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DENTAL DISEASES AND PAIN IN CATS *(Felis catus)*

Orientadora: Prof.ª Doutora Joana Tavares de Oliveira

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Universidade Lusófona de Humanidades e Tecnologias

Faculdade de Medicina Veterinária

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Dissertação apresentada para a obtenção do Grau de Mestre em Medicina Veterinária no curso de Mestrado Integrado em Medicina Veterinária conferido pela Universidade Lusófona de Humanidades e Tecnologias

Orientadora: Prof.ª Doutora Joana Tavares de Oliveira

Co-orientador: Prof. Doutor João Filipe Requicha

Orientadores externos: Dr.ª Maria João Dinis da Fonseca,

Prof. Doutor Pietro Asproni

Constituição do júri

Presidente: Professora Doutora Laurentina Pedroso

Arguente: Professora Doutora Sónia Campos

Orientador: Professor Doutor João Requicha

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Those delicate feline oral structures require all the skill and knowledge that we have and deserve our best efforts to ensure that we are not continuously restarting the steep-slope part of the learning curve.

Colin E. Harvey

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Resumo

A dor na cavidade oral em gatos, é frequentemente negligenciada. O principal objectivo do presente trabalho foi avaliar se as doenças dentárias felinas causam dor, e se, a sua gravidade está correlacionada com a dor sentida. O objectivo secundário consistiu em avaliar se a Feline Acute Pain Scale (escala de dor) of Colorado State University Veterinary Teaching Hospital (CSUVTH) é adequada para identificar dor causada por doenças dentárias.

A série foi composta por 53 gatos. Todos foram submetidos a um exame minucioso da cavidade oral, e a presença de dor foi investigada recorrendo à escala de dor do CSUVTH. Seis parâmetros dentários primários (reconhecidos em Dentisteria Veterinária pelo American Veterinary Dental College) e 5 parâmetros dentários secundários (avaliados por observação visual) foram estatisticamente comparados com os graus de dor.

Todos os parâmetros dentários secundários mostraram estar estatisticamente correlacionados com graus de dor. O número de dentes visivelmente ausentes foi o único parâmetro primário estatisticamente correlacionado com graus de dor. Embora não estatisticamente significativo, observou-se uma tendência na correlação de graus de dor e reabsorção dentária.

Definitivamente, os gatos com doenças dentárias frequentemente sentem dor, e essa dor está diretamente correlacionada com a gravidade da doença. Embora mais minuciosa na avaliação de parâmetros secundários baseados em observações visuais de comportamento, a presente escala demonstrou ser uma ferramenta adequada.

Palavras-chave: Avaliação de dor; doenças dentárias; gatos; observação de comportamento; saúde oral.

Abstract

Oral cavity pain is frequently overlooked in cats. This study aimed primarily to evaluate if feline dental diseases are cause of pain and if their severity correlates to pain. Secondarily evaluating if the Feline Acute Pain Scale of Colorado State University Veterinary Teaching Hospital (CSUVTH) is adequate to identify pain caused by dental diseases.

Fifty-three cats composed the studied series. All the cats were submitted to an accurate oral cavity examination and the presence of pain was assessed according to the Colorado feline acute pain scale. Six primary dental parameters (recognized in Veterinary Dentistry by the American Veterinary Dental College) and 5 secondary dental parameters (evaluated by visual observation) were statistically compared to pain grades.

All the secondary dental parameters were statistically correlated to pain scores. The number of missing teeth was the only primary parameter statistically correlated to pain grades. Although not statistically significant, a trend was observed regarding higher pain scores and tooth resorption.

This work allowed to definitely clarifying that cats with dental disease often feel pain, and that it increases in a disease severity-dependent manner. Although more accurate in detecting pain by visual observations as the secondary parameters, the present scale is a promising, readily available tool in this setting.

Keywords: Behavior observation; cats; dental diseases; oral health; pain assessment.

Resumo da Dissertação de Mestrado em Português

Doença periodontal

A doença periodontal (PD) é a doença oral mais comum em gatos, dividida em duas apresentações clínicas: gengivite e periodontite (Clarke & Cameron, 1998; Harvey, 2005; Lyon, 2005; Bellows, 2010d; Perry & Tutt, 2015). Caracteriza-se por uma inflamação do periodonto causada pelo efeito da placa bacteriana sobre os tecidos e resposta do hospedeiro (Reichart *et al*., 1984; Gorrel *et al*., 1998; Gorrel, 2004b; Harvey, 2005; Girard *et al*., 2009).

O periodonto é o aparelho de suporte do dente, constituído por gengiva, cemento, o ligamento periodontal e osso alveolar. (Mitchell, 2002; Holmstrom, *et al*., 2007; Bellows, 2010a; DeBowes, 2010; Holmstrom *et al*. 2013; Niemiec, 2013g; Reiter & Soltero-Riviera, 2014).

A gengivite é o estadio inicial da doença e é caracterizada por inflamação da gengiva, a qual pode ser prevenida através do controlo de placa e reversível com a higiene professional da cavidade oral (Lobprise, 2007; Niemiec, 2013c; Perry & Tutt, 2015). A periodontite é a inflamação dos tecido mais profundos do periodonto, resultando na destruição progressiva do ligamento periodontal, do osso alveolar e do cemento, se não for tratada (Niemiec, 2013e; Perry & Tutt, 2015).

Diagnóstico

A avaliação sistemática do periodonto requer o exame da gengiva com sonda periodontal e exame radiográfico intraoral sob anestesia (Mills, 1992; Holmstrom *et al*., 2013; Niemiec, 2013e; Clarke & Caiafa, 2014; Perry & Tutt, 2015).

Os sinais clínicos e alterações observadas são registadas no odontograma (Gorrel, 2004b; Bellows, 2010b,d). O odontograma utiliza um diagrama da dentição, que permite a anotação de informação ao lado da sua localização, desta forma as alterações são anotadas de forma rápida, fácil e concisa (San Román *et al*., 1998). Neste documento, em cada dente, é anotado o índice de gengivite, a profundidade do sulco gengival ou da bolsa periodontal, o nível de inserção do epitélio juncional, o índice de exposição da furca, o índice de placa e de

cálculo dentários, o índice de mobilidade e a ausência de peças dentárias (Anexo I) (Gorrel, 2004b; Bellows, 2010b,d).

Estadios de doença periodontal

A doença periodontal é classificada de acordo com o seu estadio, sendo a sua pontuação atribuída consoante uma estimativa geral de todos os dentes avaliados individualmente (Bellows, 2010d, Niemiec, 2013e) (Tabela 1).

