

IC – Índice Cefálico

Icr – Índice do Crânio

L – Skull width

mm – milímetros/milimeters

ML – Muzzle length

NL – Neurocranium length

OD – Oculus Dexter

OS – Oculus Sinister

OSA – Ocular Surface Analyzer

OU – Oculus unitas

PW – Palpebral Width

RCF – Razão Craniofacial

RPW – Relative Palpebral Width

SI – Skull Index

SOB – Síndrome Ocular do Braquicefálico

SW – Skull Width

TMH – Tear Meniscus Height

CAPÍTULO I

INTRODUÇÃO

Contextualização

A emergência de cães braquicefálicos é notável dentro da Medicina Veterinária, não estando a Oftalmologia Veterinária distante desta realidade. Os cães braquicefálicos são definidos, de modo geral, como cães de focinho curto e cabeça larga (EVANS & DELAHUNTA, 2013). Sobretudo, apresentam condições oculares pertencentes à denominada Síndrome Ocular do Braquicefálico, a exemplo o macrobléfaro, lagoftalmia, órbita rasa, exoftalmia, fissura palpebral exacerbada e menor sensibilidade corneana (BOLZANNI et al., 2018; COSTA et al., 2021; SEBBAG et al., 2023; RAJAEI et al., 2024). Por este motivo a avaliação ocular é vital para estes cães.

Problemática e Relevância

A raça Shih Tzu figura dentre as 20 raças mais populares de acordo com o *American Cannel Club* (SEBBAG et al., 2023), sendo classificada como braquicefálica, herdando as características deletérias inerentes à raça, como a predisposição a alterações da superfície ocular (SEBBAG E SANCHEZ, 2023; SEBBAG et al., 2023; RAJAEI et al., 2024).

Estudos da última década buscaram diminuir a classificação subjetiva de cabeça larga e focinho curto para denominar a braquicefalia, empregando parâmetros morfométricos para calcular o grau de braquicefalia, a exemplo dos índices cefálico, craniano, fissura palpebral, fissura palpebral relativa e razão craniofacial (PACKER et al., 2015a; PACKER et al., 2015b; SIESLACK et al., 2021; ÌLGÜN et al. 2022; OKSA-MINALTO et al., 2023). No entanto, poucos estudos de associação clínica entre parâmetros oculares e morfometria foram realizados.

Objetivo

O objetivo deste trabalho foi avaliar a associação entre fissura palpebral, fissura palpebral relativa, sensação tátil da córnea e altura do menisco lacrimal, com parâmetros craniomorfométricos e a idade, em cães da raça Shih Tzu.

REVISÃO BIBLIOGRÁFICA

A Síndrome Ocular do Braquicefálico e a raça Shih Tzu

As raças braquicefálicas estão espalhadas ao redor do mundo, com crescente popularidade nos anos recentes, e possuem como características evidentes o focinho curto, cabeça larga e rosto achatado (EVANS & DELAHUNTA, 2013; COSTA; STEINMETZ; DELGADO, 2021). A raça Shih Tzu é orginária do Tibete, e está entre as 20 raças caninas mais populares de acordo com o American Kennel Club (SEBBAG et al., 2023). Acredita-se que sua personalidade, rostos enrugados e grandes olhos semelhantes aos de bebês, sejam fatores determinantes em sua popularidade (COSTA et al,, 2021; SEBBAG et al., 2023).

Porém, a seleção artificial que deu origem à raça, selecionando padrões específicos de estética, podem desencadear problemas relacionados ao olho e seus anexos (COSTA et al., 2021), levando ao desenvolvimento da Síndrome Ocular do Braquicefálico (SOB) (COSTA et al., 2021; SEBBAG & SANCHEZ, 2023; SEBBAG et al., 2023; RAJAEI et al., , 2024).

A SOB envolve anormalidades anatômicas e fisológicas (SEBBAG E SANCHEZ, 2023). Anatomicamente, tem-se a modificação da conformação do crânio, com órbitas rasas, olhos expostos (exoftalmia), estrabismo, semicerramento de pálpebras (lagoftalmia), anomalias de cílios (distiquíase, cílio ectópico, triquíase de carúncula), baixa sensibilidade corneana e alterações de epitélio límbico (COSTA et al., 2021; SEBBAG & SANCHEZ, 2023; RAJAEI; FAGHIHI; ZHIRNIA, 2024)

Fisiologicamente, estes cães piscam menos ou piscam de forma incompleta (SEBBAG & SANCHEZ, 2023). Além disto costumam apresentar alterações qualitativas da lágrima, predispondo-os a ceratites superficiais e ulcerativas, ceratites pigmentares, ceratoconjuntivite seca e protrusão da glândula lacrimal da terceira pálpebra. Trata-se de uma síndrome complexa que requer atenção na rotina clínica. (PACKER et al., 2015a; PACKER et al., 2015b; MAINI et al., 2019; VINÃS et al., 2019; BOLZANNI et al., 2020; COSTA et al., 2021; SEBBAG & SANCHEZ, 2023; SEBBAG et al., 2023; RAJAEI et al., 2024).

Morfometria Craniana e Índices originais

O termo morfometria refere-se a ideia de forma (morfo), associada à uma mensuração (metria), sendo objeto de estudo dentro da espécie canina há várias décadas (ONAR, 1999; ONAR & PAZVANT, 2001; HELTON, 2009; SABER & GUMOW, 2015). As mensurações mais utilizadas para o estudo morfométrico em cães são variáveis diretas, avaliadas em crânios macerados. O estudo dessas variáveis considera alguns pontos anatômicos definidos como *Inion*, *Nasion, Prosthion,* e *Zygion* (ONAR, 1999;HELTON, 2009; EVANS & DELAHUNTA, 2013).

O *Inion* pode ser definido como o ponto de superfície central da protuberância occipital externa; o *Nasion* é o ponto de junção entre os planos mediano direito e esquerdo à altura das suturas nasofrontais; o *Prosthion* pode ser definido como a extremidade anterior da sutura interincisiva, localizada entre as raízes dos dentes incisivos superiores; e por fim o *Zygion* é definido como os pontos mais laterais do arco zigomático (ONAR, 1999; ONAR & PAZVANT, 2001; EVANS & DELAHUNTA, 2013).