Tabela 1: Classificação em estadios da doença periodontal. Adaptado de AVDC (1988), Bellows (2010), Niemiec (2013) e Perry & Tutt (2015)

Estadios da doença periodontal (PD)	Descrição	Perda de ligação	Índice de furca
Estadio 0	Gengiva saudável	0	0
Estadio 1	Gengivite	0	0
Estadio 2	Periodontite ligeira	Perda de ligação <25%	F1
Estadio 3	Periodontite moderada	Perda de ligação de 25 a 50%	F2
Estadio 4	Periodontite avançada	Perda de ligação >50%	F3

Legenda: F1- a sonda pode apenas detetar a entrada da furca, F2- a sonda pode entrar na furca, mas não a atravessa, F3- a sonda pode facilmente atravessar a furca de um lado ao outro.

Fraturas dentárias

As fraturas dentárias resultam da ação direta de forças traumáticas externas sobre o dente e são frequentemente causadas por acidentes com veículos motorizados, lutas com outros gatos, quedas ou simplesmente durante atividades lúdicas (Bellows, 2010d; Soukup & Snyder, 2014).

Devido ao seu papel na preensão de alimento e defesa, os dentes caninos são os mais vulneráveis às fraturas, particularmente os maxilares (Bellows, 2010d; Soukup & Snyder, 2014; Soukup *et al*., 2015). A presença de fraturas pode causar dor, bem como diminuição da função de preensão e mastigação do alimento, afetando assim a qualidade de vida do gato (Holmstrom *et al*., 2013; Soukup *et al*., 2015).

O AVDC classifica as fraturas dentárias em sete tipos diferentes, de acordo com as suas apresentações (AVDC, 1988b) (Tabela 2).

Tabela 2: Classificação de fraturas dentárias. Adaptado de AVDC (1988a)

Classificação de fratura dentária (T/FX)	Descrição
T/FX/EI Infração de esmalte	Fratura incompleta do esmalte sem perda de substância dentária
T/FX/EF Fratura de esmalte	Fratura com perda de substância de coroa confinada ao esmalte
T/FX/UCF Fratura de coroa não complicada	Fratura de coroa sem exposição de polpa dentária
T/FX/CCF Fratura de coroa complicada	Fratura de coroa com exposição de polpa dentária
T/FX/UCRF Fratura de coroa-raiz não complicada	Fratura de coroa e raiz sem exposição de polpa dentária
T/FX/CCRF Fratura de coroa-raiz complicada	Fratura de coroa e raiz com exposição de polpa dentária
T/FX/RF Fratura de raiz	Fratura que envolve apenas a raiz

Lesões de reabsorção dentária

A lesão de reabsorção dentária (TR) é uma das doenças dentárias mais comuns em gatos (Ingham *et al*., 2001; Reiter & Mendoza, 2002; Clarke & Caiafa, 2014).

Etiologia e patogenia

A etiologia da TR não é clara (Scarlett *et al*., 1999; Gorrel, 2015). Existem dois tipos diferentes de reabsorção, com diferentes etiologias: lesão de reabsorção dentária de tipo 1 (inflamatória e associada à doença periodontal) e lesão de reabsorção dentária de tipo 2 (verdadeiramente idiopática) (Reiter *et al*., 2005; Gorrel, 2015).

A TR ocorre devido à destruição dos dentes por odontoclastos (células multinucleadas clásticas) que reabsorvem os tecidos dentários duros (cemento e dentina) (Okuda & Harvey, 1992; Scarlett *et al*., 1999). Esta destruição pode começar na parede da câmara pulpar (reabsorção interna) ou na superfície externa da raiz (reabsorção externa) (Reiter *et al*., 2005; Bellows, 2010d; Gorrel, 2015).

Diagnóstico

A lesão de reabsorção dentária tem o aspeto clínico de um tecido de granulação altamente vascularizado e inflamado na margem gengival, geralmente na junção cemento-esmalte, que pode ser doloroso e sangrar facilmente quando sondado (Lommer & Verstraete, 2000; Reiter & Mendoza, 2002; Harvey *et al*., 2004; Reiter et al., Clarke & Caiafa, 2014; Gorrel, 2015).

A radiografia dentária identifica lesões de reabsorção dentária localizadas nas superfícies radiculares como áreas radiotransparentes nos dentes afetados, também adiciona a possibilidade de identificar lesões em estadio inicial e classificá-las de acordo com estadios de TR (AVDC, 1988d; Wessum *et al*, 1992; Lommer & Verstraete, 2000; Gorrel, 2004a; Gorrel, 2015).

As lesões de reabsorção dentária são classificada pelo AVDC com base na aparência radiográfica, de acordo com a destruição do tecido dental e envolvimento da polpa dentária (Tabelas 3 e 4) (AVDC, 1988d; DuPont & DeBowes, 2002; DuPont, 2005; Bellows, 2010d,e; Clarke & Caiafa, 2014; Farcas *et al*., 2014, Gorrel, 2015).

Tabela 3: Descrição completa dos estadios das lesões de reabsorção dentária. Adaptado de AVDC (1988d)

Estadio da reabsorção dentária (TR)	**Descrição**
Estadio 1 (TR 1)	Perda ligeira de tecido dentário duro, cemento ou cemento e esmalte
Estadio 2 (TR 2)	Perda moderada de tecido dentário duro, cemento ou cemento e esmalte com perda de dentina que não se extende à cavidade pulpar
Estadio 3 (TR 3)	Perda profunda de tecido dentário duro, cemento ou cemento e esmalte com perda de dentina que se extende à cavidade pulpar. A maioria da integridade dentária é mantida
Estadio 4 (TR 4)	Extensa perda de tecido dentário duro, cemento ou cemento e esmalte com perda de dentina que se extende à cavidade pulpar. A maioria da integridade dentária é perdida
	4 a) Coroa e raiz são igualmente afectadas
	4 b) Coroa mais afectada que a raiz
	4 c) Raiz mais afectada que a coroa
Estadio 5 (TR 5)	Vestígios de tecido dentário duro visíveis apenas como radiopacidades irregulares Cobertura gengival completa

Tabela 4: Aparência radiográfica dos tipos de lesão de reabsorção dentária. Adaptado de AVDC (1988d)

Tipos de reabsorção dentária (T)	Descrição
Tipo 1 (T1)	Radiotransparência focal ou multifocal presente no dente com radiopacidade normal e ligamento periodontal normal
Tipo 2 (T2)	Existe um estreitamento ou desaparecimento do espaço do ligamento periodontal em pelo menos algumas áreas e diminuição da radiopacidade em parte do dente
Tipo 3 (T3)	Características de ambos os tipos 1 e 2 estão presentes no mesmo dente. Um dente com esta aparência tem o espaço periodontal normal, encurtado ou inexistente, e existe uma radiotransparência focal ou multifocal no dente e diminuição da radiopacidade

Sinais clínicos gerais de doenças estomatológico-dentárias associadas a dor oral

Halitose

A halitose é um odor desagradável e anormal da respiração (Mitchell, 2002; Robinson, 2002; Holmstrom *et al*., 2007). Pode ser sinal de doença oral e é, na maioria dos casos, causada pelos mesmos microorganismos que causam gengivite e periodontite e que produzem compostos sulfurados voláteis (Holmstrom *et al*., 2013; Niemiec, 2013e; Clarke & Caiafa, 2014). O grau de halitose está positivamente correlacionado com o nível de inflamação periodontal (Yaegaki & Sanada, 1992). No entanto, a halitose também pode estar presente em gatos com reabsorção dentária, devido à inflamação tecidual (Lee *et al*., 2003; DuPont, 2005).

Hipersalivação

A dor com origem dentária pode manifestar-se pela sialorreia do lado afectado e hipersalivação devido ao facto da dor provocar aumento de salivação (Holmstrom *et al*., 2007; Clarke & Caiafa, 2014). Esta é muito comum no casos de reabsorção dentária devido à inflamação dolorosa dos tecidos moles circundantes (Bellows, 2010d).

Desconforto oral

As doenças orais são comuns em gatos e, muitas delas, causam desconforto intenso, tais como a doença periodontal, alguns estadios de reabsorção dentária, má oclusão, as fraturas dentárias e o complexo gengivite-estomatite-faringite felino (Gorrel *et al*., 1998; Hellyer *et al*., 2007; Quimby *et al*., 2008; Pittari *et al*., 2009; Bellows, 2010g; Robertson & Lascelles, 2010). Todavia, a maioria dos gatos com fraturas dentárias não apresentam sinais e muitas das reabsorções dentárias não causam sinais clínicos (Bellows, 2010; DuPont, 2005).

Até agora, grande parte da informação sobre desconforto e as consequências locais em gatos resulta da observação de seres humanos, como modelo (DuPont, 2005; Niemiec, 2008b; Perry & Tutt, 2015).

Dificuldade na preensão e mastigação, e várias tentativas em segurar o alimento

Para completar o exame oral, a história clínica composta pela observação do tutor acerca dos comportamentos alimentares irá elucidar os problemas dentários (Logan, 2006; Pittari et al., 2009). Os seus efeitos sobre a função dos dentes e desconforto associado podem levar a mudanças de comportamento nos hábitos alimentares (Merola & Mills, 2016a).

Dor

Fisiopatologia

A dor é um processo complexo que começa quando um estímulo nocivo activa as terminações nervosas aferentes que convertem esse estímulo em energia elétrica (Taylor & Robertson, 2004; Woolf, 2011). Os impulsos neurais aferentes da cavidade oral são transmitidos através dos nervos aferentes do nervo trigémio para realizar a sinapse com os neurónios localizados no núcleo caudal da medula, resultando na percepção da dor pelo cérebro (Beckman, 2006; Beckman, 2013a,b).

Inervação da cavidade oral

A inervação sensorial é fornecida pelo nervo trigémio (nervo craniano V) que se divide em três ramos: oftálmico, maxilar e mandibular. Os dois ramos nervosos mais importantes são o nervo maxilar e o nervo mandibular (De Vries & Putter, 2015).

Sensibilidade das peças dentárias

A cavidade pulpar é constituída pela câmara pulpar na coroa e canal radicular na raiz, contendo vasos sanguíneos, nervos, vasos linfáticos e odontoblastos (DuPont & DeBowes, 2009). A câmara pulpar do gato está muito próxima da superfície do esmalte, de modo que, qualquer fratura no dente requer tratamento endodôntico ou exodôntico (Charlier, 2013).

A dentina é o tecido vivo que compreende a parte do dente que envolve a cavidade pulpar e é coberta por cemento e esmalte (Logan, 2006; Charlier, 2013). A dentina é uma estrutura porosa que contém túbulos dentinários, que se estendem desde a superfície interna da dentina, até ao cemento ou ao esmalte, da raiz e da coroa, respetivamente. Estes são

responsáveis pela transmissão de estímulos dolorosos em caso de exposição da dentina (Charlier, 2013).

Avaliação da dor em gatos

Na natureza, os gatos são simultaneamente predadores e presas (Landsberg & Ley, 2012). Tal como os seus antepassados silvestres (*Felis lybica*), evitam demonstrar sinais externos de dor e doença como mecanismo de proteção (Rodan & Sparkes, 2012). Infelizmente, esta importante questão adaptativa de sobrevivência, ocorre também em gatos domésticos, atrasando muitas vezes o reconhecimento da doença (Bellows, 2010, Rodan, 2013).

No caso de animais não capazes de falar gestual ou verbalmente, a dor é definida pela reação comportamental a essa sensação (Lamont *et al*., 2000). As mudanças comportamentais do gato associadas à dor podem ser muito subtis, sendo por isso importante pesquisar criteriosamente os sinais típicos de dor e colocar perguntas acertadas aos seus tutores (Tobias *et al*., 2006; Aguiar *et al*., 2015).

Escalas de dor

Atualmente, não existe um método ideal aceite para avaliar a dor em animais, embora a pontuação de dor seja considerada o quarto sinal vital, após a avaliação da temperatura, do pulso e da respiração (Epstein *et al*., 2015).

As directrizes de maneio de dor da *American Animal Hospital Association/American Association of Feline Practitioners* (AAHA/AAFP) recomendaram, recentemente, a aplicação de duas escalas de dor para gatos: a) *Feline Acute Pain Scale* (escala de dor) *of Colorado State University Veterinary Teaching Hospital* (CSUVTH); b) *Escala Felina de Dor Aguda da Universidade Estadual Paulista-Botucatu* (UNESP-Botucatu) (Epstein *et al*., 2015).

A escala de dor do CSUVTH (Anexo II) é frequentemente utilizada na prática medico-veterinária, sendo também recomendada pela *International Veterinary Academy of Pain Management* (Hellyer *et al*., 2006; Brondani *et al*., 2011; Epstein *et al*., 2015; Mathews *et al*., 2014; Merola & Mills, 2016a,b). Além disso, a escala de dor do CSUVTH avalia os indicadores psicológicos e comportamentais de dor e resposta à palpação (Epstein *et al*., 2015). O presente trabalho é, de acordo com o nosso conhecimento, o primeiro estudo que

visa correlacionar as doenças estomatológico-dentárias felinas com a dor causada e a sua intensidade.