Com base nas posições de pontos anatômicos, índices envolvendo a menor distância entre eles (ou seja, uma reta) foram estabelecidos para definições conformacionais, promovendo subdivisões na calota craniana (ONAR, 1999; ONAR & PAZVANT, 2001; HELTON, 2009; SABER & GUMMOW, 2015; ÌLGÜN et al., 2022). O termo crânio em português, no entanto, não engloba as duas definições de crânio utilizadas na língua inglesa. Nas definições, os autores definem *cranial* como medidas restritas à calota craniana (*neurocranium*), enquanto *skull* define a estrutra do crânio como um todo (ONAR, 1999). Portanto, adaptações de tradução serão feitas para facilitar o manuseio entre os índices.

A reta entre *Inion* e *Prosthion* pode ser definida como comprimento do crânio como um todo, definindo a *Skull Length*; a reta entre *Inion* e *Nasion* fica definida como comprimento do neurocrânio, isto é, da calota craniana; a reta entre o *Nasion* e *Prosthion* fica definida como o comprimento viscerocraniano (ONAR, 1999; ONAR & PAZVANT, 2001; EVANS & DELAHUNTA, 2013).

A confecção dos índices deriva da interrelação entre as medidas morfométricas (ONAR, 1999). O índice cefálico é definido como a razão (quociente, divisão) entre a largura do crânio e comprimento do neurocrânio multiplicada por 100; já o índice do crânio é definido como a razão entre a largura e o comprimento do crânio multiplicada por 100 (ONAR, 1999; ONAR &

PAZVANT, 2001; HELTON, 2009; SIESLACK et al., 2021; OKSA-MINALTO et al., 2023). Em virtude do quociente ocorrer entre variáveis com mesma medida (milimetros) o resultado é um índice sem unidade definida.

Os índices propostos possuem referências que definem que um índice cefálico superior à 0.81, índice sem unidade definida, classifica o crânio em questão como pertencente ao grupo braquicefálico (SELBA et al., 2020).

Morfometria craniana in vivo

Os índices craniométricos foram inicialmente descritos para mensuração morfométrica e anatômica de crânios macerados, mas têm sido adaptados para mensuração *in vivo* (PACKER et al., 2015a; PACKER et al., 2015b; SIESLACK et al., 2021; OKSA-MINALTO et al., 2023). A forma mais fidedigna de realizar as mensurações é por técnicas de imagem, como radiografia ou tomografia, por permitirem um posicionamento mais preciso nos pontos anatômicos considerados nestas medidas (SIESLACK et al., 2021). No entanto, para avaliações mais diretas e menos invasivas, têm-se estabelecido algumas definições para a morfometria de animais *in vivo*, como uma adaptação dos estudos para crânios macerados, com o uso de índices similares ou adaptados (PACKER et al., 2015a; BOLZANNI et al., 2018; OKSA-MINALTO et al., 2023).

As adaptações deram origem a termos como comprimento do focinho (adaptação da definição de comprimento viscerocranial, distância entre *Nasion* e *Prosthion*), e também da adaptação do comprimento do crânio (distância entre *Ínion* e *Nasion*, comprimento do neurocrânio) (PACKER et al.,2015a ; SIESLACK et al., 2021; OKSA-MINALTO et al., 2023). Adicionalmente, foi proposto um novo índice, a razão craniofacial (RCF), consistindo na razão entre o comprimento do focinho e o comprimento do crânio (PACKER et al., 2015a ;OKSA-MINALTO et al., 2023). A partir destas mensurações, valores abaixo de 0.5, resultado que denota um índice sem unidade definida, pode ser usado para classificar os cães como braquicefálicos em maior ou menor grau, e quanto mais próxima de zero for a razão, maior será o índice de braquicefalia (PACKER et al.,2015a ;OKSA-MINALTO et al., 2023).

A aplicação clínica é capaz de conferior classificação de diferentes raças com diferentes graus de braquicefalia referenciadas, citando que o RCF do Pug tende a ser superior ao do Shih tzu , que tende a ser superior ao do Lulu da Pomerânia, por exemplo (PACKER et al.,2015a). A utilização destes índices já é consolidada na literatura, facilitando a compreensão e os graus de risco da SOB (ONAR, 1999; ONAR & PAZVANT, 2001; HELTON, 2009;PACKER et al., 2015a; PACKER et al., 2015b; SIESLACK et al., 2021 ;OKSA-MINALTO et al., 2023).

Outra adaptação permitida em pacientes vivos é a mensuração da fissura palpebral, isto é, a distância entre as comissuras palpebrais medial e lateral, que também pode ser medida com relação ao comprimento do neurocrânio, sendo denominada fissura palpebral relativa (PACKER et al., 2015a). A mensuração da pálpebra é outra possibilidade que pode caracterizar ainda mais sinais da SOB, e aumenta a possibilidade para a associação com parâmetros oftálmicos, área ainda explorada de forma tímida (PACKER et al., 2015a; BOLZANNI et al., 2018; SIESLACK et al., 2021; OKSA-MINALTO et al., 2023).

CAPÍTULO II

Model of Submission: Original Article, Veterinary Ophthalmology

Brief informative title: **Correlation between ophtalmic and craniometrics parameters on Shih tzu.**

Running title: Association of craniometry and ophthalmology in dogs

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Ethical approval statement: The study in question is a retrospective analysis, wherein the dogs were owned by private individuals, and all owners provided signed consent for the use of data for scientific purposes.

Abstract

Objective: To evaluate the correlation of ophthalmic and craniometric parameters in Shih Tzu dogs in relation to their role in brachycephalic ocular syndrome, and also the relationship between age and ophthalmic parameters.

Animals studied: Thirty-six Shih Tzu dogs, totaling 72 eyes.

Procedures: The ophtalmic parameters evaluated were: palpebral width (PW); relative palpebral width (RPW); corneal tactile sensation (CTS); tear meniscus height (TMH). The cariometric parameters evaluated were: muzzle length (ML) (A-B); neurocranium length (NL) (B-C); skull width (SW); cranial length (CL); cephalic index (CI); skull index (SI); craniofacial ratio (CFR).

Results: For ophtalmic parameters, was attested a median of 30 millimeters (mm) (95% CI 28.00:31) for PW; 26.63mm (95% CI 24.16:29.55) for RPW; 3.00 (95% CI 1.50:4.50) for CTS and 0.67 (95% CI 0.50:1.08) for TMH). For craniometric parameters, the ML showed a mean of 26.09 ± 7.38 mm; 112.2 ± 15.89 mm for SL; 156.3 ± 14.28 mm for SW; 1.41 ± for cephalic index CI; 1.13 ± 0.14 for SI, and 0.23 ± 0.07 for CFR. Correlations between craniometric and ophthalmic parameters ranged from weak to moderate. A positive and significant association was found between CTS and ML (r = .41, P = .01), PW and RPW (r = .37, P = .002), PW and TMH (r = .23, P = .04), and also PW and CFR (r = - .39, P = 0.02). Associations between indices and morphometric parameters were weak to strong, with a significant association between RPW and SL (r = - 0.86, P < .001), RPW and SW (r = - 0.37, P = 0.02), CI (r = 0.71, P < 0.001), and skull index (r = 0.73, P < 0.001). SW and NL were associated (r = 0.45, P = 0.005), as well as cephalic and skull index (r = 0.86, P < 0.001) and craniofacial ratio and cephalic index (r = 0.36, P < .001). The variable CL correlated significantly (P < 0.05) with RPW (r = -0.86), ML (r = 0.53); NL (r = 0.92); SW (r = 0.47); CI (r = -0.71), and SI (r = -0.78) Age was associated with CTS (r = - 0.44, P = 0.007) and RPW (r = 0.42, P = 0.01).

Conclusions:. A practical application of brachycephalic indices is provided for increased accuracy in managing brachycephalic ocular syndrome in Shih Tzu dogs. Through the use of these indices, it was possible to evaluate a direct correlation between muzzle length and corneal sensitivity, between age and corneal sensation, as well as the impact of brachycephaly on palpebral widths. Additionally, a high correlation between the indices and morphometric variables was observed.

Keywords: craniometry, Shih tzu, bracycephalic ocular syndrome, cornea

1. INTRODUCTION

Brachycephalic breeds are widespread worldwide, experiencing increasing popularity in recent years (1). The term brachycephaly refers to a reduced dimension in the anteroposterior axis of the skull (2,3,4), and Shih Tzu dogs are among the top 20 most popular brachycephalic breeds (3,4).

These animals frequently exhibit Brachycephalic Ocular Syndrome (BOS) (2,3,4), characterized by clinical signs such as medial entropion, medial canthal trichiasis (5), exophthalmos due to shallow orbits, exaggerated palpebral fissure (macroblepharon), epiphora, exposure keratitis, and lagophthalmos (3,4).

Racial predisposition to corneal ulcers seems to be associated with craniofacial and eyelid conformation, with morphometry serving as a tool to calculate the risks associated with ocular exposure and surface dysfunction (6). Morphometry objectively classifies the facial conformation of species, and through mathematical models, it estimates risks related to the necessary care for the breed (6,7,8).

Several indices have been proposed for the assessment of cranial morphometry and determination of brachycephaly, such as skull indices (7, 9, 10, 11, 12, 13), cephalic index (9, 10, 12, 13), and craniofacial ratio (6, 14). Morphometric studies aim to associate different brachycephalic indices with cranial parameters, including skull length and width, and muzzle length, in an attempt to elucidate their interactions (9, 13, 15).

In the literature, few studies associate ocular parameters, such as palpebral fissure, relative palpebral fissure, corneal tactile sensation, and tear meniscus height, with cephalic and cranial indices, and craniofacial ratio with ocular parameters. This study evaluated brachycephalic indicative indices with palpebral fissure, relative palpebral fissure, corneal tactile sensation, and tear meniscus height in Shih Tzu dogs.

2. MATERIAL AND METHODS

2.1. Animals

A retrospective survey (from October 2022 to September 2023) was conducted on Shih Tzu dogs undergoing routine ocular examination without reported ocular complaints. The examination included assessments of pupillary light reflex, menace response, palpebral reflexes, dazzle reflex, tear meniscus height evaluation using an ocular surface analyzer (OSA VET® SBM Sistemi), biomicroscopy with a slit lamp (Keeler®; PSL Classic 2), fluorescein staining (Ophthalmos®), rebound tonometry (Tonovet, Icare®), fundoscopy with direct ophthalmoscope (Hillrom®, Welch Allyn® PanOptic®), and corneal aesthesiometry (Luneau Technology®). Animals with no ocular alterations such as quantitative dry eye, glaucoma, uveitis, corneal ulcers, and blepharitis were included in the study. Informed consent was obtained by all owners following the guidelines for Ethical Research in Veterinary Ophthalmology (GERVO).

2.2 - Morphometrics

Morphometric evaluation was performed using a measuring tape to minimize patient stress. For measurements, an adaptation to previously proposed anatomical references (16) was utilized, given the live nature of the animals, with the defined measurement points as follows:

- *Inion: Central point of the external occipital protuberance;*

- *Nasion: Junction at the median plane of the right and left nasofrontal sutures;*

- *Prosthion: Rostral end of the interincisive suture, located between the roots of the upper incisor teeth.*

- *Zygion: The most lateral point of the Zygomatic Arch.*

The assessment points were adapted from those proposed in the literature (6), incorporating the following dimensional concepts:

- *Muzzle length (ML): Distance from Prosthion (P) to Nasion (N);*

- *Neurocranium length (NL): Distance from Nasion (N) to Inion (I);*

- *Skull width (SW): The greatest interzygomatic distance;*

- *Cranial length (CL): Distance from Prosthion to Inion;*

- *Palpebral width (PW): The greatest distance between the medial and lateral palpebral commissures.*

The measurement of variables was carried out using a measuring tape, and some of the measurements, such as palpebral fissure and cranial length (NL) (6,14) (Figure 1).

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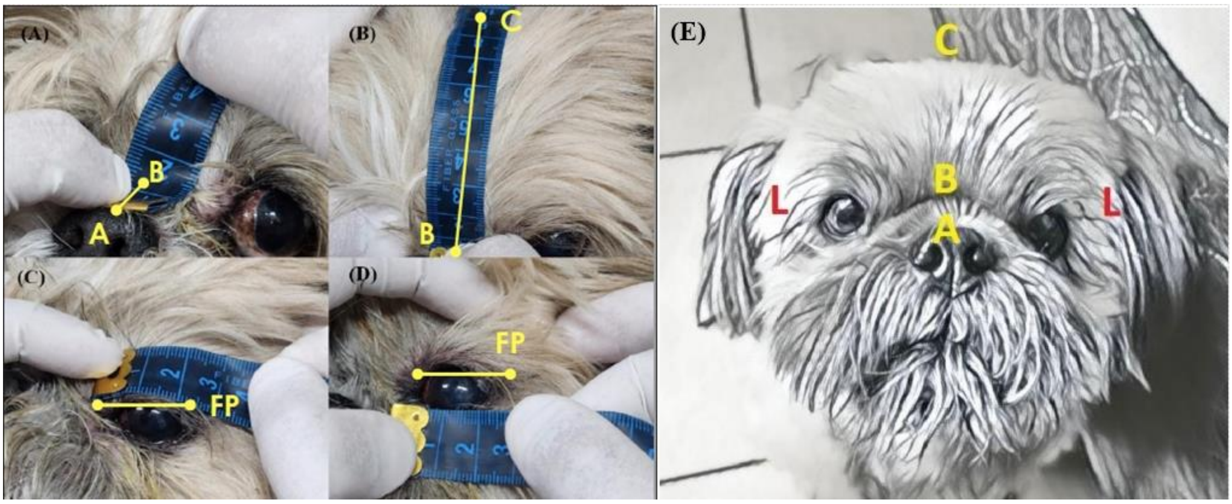