Objetivos

Este estudo foi desenvolvido com dois objetivos principais:

• Avaliar se as doenças dentárias felinas são uma causa de dor, e se, a sua gravidade se correlaciona com o grau de dor;

• Avaliar se a Feline *Acute Pain Scale* (escala de dor) *of Colorado State University Veterinary Teaching Hospital* (CSUVTH), é a escala adequada para identificar a dor causada por doença dentária em gatos.

Materiais e Métodos

Localização do estágio curricular

A recolha de dados foi realizada entre Agosto de 2015 e Janeiro de 2016 no Hospital do Gato (Lisboa, Portugal). A análise estatística e a redação da dissertação decorreram no Institute de Recherche em Sémiochimie et Ethologie Appliquée (IRSEA) durante o programa ERASMUS + entre Março e Agosto de 2016.

Descrição da série estudada

A série estudada, composta por 53 gatos domésticos (*Felis catus*), incluiu animais submetidos a exames clínicos e procedimentos cirúrgicos necessários no Hospital Viver o Gato *vulgo*, Hospital do Gato (Lisboa), durante o período do estudo.

As raças de gatos, distribuídas de forma não estatística, incluíram 41 Domésticos de Pêlo Curto, 6 Bosques da Noruega, 4 Persas, 1 Angorá Turco e 1 Sagrado da Birmânia. O estilo de vida da população variou entre *interior* e/ou *exterior*.

Critérios de inclusão: todos os gatos nos quais foi possível avaliar os parâmetros selecionados.

Critérios de não inclusão: (i) gatos que apresentam dor nível 4 (dor forte) não relacionada com doença dentária grave, (ii) impossibilidade de preencher o odontograma e (iii) impossibilidade de avaliar o nível de dor.

Protocolo resumido do estudo

1. Revisão dos problemas orais actuais e da história pregressa dos animais;
2. Exame físico geral e extraoral;
3. Exame extraoral e intraoral com o animal consciente;
4. Preenchimento da *Feline Acute Pain Scale of Colorado State University Veterinary Teaching Hospital* de acordo com a resposta dos gatos à inspeção oral;
5. Exame extraoral e intraoral sob anestesia e registo das observações no odontograma.

Parâmetros estudados

Os parâmetros relativos à condição dentária dos gatos foram divididos em 2 grupos, num total de 11 parâmetros avaliados: 6 parâmetros dentários primários e 5 parâmetros dentários secundários.

A distinção entre primários e secundários baseou-se no facto de que os parâmetros dentários primários estão classificados e reconhecidos em Medicina Dentária Veterinária pelo AVDC, enquanto os parâmetros dentários secundários são avaliados por observação visual e, portanto, mais propensos à subjectividade do observador.

Descrição dos parâmetros e classificação

Parâmetros demográficos

Na ficha clínica dentária, os parâmetros demográficos: idade, sexo e tipo de alimento, foram registados para cada gato. A idade foi classificada como uma data linear em meses. O sexo foi dividido em feminino (0) e masculino (1). O tipo de alimento foi classificado devido à preferência do gato para o alimento húmido (1), seco (2) e húmido e seco (3).

Parâmetros dentários primários

Estadio de doença periodontal (PD):

- PD 0: Gatos saudáveis

- PD 1: Gengivite

- PD 2: Periodontite (inclui PD 2 + PD 3 + PD 4)

Índice de gengivite (GI), de acordo com Löe (1967):

- GI 0: Gengiva saudável, cor normal

- GI 1: Inflamação leve, alguma alteração de cor e edema apenas na margem gengival, sem hemorrragia com a sondagem (BOP, do inglês, *bleeding on probing*)

- GI 2: inflamação moderada, eritema e edema da margem gengival, sem BOP

- GI 3: inflamação grave, eritema e edema acentuados, bem como ulceração e tendência para hemorragia gengival espontânea.

Índice de cálculo dentário (CI), de acordo com o AVDC:

- CI 0: Sem cálculo observável

- CI 1: Cálculo dentário mínimo com cálculo supragengival cobrindo menos de 1/3 da superfície bucal do dente;

- CI 2: Cálculo dentário moderado, cobrindo entre 1/3 a 2/3 da superfície bucal, com cálculo subgengival mínimo;

- CI 3: Cálculo dentário abundante, cobrindo mais de 2/3 da superfície bucal do dente, e estendendo-se subgengivalmente.

Reabsorção dentária (TR) foi diagnosticada clinicamente em cada dente e foi numerada para analíse estatística como: ausência (TR 0) ou presença (TR 1).

Fratura dentária (FX): foi diagnosticada clinicamente e classificada de acordo com a sua ausência (FX 0) ou presença (FX 1).

Dentes clinicamente ausentes (MT): é uma variável quantitativa, medida através da contagem do número de dentes ausentes registando-os no odontograma. (Tabela 5).

Tabela 5: Parâmetros dentários primários

Doença periodontal
Índice de gengivite
Índice de cálculo dentário
Reabsorção dentária
Fratura dentária
Dentes clinicamente ausentes

Parâmetros dentários secundários

Para avaliar a dor decorrente da doença dentária, o tutor foi questionado sobre os sinais clínicos de rotina dos seus gatos (Tabela 6). Estes parâmetros foram classificados em ausentes (0) e presentes (1).

Tabela 6: Apresentação dos parâmetros dentários secundários

Halitose
Hipersalivação
Desconforto oral
Dificuldade na preensão e mastigação
Várias tentativas em segurar o alimento

Parâmetro de dor

O índice de dor foi avaliado com recurso à *Feline Acute Pain Scale* (escala de dor) *of Colorado State University Veterinary Teaching Hospital* (CSUVTH), tendo em consideração os seguintes aspetos de cada gato: imagem representativa do grau de dor, estado psicológico e comportamental, resposta à palpação oral, terminando com a atribuição de um grau de dor devido à tensão do corpo, resultando numa pontuação numérica para cada gato (Tabela 7).