Figure 1 A) Measurement of the muzzle length. B) Measurement of the neurocranial length.C and D) Measurement of the palpebral width; E) Reference points for muzzle length (A-B), neurocranial length (B-C), cranial length (A-C), and zygion (L-L).

Skull indices (SI), cephalic index (CI), craniofacial ratio (CFR), palpebral width (PW), and relative palpebral width (RPW) were calculated The variables were adapted for calculation and measurement using a soft measuring tape according to the literature's recommendations (6, 7, 13, 14, 17, 18), as specified below:

- Cephalic Index (CI): ratio of skull width (SW) to neurocranium length (NL) multiplied by 100;

- Skulll Index (SI): ratio of skull width (SW) to cranial length (CL) multiplied by 100;

- Craniofacial Ratio (CFR): ratio of muzzle length (ML) to neurocranium length (NL) multiplied by 100;

- Relative Palpebral Fissure (RPW): ratio of palpebral fissure (FP) to neurocranial length (NL) multiplied by 100.

The formulas are exemplified below:

$$IC = \frac{SW}{NL}\ X\ 100\ \ ;\ \ SI = \frac{SW}{CL}\ X\ 100\ ;\ CFR = \frac{NL}{CL}\ X\ 100\ ;\ RPW = \frac{PW}{NL}\ X\ 100$$

The references for brachycephaly will be based on the cephalic index and craniofacial ratio, as outlined in Table 1.

2.3 – Corneal Tactile Sensation (CTS)

The tactile sensation of the central cornea in both eyes was assessed using a Cochet-Bonnet aesthesiometer (Luneau Ophtalmologie®), equipped with a 0.12 mm diameter nylon filament ranging from 0.5 cm to 6.0 cm in length. The evaluation commenced with a 6 cm length, positioned perpendicular to the cornea, applying gentle pressure until filament deflection (Figure 3). Five measurements were taken in the central corneal region (13,18). The filament was progressively reduced by 0.5 cm increments, and a blink response was considered when 60% of attempts (3/5) resulted in blinks. Results were recorded in centimeters, as the grading in grams per square millimeter (g/mm^2) may exhibit extensive variability due to evaluator-specific nuances across different studies (3, 13, 18). The procedura can be seen in figure 3.

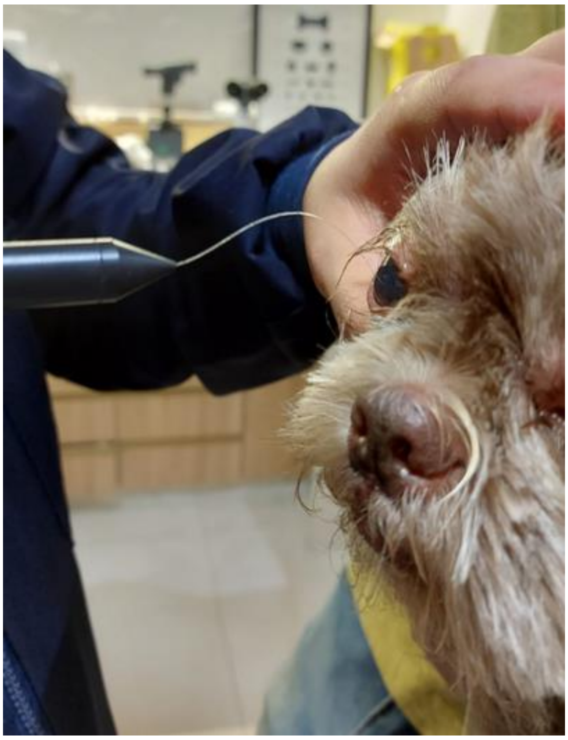

Figure 2 – Execution of corneal tactile sensation assessment using the Cochet-Bonnet aesthesiometer. Note the deflection of the nylon filament and the absence of patient response.

2.4 – Teart Meniscus Height (TMH)

The Tear Meniscus Height (19,20) was measured using a portable ocular surface analyzer (OSA-VET®, SBM Sistemi) equipped with white lights, a 5-megapixel color camera in manual focus, and an interferometry probe, coupled with a computer program ICP Medical System for Windows (SBM Sistemi ICP Medical System® For Windows). The examination was consistently performed by the same professional, a veterinarian specialized by the Brazilian College of Veterinary Ophthalmology (CBOV), to avoid discrepancies (19). Real-time images were captured in an average time of 4 minutes and were promptly analyzed.

Patients were positioned in sternal recumbency or remained seated, depending on the optimal restraint for each animal (20,21), while images of the right and left tear meniscus were captured, always conducted by the same professional (19). From each photograph, one image was selected for tear meniscus analysis (19). For measurement, calibration was performed considering the central circle projected by the device on the ocular surface. Two anchor points were positioned, one at the upper edge of the meniscus and another at the lower edge, creating a digital ruler that provided the Tear Meniscus Height value in millimeters (21) (Figure 4).

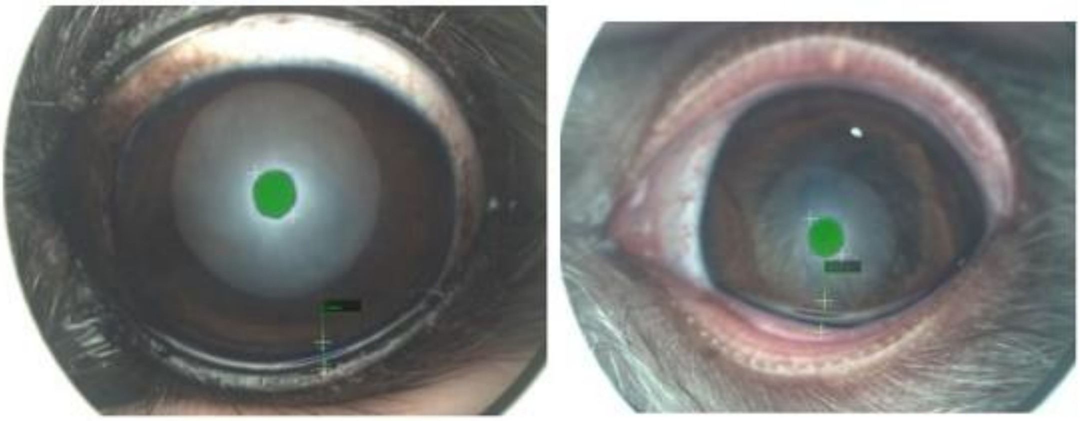

Figure 3 - Exemplification of the measurement of Tear Meniscus Height using the ocular surface analyzer coupled with the OSA program.

2.5 - Statiscal Analysis

Statistical analysis was performed using the Graphpad Prism program (GraphPad Software, version 10 for Macbook, 2023). Data from all individual variables per eye and morphometric measurements were subjected to descriptive statistics (Median and quartiles/confidence interval) and histogram construction. Non-parametric variables underwent logarithmic transformation for normality testing. A Shapiro-Wilk test was conducted at a significance level of 5% for normality analysis of variables per eye and morphometric variables. Non-parametric variables were normalized through logarithmic transformation, in pursuit of a parametric evaluation to yield more robust results.. Subsequently, a paired t-test was conducted between palpebral fissure variables, relative palpebral fissure, corneal tactile sensation, and tear meniscus height for eye-to-eye comparison at a significance level of 5%.

An approach was employed to consider data from both eyes, using correlation graphs and assessing variables for conducting paired t-test between the right and left eyes. (22). Sequentially, data from the right and left eyes for all variables were unified into a single variable for both eyes (oculus unitas - OU) and subjected to the D'Agostino-Pearson normality test at a significance level of 5%. For non-parametric OU variables, logarithmic transformation was performed for sequential analysis using the same normality test for analysis.

Pearson correlations, in the form of a correlation matrix, were conducted between tear meniscus height, palpebral width, relative palpebral fissure, corneal tactile sensation, muzzle length, neurocranial length, skull width, cephalic index, cranial index, and craniofacial ratio at a significance level of 5%. Sequentially, Pearson correlation was performed between age and tear meniscus height, palpebral fissure, relative palpebral fissure, and corneal tactile sensation at a significance level of 5%. The correlation of age with the aforementioned four variables was conducted individually due to variables that may undergo age-related changes. To assess the strength of correlations, the proposed literature standards (13, 22, 23) were used, where the correlation between 0-0.19 is very weak; between 0.2 and 0.39 weak; between 0.4 and 0.59 moderate; between 0.6 and 0.79 strong, and between 0.80 and 1 very strong.

Parametric variables (ML, SW, CI, SI, NL) were presented as mean ± standard deviation of the mean. Non-parametric variables (PW, RPW, CTS, TMH) were presented as median with their respective confidence interval and quartiles.

3. RESULTS

Among the evaluated dogs, 36 (72 eyes) met the inclusion criteria for the study, with a mean age of 8.16 ± 3.26 years.

All dogs were classified as brachycephalic (CI > 0.81; CFR < 0.5). The means for craniometric variables and their indices were as follows: ML had a mean of 26.09 ± 7.38 mm;

NL of 112.2 ± 15.89 mm; 138.3 ± 18.47 mm for CL; 156.3 ± 14.28 mm for SW; 1.41 ± for IC; 1.13 ± 0.14 for SI, and 0.23 ± 0.07 for CFR (Table 3).

Data for palpebral wifth of the right eye, relative palpebral width of the right eye, corneal tactile sensation of both right and left eyes, and tear meniscus height of both right and left eyes were subjected to logarithmic transformation and achieved normal distribution for comparison. The values for palpebral fissure, relative palpebral width, corneal tactile sensation, and tear meniscus height can be observed in Table 3, and their comparison is shown in figure 4.