Tabela 7: Descrição de acordo com o parâmetro de dor

0: Dor ausente
1: Dor fraca
2: Dor média
3: Dor moderada
4: Dor forte

Análise estatística

A análise estatística foi realizada utilizando o Software 9.4 SAS (Instituto SAS, Estados Unidos da América). Sempre que a variável dependente tinha mais que 2 grupos, foram utilizados os procedimentos Glimmix ou Genmod SAS. As comparações de meios múltiplos pós-hoc foram realizadas utilizando a instrução lsmeans em proc Genmod e Glimmix utilizando o ajustamento de Tukey-Kramer. A comparação entre os parâmetros dentários e a dor, assim como os parâmetros dentários e demográficos foram realizados pelo teste qui-quadrado, excepto quando as variáveis eram dados contínuos. Neste caso, se os dados contínuos eram comparados com outros dados contínuos, estes foram analisados utilizando uma regressão logística, pelo procedimento logístico do software SAS 9.4. O nível de significância estatística considerado foi de 5% ($p < 0,05$).

Resultados

O estudo abrangeu desde gatos mais jovens apresentados para esterilização a gatos mais velhos apresentados para higiene professional da cavidade oral e extração dentária, tendo a idade média sido de 8 anos. Não houve diferença quanto ao sexo. A maioria dos gatos (60%) preferiam comer alimentos húmidos e secos.

Não foram observadas correlações estatísticas entre as condições periodontais específicas e os grupos de pontuação de dor ($p = 0,1140$). Não foram observadas correlações estatísticas entre o índice de gengivite com diferentes graus de dor ($p = 0,6545$), nem entre o índice de cálculo dentário e os diferentes graus de dor ($p = 0,2440$). As fraturas dentárias não foram estatisticamente associadas a diferentes graus de dor ($p = 0,2925$). O número de dentes clinicamente ausentes foi o único parâmetro dentário primário correlacionado estatisticamente

com o grau de dor ($p < 0,0001$). Os resultados mostram que mais dentes clinicamente ausentes foram associados a maior pontuação na escala de dor. Não houve correlação estatisticamente significante entre a reabsorção dentária e grau de dor, porém observou-se uma tendência ($p = 0,0844$), na qual, a ausência de dor foi maioritariamente encontrada na ausência de TR.

Todos os parâmetros dentários secundários foram estatisticamente associados aos graus de dor avaliados de acordo com a escala de dor do CSUVTH. As importantes correlações estatísticas entre a presença de dor e os parâmetros dentários secundários são apresentados na Tabela 8.

Tabela 8: Parâmetros dentários secundários de acordo com a escala de dor

Desconforto oral	p = 0,0239
Halitose	p = 0,0293
Hipersalivação	p = 0,0055
Dificuldade na preensão e mastigação	p = 0,0013
Várias tentativas em segurar o alimento	p = 0,0013

Um dos exemplos, a presença de desconforto oral (MD) foi correlacionada estatisticamente com a presença de dor ($p = 0,0239$). Uma análise estatística adicional (teste qui-quadrado) permitiu avaliar que: quando comparado com a pontuação da escala de dor 0, o risco de desconforto oral foi 38 vezes maior (odds ratio 38,091), 75 vezes maior (odds ratio 75,028) e 135 vezes maior 135,054) de ocorrerem na escala de dor, pontuações 1, 2 e 3, respetivamente. A presença de desconforto oral foi diretamente correlacionada com a presença de dor. Os restantes parâmetros dentários secundários, foram avaliados, inclusivé pela mesma análise estatística adicional (teste qui-quadrado).

A análise estatística mostrou que a idade foi o parâmetro demográfico mais frequentemente associado à presença de alterações dentárias. De facto, os gatos mais velhos apresentaram diversas alterações dentárias, como doença periodontal ($p = 0,0159$) e dentes clinicamente ausentes ($p <0,0001$), e sinais clínicos como desconforto oral ($p = 0,0156$), halitose ($p = 0,0056$), hipersalivação ($p = 0,0083$), dificuldade na preensão e mastigação ($p = 0,0005$) e várias tentativas em segurar o alimento ($p = 0,0005$).

O índice de gengivite (GI) foi estatisticamente correlacionado com o tipo de alimento ($p < 0,0001$). A significância estatística foi encontrada entre o GI 3 e o tipo de alimento ($p = 0,0025$). A análise estatística também permitiu avaliar que o risco de ocorrência de GI 3 com alimentos secos era 0,067 vezes menor (odds ratio 0,067) do que com alimentos secos e 0,022 vezes menor (odds ratio 0,022) com alimentos húmidos e secos comparados com alimentos secos. Os alimentos secos, húmidos e secos foram factores protetores para GI 3, quando comparados com alimentos húmidos isoladamente.

Também, de acordo com os dentes clinicamente ausentes, houve uma correlação significativa entre dentes clinicamente ausentes e tipo de alimento ($p < 0,0001$). Os gatos que comiam alimentos húmidos e secos tiveram menor número de dentes clinicamente ausentes quando comparados com gatos que comiam apenas alimentos húmidos ou secos.

Observou-se uma diferença estatisticamente significativa entre sexo e dificuldade na preensão e mastigação ($p = 0,0201$) e entre sexo e várias tentativas em segurar o alimento ($p = 0,0201$). O risco para os gatos de terem dificuldade em preender e mastigar, e várias tentativas em segurar alimentos foi 0,253 vezes menor (odds ratio 0,253) em machos quando comparado com as fêmeas, mostrando que o sexo é um factor protetor em ambos os casos. Isso pode significar que os gatos machos são menos propensos a ter dificuldade na preensão e mastigação e várias tentativas em segurar o alimento do que as gatas.

Quanto à comparação entre o tipo de alimento e a dor, com base na *Feline Acute Pain Scale (*escala de dor) of *Colorado State University Veterinary Teaching Hospital* (CSUVTH), não se observou correlação estatística nem tendência ($p = 0,7243$).

Discussão

Este estudo demonstrou que todos os parâmetros dentários secundários incluídos na análise estatística estavam estatisticamente correlacionados com os grupos de dor da escala de dor do CSUVTH. No estudo, incluímos na categoria de parâmetros secundários, os parâmetros baseados em observações realizadas pelos tutores (desconforto oral, halitose, hipersalivação, dificuldade na preensão e mastigação, várias tentativas em segurar o alimento). Assim, a análise estatística mostrou que a *Feline Acute Pain Scale* (escala de dor) *of Colorado State University Veterinary Teaching Hospital* (CSUVTH), que se baseia em

observações comportamentais, parece ser adequada para avaliar condições de dor relacionadas com os sintomas orais detetados pelas observações visuais dos proprietários. Ao contrário, quanto aos parâmetros dentários primários, apenas o número de dentes clinicamente ausentes foi correlacionado estatisticamente com os grupos de dor da escala de dor. Os parâmetros primários são os parâmetros medidos por exame clínico profundo, e com base em categorias de escala precisas definidas pelo AVDC. Esta geral falta de associação estatística parece revelar que a escala de dor do CSUVTH foi menos adequada para avaliar as condições de dor relacionadas com doenças orais avaliadas por exames clínicos precisos, no entanto é uma ferramenta existente e promissora para este caso.