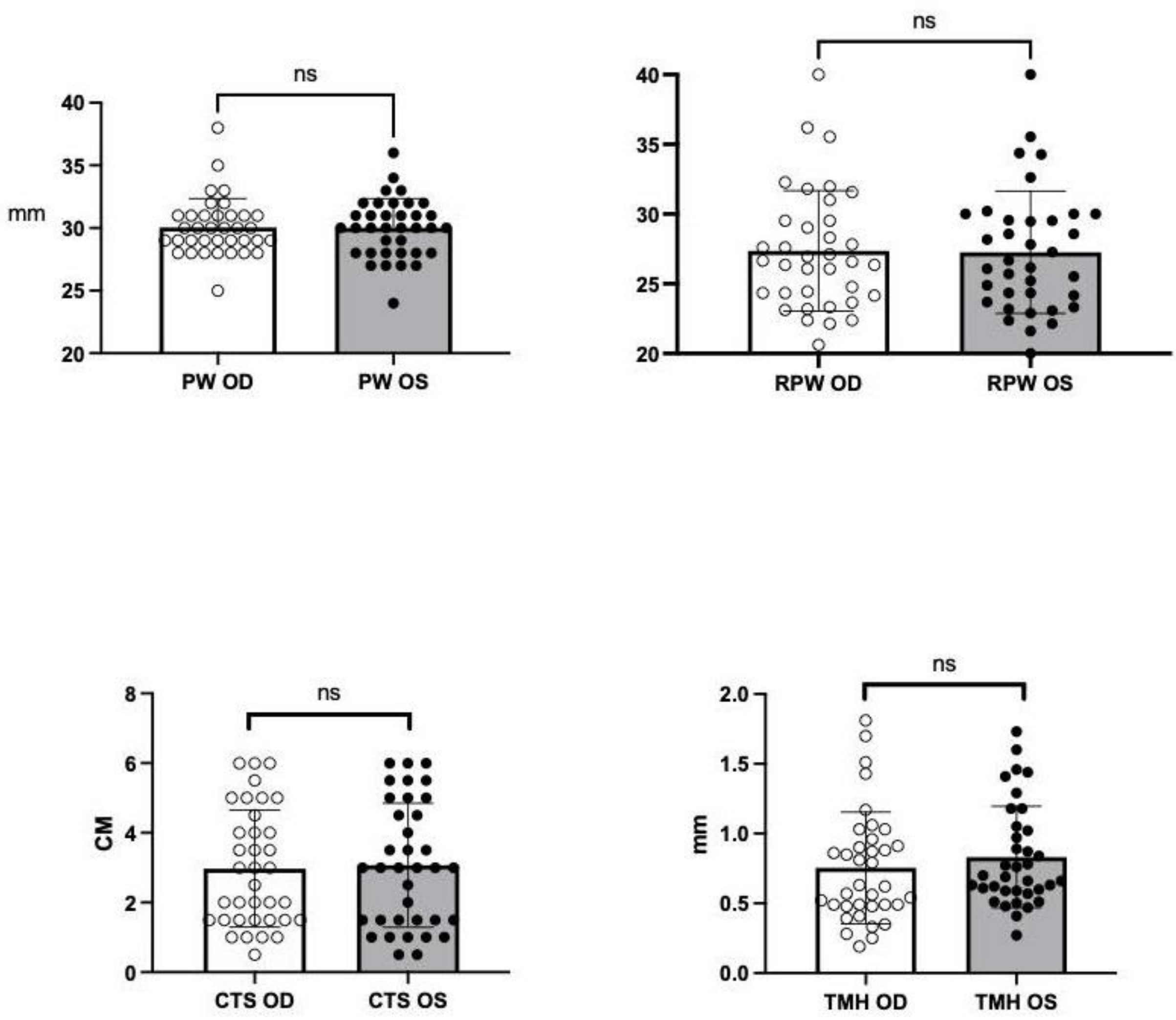

Figure 4 – Representative graph of the comparison (paired t-test after normalization through logarithmic transformation) between right eye (OD) and left eye (OS) for the variables palpebral fissure, relative palpebral fissure, corneal tactile sensation, and tear meniscus height.

There was no significant difference between eyes (OD, OS) for any of the measurements conducted. Therefore, the use of both eyes (*occulus unitas* - OU) was chosen for the analysis, totaling 72 eyes (Table 4).

The variables PW, RPW, CTS, and TMH for both eyes were subjected to logarithmic transformation, due to non-normality, and then achieved normal distribution. This was done to assess whether, for occulus unitas, the variables would attain normality, allowing for the application of Pearson correlations. The strength of the associations can be visualized in Figure 6. The associations between age and ophthalmic variables can be seen in Figure 7.

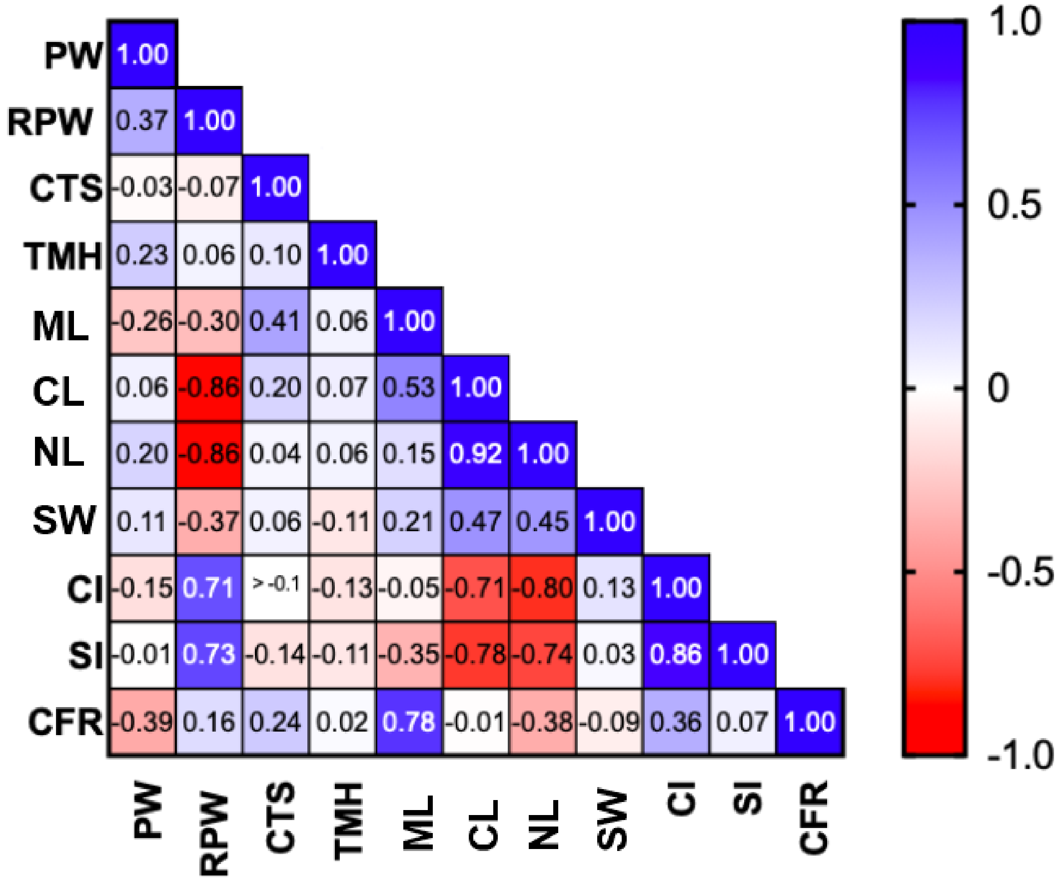

Figure 5 – Pearson Correlation Heatmap of all studied variables. Perfect correlations in blue indicate correlation of identical variables. ML –Muzzle length; NL – neurocranium length; SW – Skull Width; CL – Cranial Length; PW – Palpebral Width; RPW – Relative Palpebral Width; TMH – Tear Meniscus Height; CTS – Corneal Tactile Sensation; CI – Cephalic Index; SI– Skull Index; CFR – Craniofacial Ratio.

There was a significant association of PW with RPW (p = 0.002); with AML (p=0.04); and with CFR (p=0.02). There was a significant association of RPW with skull length (p<0.0001); with skull width (p=0.02); with CI (p<0.0001); and with SI (p<0.0001). Significant association was found between CTS and muzzle length (p=0.01). There was a significant association between skull width and skull length (p = 0.005). CI had a significant association with skull length (p<0.0001); SI (p<0.0001); and CFR (p = 0.02). SI had a significant association with skull length (p<0.0001). CFR had a significant association with muzzle length (p<0.0001); and head length (p=0.02). The variable CL exhibited significant correlations (P < 0.05) with RPW (r = -0.86), ML (r = 0.53); NL (r = 0.92); SW (r = 0.47); CI (r = -0.71), and SI (r = -0.78). Age showed associations with CTS (r = -0.44, P = 0.007) and RPW (r = 0.42, P = 0.01).