Algumas doenças dentárias têm sido relatadas anteriormente como causadoras de desconforto em gatos (Gorrel *et al*., 1988; Gorrel, 2004a; Tobias *et al*., 2006; Hellyer *et al*., 2007; Quimby *et al*., 2008; Pittari *et al*., 2009; Bellows, 2010g; Robertson & Lascelles, 2010). Os resultados estão de acordo com esses estudos e, além disso, também evidenciam que o desconforto oral está associado à dor. O desconforto oral ocorre na presença de doenças orais com diferentes etiologias devido ao importante sistema nervoso que inerva os dentes e toda a cavidade oral (Bellows, 2010; De Vries & Putter, 2015; Perry & Tutt, 2015).

A halitose é um sinal de doença oral (Holmstrom *et al*., 2013; Niemiec, 2013e, Clarke & Caiafa, 2014). Os nossos resultados demonstraram que a halitose não é apenas um sinal de doença oral, mas também está associada à presença de dor oral como consequência da desordem oral subjacente.

Os resultados referentes à hipersalivação estão de acordo com a literatura consultada. Estudos anteriores relatam que a hipersalivação pode ser um sinal de doença dentária e também um comportamento associado à dor oral (Bellows, 2004b, Bellows, 2010d, Clarke & Caiafa, 2014, Merola & Mills, 2016a). A dor sentida pelo gato na cavidade oral pode estar relacionada com a inflamação dos dentes em torno dos tecidos moles e dor endodôntica, devido às doenças dentárias apresentadas (Holmstrom *et al*., 2007).

Mesmo a dificuldade na preensão e mastigação, e a necessidade de várias tentativas para segurar alimentos, foi correlacionada com a dor. A presença de dor oral pode ter várias consequências na ingestão de alimentos, levando por vezes a mudanças nos hábitos alimentares (Logan, 2006; Merola & Mills, 2016a). Quando o gato está a comer, a comida pode cair da sua boca devido à dor sentida pelo contato com uma área afectada nos dentes ipsilaterais.

Quanto aos parâmetros dentários primários, apenas o número de dentes clinicamente ausentes foi estatisticamente correlacionado com o aumento de dor e observou-se uma tendência quanto à presença de lesão de reabsorção dentária. A literatura descreve que o número de dentes ausentes está associado a um estadio tardio da doença periodontal e a uma fase tardia de reabsorção dentária (Bellows, 2010a; DeBowes, 2010; Niemiec, 2013e, Clarke & Caiafa, 2014). O presente estudo mostra que os dentes clinicamente ausentes também estão associados à dor em gatos. Estas causas subjacentes de dentes ausentes podem ser também as causas da dor oral em gatos com esta condição dentária.

Os dentes clinicamente ausentes também podem ser encontrados em gatos mais jovens. A dor e descoforto nestas idades pode dever-se ao fenómeno de erupção dentária (Rusbridge *et al*., 2010). Está descrito que os gatos que apresentam gengivite grave podem ter dentes ausentes, e os resultados deste estudo corroboram essa hipótese (Bellows, 2010d).

No presente estudo, a maioria da TR foi diagnosticada clinicamente, o que significa que as únicas lesões de TR diagnosticadas foram lesões em estadio tardio (Gorrel, 2015). O que pode explicar, o facto de que, embora não houvesse uma associação estatisticamente significativa, foi encontrada uma tendência entre TR e dor da escala de dor. Conforme descrito na literatura e também na opinião da autora sobre os dados apresentados neste trabalho, a TR pode estar acompanhada de aumento da dor (Lommer & Verstraete, 2000; Clarke & Caiafa, 2014; Gorrel, 2015).

Quase todas as fraturas de cúspide felina expõem a câmara pulpar, no entanto, quando a polpa é completamente necrosada, a dor diminui (Bellows, 2004b, Niemiec, 2005, Bellows, 2010d). Como não foi possível determinar o momento em que a fratura ocorreu nos gatos do presente estudo e alguns gatos apresentaram fraturas que não afetaram a polpa em outros dentes, a ausência de associação estatisticamente significativa à dor pode estar relacionada com o facto de que os gatos não sentiam dor no momento do exame ou ao facto de que as fraturas não eram complicadas.

Não foram observadas correlações estatisticamente significativas entre doença periodontal, índice de gengivite e índice de cálculo dentário com índices de dor da escala de dor. Na opinião dos autores esse resultado pode ser devido ao facto da escala da dor aguda felina não estar totalmente adaptada para avaliar a dor relacionada com tais alterações patológicas dentárias específicas.

A idade dos gatos foi estatisticamente correlacionada com vários parâmetros dentários. A associação entre PD e idade tem sido relatada anteriormente por vários estudos, que descreveram que a PD pode afetar gatos em todas as idades e a gravidade aumenta com a mesma (Gengler *et al*., 1995; Lommer & Verstraete, 2001). Isto pode ser explicado pelo facto da doença periodontal ser uma condição progressiva e que tende a agravar se a causa inicial não é tratada. Também o número de dentes clinicamente ausentes foi associado ao aumento da idade, provavelmente porque as doenças que causam dentes clinicamente ausentes são progressivas e precisam de tempo antes para levar à queda ou destruição do dente (DuPont, 1998; Richards *et al*., 2005; Lobprise, 2007; Bellows, 2010d; DeBowes, 2010; Niemiec, 2013c,e; Perry & Tutt, 2015). Quanto aos outros parâmetros primários, a TR merece algumas explicações. De acordo com os resultados obtidos, a idade não influenciou a prevalência de TR. A literatura consultada descreve que a incidência de TR aumenta com o aumento da idade (Wessum *et al*., 1992, Gorrel, 2015). Por outro lado, outro estudo, revela que a idade não foi correlacionada com a incidência de TR na população de gatos raças puras (Girard *et al*., 2008). Os resultados do nosso estudo estão de acordo com este último, podendo dever-se ao facto de que a população estudada foi composta por gatos mistos e puros, e por um grande número de gatos jovens.

Todos os sinais clínicos gerais de doenças estomatológico-dentárias associados a dor oral (os parâmetros percebidos pelos tutores) foram correlacionados com a idade. Como explicado anteriormente, a maioria das doenças orais são progressivas no tempo, assim mesmo, as suas manifestações comportamentais são mais comuns e detetáveis com o aumento da idade.

O género não foi correlacionado com alterações patológicas dentárias, excepto pelos dois parâmetros sobre a capacidade preender e de segurar alimentos, dos quais as fêmeas parecem ser mais afetadas. Foi previamente demonstrado que a doença periodontal não está correlacionada com o sexo (DuPont, 1988, Verhaert & Wetter, 2004, Girard *et al*., 2009). Quanto à relação entre TR e sexo, vários achados contraditórios estão presentes na literatura. No passado, alguns autores relataram que poderia haver predisposição sexual (Reiter & Mendoza, 2002), com relatos de serem os machos mais afetados (Wessum *et al*., 1992) ou as fêmeas (Lund *et al*., 1998). Estudos mais recentes, demonstraram que não há associação entre sexo e TR (Scarlett *et al*., 1999, Ingham *et al*., 2001, Girard *et al*., 2008, Mestrinho *et al*., 2013, Gorrel, 2015). No presente estudo, o sexo não afetou a prevalência de TR, estando de acordo com os estudos mais recentes.

Quanto ao tipo de alimento, observou-se uma correlação estatisticamente significativa, tanto com o índice de gengivite como com o número de dentes clinicamente ausentes. Curiosamente, os resultados obtidos neste trabalho mostraram que os gatos que se alimentavam apenas com alimentos húmidos eram aqueles que apresentavam um GI 3, quando comparados com gatos que comiam alimentos secos e húmidos ou apenas alimentos secos. Esta correlação pode ter duas explicações possíveis. Uma delas é que um gato que apresenta GI 3 poderia preferir alimentos húmidos para reduzir o desconforto oral durante o consumo (Jennings *et al*., 2015, Rolim *et al*., 2016). A segunda explicação pode ser que esses gatos têm uma inflamação grave, porque comem apenas comida húmida, descrita na literatura não realizar uma remoção mecânica eficiente da placa dentária (Watson, 1994, Reiter & Mendoza, 2002, Logan, 2006, Niemiec, 2013d, Perry & Tutt, 2015). Em relação à influência do tipo de alimento no número de dentes clinicamente ausentes, os nossos resultados mostraram que uma dieta equilibrada composta por alimentos secos e húmidos está associada aos gatos que apresentaram todos ou mais dentes do que os gatos que comem somente alimentos secos ou apenas húmidos.

Conforme descrito anteriormente, a forma dietética e a ingestão nutricional afetam a integridade dentária e óssea, e a mucosa e a longevidade dentária (Logan, 2006). A análise estatística também revelou que não houve correlação entre o tipo de alimento e os grupos de dor da escala de dor.

Tanto quanto sabemos, este é o primeiro estudo que avalia a eficácia de uma escala de dor na deteção de dor devido a distúrbios orais em gatos. A descoberta mais importante é que a *Feline Acute Pain Scale* (escala de dor) *of Colorado State University Veterinary Teaching Hospital* (CSUVTH) parece ser muito precisa na deteção de dor associada a distúrbios orais que neste estudo foram identificados por vários parâmetros avaliados pelas observações dos tutores. Na opinião dos autores, este aspeto é muito importante, pois os nossos dados parecem ilustrar uma estreita correlação entre uma escala baseada em observações visuais de manifestações de dor e condições orais avaliadas da mesma maneira, sempre observando as manifestações comportamentais de uma alteração oral. Ao contrário, esta escala parece não estar totalmente adaptada para detetar a dor causada por uma condição oral precisa, tal como as doenças analisadas por uma avaliação clínica oral completa e medidas de acordo com graus de pontuação precisas (as condições que aqui incluímos na categoria de parâmetros primários). Como tal, esta escala mostra uma falta de eficácia, se aplicada a doenças orais específicas diagnosticadas com métodos clínicos precisos. A escala de dor do CSUVTH foi

concebida para detetar a dor aguda em gatos, enquanto algumas das alterações dentárias apresentadas neste estudo são fenómenos crónicos e progressivos (Okuda e Harvey, 1992; Perry & Tutt, 2015).

Outro aspeto importante confirmado pelo nosso estudo é que as doenças dentárias são um problema importante e comum em gatos, o que deve ser evitado e avaliado com precisão para melhorar a saúde oral e o bem-estar dos gatos (Lommer & Verstraete, 2001, Vogt *et al*., 2010; Perry & Tutt, 2015). O exame da cavidade oral no gato envelhecido deve começar pela formulação de questões ao proprietário, sobre sinais de dor e doenças bucodentárias, tais como os parâmetros que são sinais clínicos comuns de doença estomatológico-dentária (Richards *et al*., 2005, Bellows, 2016a,b). Uma vez que os sinais clássicos de envelhecimento observados pelos proprietários de gatos são geralmente comportamentais, esta correlação sugere que os gatos envelhecidos que durante a sua vida não tiveram cuidados orais adequados, inevitavelmente desenvolverão doença estomatológico-dentária (Pittari *et al*., 2009).

A formação do cliente sobre as doenças da cavidade oral é fundamental. De facto, o vínculo entre cliente-animal-veterinário é fortalecido e a qualidade da vida dos gatos melhora (Lommer & Verstraete, 2001, Vogt *et al*., 2010). A escovagem dentária é considerada o padrão em cuidados da cavidade oral domiciliários, sendo o único meio mais eficaz de remover a placa dentária (Gorrel, 2004c; Ray & Eubanks, 2009). As pastas dentífricas veterinárias estão disponíveis com sabores apreciados pelos felinos.

Conclusão

Em conclusão, a *Feline Acute Pain Scale* (escala de dor) *of Colorado State University Veterinary Teaching Hospital* (CSUVTH) parece ser eficaz na avaliação da dor induzida por estímulos no contexto de um agravamento geral da saúde oral em gatos (parâmetros secundários), sendo detectáveis principalmente por observações visuais, como a escala. Esta subjectividade pode ser a causa da falta de resultados significativos quando se utiliza esta escala na avaliação da dor devido a doenças felinas orais precisas. A associação estatisticamente significativa encontrada entre os graus de dor e a alta gravidade associada ao número de dentes clinicamente ausentes, bem como a tendência de reabsorção dentária reforça essa hipótese. Estudos adicionais também se devem focar na avaliação da eficácia de outras escalas concebidas para medir a dor em animais e na padronização de protocolos

necessários para avaliar a saúde oral em gatos. Este trabalho, permitiu esclarecer, definitivamente, que os gatos com doença oral sentem dor e que a mesma aumenta de forma dependente da gravidade da doença. A prevenção de distúrbios orais é de extrema importância para contribuir para a melhoria do bem-estar e da qualidade de vida em gatos.