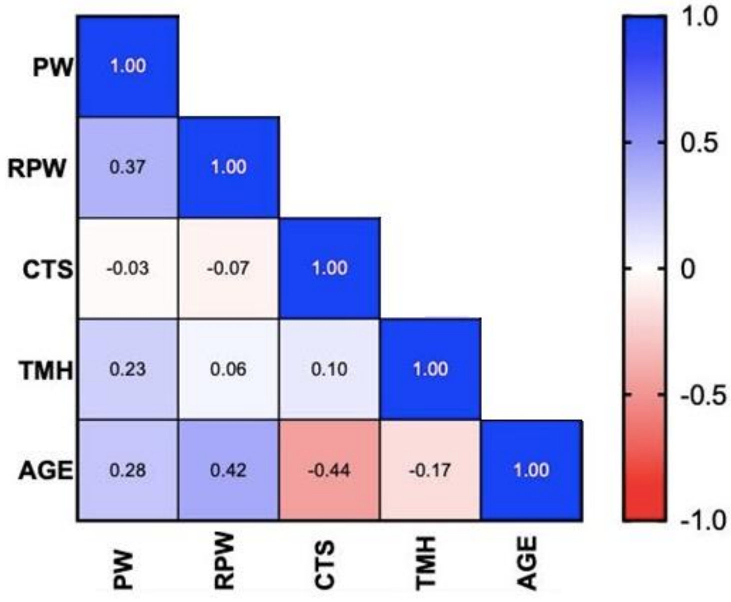

Figure 6 – Correlation matrix between age and ophthalmic variables. Perfect correlation (1.00) in blue indicates correlation of identical variables.

4. DISCUSSION

It is worth noting that human-driven selection for aesthetic purposes is the primary cause of the facial reduction observed in brachycephalic dogs, with morphological compromise being the main characteristic of this trend (7). New studies aiming to correlate variables such as palpebral fissure, relative palpebral fissure, cephalic index, craniofacial ratio, and cranial index with qualitative and quantitative tear assessments must be encouraged.

The present study demonstrates the interrelation of cranial morphometry with some ocular parameters in Shih Tzu dogs in a pioneering way, using numerical indices with less subjectivity. The relationship between relative palpebral width and cranial length and width suggests that variation in skull size influences the length of the palpebral fissure, both directly and relatively. Brachycephalic dogs have wider and less elongated heads, implying a smaller anteroposterior spatial dimension, with an increase in the proportion of palpebral widths (6,16). The comparison of cranial conformations and dimensions between males and females is of outmost importance; however, the present study had a numerical predominance of male dogs. Consequently, a sex-based comparative analysis was not conducted.

Regarding ophthalmic parameters, the association between palpebral width and tear meniscus height may be related to the instability of the tear film in brachycephalic dogs with exaggeratedly sized eyelids, causing an increase in tear meniscus height due to non-adherence of the aqueous portion to the cornea, resulting from qualitative deficiency (1,3,4,5). The observed association between corneal tactile sensation and muzzle length supports the characteristic that brachycephalic dogs have decreased corneal sensitivity (3,4), and a shorter muzzle leads to a lower craniofacial ratio, increasing the degree of brachycephaly, implying different indices with values further from 0.5 for the craniofacial ratio, which utilizes muzzle length. Among the differences, the craniofacial ratio of breeds such as Pekingese (0.12), Pug (0.08), Bulldog (0.22), Boston Terrier (0.15), French Bulldog (0.19), and Pomeranian (0.43) can be mentioned (6).

The mathematical correlation of corneal tactile sensation with muzzle length is described for the first time in this study, as well as the correlation of age with corneal tactile sensation, demonstrating a reduction in corneal sensitivity as the dog ages. It has been previously shown that corneal sensitivity in brachycephalic dogs is reduced compared to mesocephalic and non-brachycephalic dogs (18, 24), which was supported in this study by the association between muzzle length and sensitivity. Low corneal sensitivity increases the permeability of epithelial cells, reduces migration and mitosis, and is an important risk factor for infections, poor healing, and erosions (18, 24). A strong correlation between cephalic index and corneal tactile sensation has been previously demonstrated (18), but this was not observed in the present study. Moreover, the correlation between age and corneal sensitivity, to the best of the authors' knowledge, was also demonstrated in a pioneering manner. Further studies associating age, or even systemic disorders that may influence a decrease in corneal sensitivity associated with age, are encouraged.

The correlation of cranial indices with relative palpebral width is of particular interest, as the palpebral width expands as the indices increase, aligning with changes resulting from brachycephalic ocular syndrome (3,4). Although previous studies on ophthalmic parameters in Shih Tzu breed have been conducted (6,14), the correlation between palpebral widths and cranial indices is described for the first time, suggesting a new approach in evaluating these measures, both for prognostic and diagnostic factors.

The values obtained for relative palpebral width were similar to those described in the literature (6), estimated at 28.53mm, and a 10% increase in the size of this measure increases the risk of corneal ulcer development up to three times (3,4,6), making it an excellent predictive factor for ocular surface changes. The correlation between relative palpebral width and age was previously described only in puppies up to 6 months of age (25). The mean palpebral width for Shih Tzu breed in the present study was below the average proposed in the literature (6, 26) of 33.6 mm when evaluating adult dogs but above what has been reported in other studies (3,4) of 23.8 mm. The methodology employed, the intrinsic variability of the breed, the analysis of only one eye in some studies (3,4), limited sample size, and the anesthesia of animals (25) , however, are factors that can interfere with the variability of the results.

The CFR was correlated with muzzle size, and skull length, but most notably, there was a negative association with palpebral width. This association suggests the possibility that larger palpebral fissures are found in dogs with a lower CFR, supporting the presence of more exacerbated palpebral fissures in brachycephalic dogs (6). The association between RCF and muzzle length, along with the association between muzzle length and corneal tactile sensation, reinforces the concept that brachycephalic dogs tend to have short noses and low corneal sensitivity, as documented by other studies (1, 3, 4, 5, 16, 26, 27). The average for CFR in this study, below 0.5 for the Shih Tzu breed aligns with the literature (6, 26); however, it is higher than the values reported for Pugs, Bulldogs, French Bulldogs, Boston Terriers, Pekingese, Pinschers, and Brussels Griffons (6, 26).

This index deserves attention as it has been used in studies on ocular health in dogs (6), brachycephalic airway obstructive syndrome in brachycephalic dogs (26), references for tomography (17), and analyses of ocular parameters in cats (13), as well as in assessing the overall health of Pug dogs (29, 30). Studies conducted in brachycephalic animals have not explored the correlations between indices (CI, SI, and CFR), a new approach achieved in this study, showing the association between them (6, 7, 17, 26, 28, 29). In felines, there is already a description of a moderate and negative correlation of CFR with variables related to the aqueous part of the tear film (13), but the same was not observed when correlating CFR with the height of the lacrimal meniscus in dogs.

The measurement of variables related to cranial morphometry can be performed using a soft measuring tape (6) or a digital caliper (3, 13, 26, 30), but the use of a measuring tape was chosen in this study to minimize stress on the animals (6). In the present study, the relative palpebral width showed correlation only with the palpebral fissure, and there was no correlation with corneal tactile sensation, as expected, to support the established higher risks of corneal ulceration due to increased exposure and reduced sensitivity (3, 4, 6, 27). However, in Pugs, the palpebral width was already correlated with a higher risk of developing pigmentary keratitis, but this alteration was not the focus of this study.

The Shih Tzu breed ranks among the top 20 most popular breeds according to the American Kennel Club but is also one of the main breeds seen in veterinary centers with ocular complaints (3, 4, 30, 31). These brachycephalic breeds, such as the Shih Tzu, are known to be prone to developing issues related to brachycephalic obstructive airway syndrome (BOAS), such as caruncular trichiasis, medial entropion, reduced tear film breakup time, and dry eye (1, 3, 5, 30, 31).

The main limitations of this study include a low sample size, a limited number of ophthalmic tests, the inability to compare craniofacial parameters between males and females, and the lack of a more in-depth analysis of the correlation between age and corneal tactile sensation due to variability. Additionally, the study focused on a single breed, preventing broader generalizations. It is crucial to note that the study did not aim to establish craniometric parameters for Shih Tzus but rather to preliminarily assess potential associations. Future studies should consider sexual dimorphism, age, a more significant sample size, and explore diverse brachycephalic breeds for comprehensive comparisons and broader insights.

This study contributes to the documentation of significant risks associated with breeding Shih Tzus without adhering to selection criteria. The expectation is that the dissemination of scientific data will enhance awareness regarding the importance of breeding the breed in accordance with standards, thereby ensuring a superior quality of life for these dogs..

5. CONCLUSION

It can be concluded that there is a correlation between ophthalmic and craniometric parameters in Shih Tzu dogs. For instance, the muzzle length correlates with corneal sensitivity, and cranial dimensions correlate with palpebral width. Additionally, age appears to play a significant role in corneal sensitivity. The indices demonstrated extensive interactions among themselves and with craniometric indices, emerging as a new approach to contribute to the accuracy of interpreting brachycephalic ocular syndrome.

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TABLES

PARAMETER	**BRACHYCEPHALIC**	**NONBRACHYCEPHALIC**	**REFERENCE**
CI	CI > 0.81	CI < 0.81	(7, 14, 18)
CFR	CFR < 0.5	CFR > 0.5	(6,14)

Table 1 – Reference indices for the brachycephaly classification.

VARIÁVEL	***OD***	***OS***	***P***
PW (mm)	30 (29.00:31.00)	30.00 (28.00:31.75)	0.95
RPW	26.63 (24.21/29.52)	26.42 (23.82:29.89)	0.92
CTS (cm)	2.75 (1.50:4.37)	3.00 (1.50:4.87)	0.90
TMH (mm)	0.62 (0.48:0.94)	0.69 (0.59:1.04)	0.39

Table 2 – Medians (quartiles) and p-values for the analyzed ophthalmic variables. Data presented as medians are non-parametric, and were subsequently normalized through logarithmic transformation.

PARAMETER	*RESULT*
(ML) (mm)	26.09 ± 7.382
(NL) (mm)	112.2 ± 15.89
(CL)	138.3 ± 18.47
SW (mm)	156.3 ± 14.28
CI	1.41 ± 0.18
SI	1.13 ± 0.14
CFR	0.23 ± 0.07

Table 3 - Mean ± standard deviation for craniometric variables (N=36).

PARAMETER	*RESULT*
PW (mm) (OU)	30.00 (28.00:31.00)
RPW mm) (OU)	26.63 (24.16:29.55)
CTS (cm) (OU)	3.00 (1.50:4.50)
TMH (mm) (OU)	0.67 (0.50:1.08)

Table 4 – Medians and quartiles, for the analyzed variables. For palpebral width (PW), relative palpebral width (RPW), corneal tactile sensation (CTS), and tear meniscus height (TMH), N=72.

FIGURE LEGENDS

Figure 1 – A) Measurement of the muzzle length. B) Measurement of the neurocranial length.C and D) Measurement of the palpebral width; E) Reference points for muzzle length (A-B), neurocranial length (B-C), cranial length (A-C), and zygion (L-L).

Figure 2 – Execution of corneal tactile sensation assessment using the Cochet-Bonnet aesthesiometer. Note the deflection of the nylon filament and the absence of patient response. .

Figure 3 - Exemplification of the measurement of Tear Meniscus Height using the ocular surface analyzer coupled with the ICP for Windows program, SBM Sistemi.

Figure 4 – Representative graph of the comparison (paired t-test after normalization through logarithmic transformation) between right eye (OD) and left eye (OS) for the variables palpebral fissure, relative palpebral fissure, corneal tactile sensation, and tear meniscus height.

Figure 5 – Pearson Correlation Heatmap of all studied variables. Perfect correlations in blue indicate correlation of identical variables. A-B - Distance from Inion to Nasion. B-C – Distance from Nasion to Prosthion. L – Skull Width. PW – Palpebral Width; RPW – Relative Palpebral Width; TMH – Tear Meniscus Height; CTS – Corneal Tactile Sensation; CI – Cephalic Index; SI– Skull Index; CFR – Craniofacial Ratio

Figure 6 – Correlation matrix between age and ophthalmic variables. Perfect correlation (1.00) in blue indicates correlation of identical variables.

CAPÍTULO III

CONSIDERAÇÕES FINAIS

Considerando a análise entre os parâmetros oftálmicos selecionados e cães da raça Shih tzu, os resultados mostram associações pioneiras entre índices craniomorfométricos e oftálmicos e abrem campo para novas pesquisas envolvendo as correlações.

Estudos que visem expandir o uso das associações para diferentes raças de cães são encorajados. Sobretudo, estudos que visem avaliar possíveis relações de causa e efeito com aplicações clínicas plausíveis entre as variáveis são encorajados.

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