List of Abbreviations, Acronyms and Symbols

A: Absent

AL: Attachment Loss

AVDC: American Veterinary Dental College

BOP: Bleeding on Probing

CCF: Complicated Crown Fracture

CEJ: Cementoenamel Junction

CI: Calculus Index

CSUVTH: Colorado State University Veterinary Teaching Hospital

DHF: Difficulty Holding Food

F: Furcation Exposure

FX: Tooth Fracture

GI: Gingival Index

Ha: Halitosis

Hy: Hypersalivation

MD: Mouth Discomfort

M: Tooth Mobility

MT: Missing tooth

mm: Millimeters

P: Present

PD: Periodontal Disease

SAAF: Several Attempts Arresting Food

T: Types of Tooth Resorption

TR: Stages of Tooth Resorption

UCF: Uncomplicated Crown Fracture

UNESP: Universidade Estadual Paulista

%: Percentage

General Index

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Chapter I: Internship casuistics

The internship was made in two different places. The first was in Hospital do Gato (Lisbon, Portugal) from August of 2015 until January of 2016, and the second one in Research Institute in Semiochemistry and Applied Ethology (IRSEA) (Apt, France) from March until August of 2016. Both were enriching in clinical and scientific knowledge.

The present report will be a representation of all activities performed in both places, divided in two sections: 1) casuistic of cases involved in Hospital do Gato; 2) description of the activities carried out in IRSEA.

Hospital do Gato

Hospital do Gato is the first veterinary hospital in Portugal specialized solely on cats. Its team has professionals with more than 20 years of experience in veterinary medicine, and continued professional development in feline medicine. The Hospital is a practice member of the International Society of Feline Medicine (ISFM) and is denominated a Cat Friendly Clinic at gold level by this Society (ISFM). Statistical distribution can be observed in Tables 9 to 28.

Observed procedures division

Table 9: Division of observed procedures at Hospital do Gato	%
Clinical and Surgical Medicine	68,7 %
Preventive Medicine	31,3 %

Noticed that preventive medicine is a common practice in the Hospital.

Preventive medicine description

Table 10: Preventive health care for cats	%
Parasite control	19 %
Microchipping	14 %
Retrovirus testing	14 %
Vaccination	9,5 %
Grooming and claw care	5,7 %
Preventive dental care education	5 %
Minimum database check-up	4,8 %
Nutrition and weight management	2 %
Behavioral problems prevention	1 %
Neutering	
Ovariohysterectomy	15 %
Surgical castration	10 %

Clinical and surgical medicine description

Table 11: Distribution of clinical and surgical medicine	%
Dental and oral diseases	28 %
Digestive system, liver and abdominal cavity diseases	22 %
Urinary tract disorders	14 %
Respiratory apparatus	5,6 %
Opthalmology	5 %
Dermatology	4,3 %
Endocrinology	4 %
Infectious diseases	4 %
Cardiovascular diseases	3 %
Hematology and immune-related disorders	2 %
Neurology	2 %
Oncology	1,9 %
Reproduction	1,7 %
Musculoskeletal diseases	1 %
Behavior problems	0,9 %
Nutritional management of diseases	0,4 %
Toxicology	0,2 %

Clinical and surgical cases description

Table 12: Dental and oral diseases	%
Internal Medicicine	
Periodontal disease	29,5 %
Tooth resorption	10 %
Dentoalveolar trauma	9 %
Feline chronic gingivostomatitis	3 %
Juvenile hyperplastic gingivitis	3 %
Squamous cell carcinoma	2 %
Eosinophilic granuloma complex	1 %
Fibrosarcoma	0,8 %
Jaw fractures	0,7 %
Surgery	
Scaling	24%
Tooth extraction	17%

Table 13: Digestive system, liver and abdominal cavity diseases	%
Esophagus	
Esophageal strictures	1 %
Megaesophagus	1 %
Stomach	
Gastritis	14,7 %
Gastric lymphoma	1 %
Intestines	
Enteritis	16,8 %
Intestinal lymphoma	10 %
Intestinal foreign bodies	6 %
Anal sac impaction	5 %
Constipation	4 %
Gastrointestinal parasites	3 %
Inflammatory bowel disease	2 %
Anal sac abscessation	1 %
Intussusception	1 %
Rectal prolapse	1 %
Exocrine Pancreas	
Pancreatitis	15,7 %
Liver	
Hepatic lipidosis	10,8 %
Cholangitis	3 %
Ascites	2 %
Hepatic encephalopathy	1 %

Table 14: Urinary tract disorders	%
The upper urinary tract	
Chronic kidney disease	47,7 %
Glomerulonephritis	3 %
Hydronephrosis	3 %
Polycystic kydney disease	3 %
Pyelonephritis	3 %
Renal amyloidosis	2 %
Acute renal failure	1,5 %
Perinephric pseudocysts	1,5 %
Ureteronephrolithiasis	1,5 %
The lower urinary tract	
Urolithiasis and urethral plugs	18,8 %
Idiopathic cystitis	9 %
Lower urinary tract infection	6 %

Table 15: Respiratory apparatus	%
The upper respiratory tract	
Aspergillus spp	3,8 %
Chronic rhinosinusitis	3,8 %
Feline nasopharyngeal polips	3,8 %
Nasopharyngeal stenosis	3,8 %
Lower respiratory tract	
Asthma	15 %
Pneumonia	15 %
Pulmonary edema	11,5 %
Chronic bronchitis	7,7 %
Influenza	7,7 %
Lungworm	7,7 %
The thoracic cavity	
Pleural effusion	8,7 %
Thoracic neoplasy	7,7 %
Pneumothorax	3,8 %

Table 16: Ophtalmology	%
Conjunctivitis	30 %
Cataract	15 %
Chlamydophila felis	10 %
Entropion	10 %
Eosinophilic keratoconjunctivitis	10 %
Feline Herpesvirus	10 %
Uveitis	10 %
Corneal ulcerations	5 %

Table 17: Dermatology	%
Dermatophytosis	32 %
Chin acne	21 %
Flea allergy dermatitis	16 %
Alopecia	10,5 %
Otitis	10,5 %
Atopic dermatitis	5 %
Pemphigus foliaceus	5 %

Table 18: Endocrinology	%
Tyroid	
Hyperthyroidism	68 %
Endocrine Pancreas	
Diabetes *Mellitus*	32 %

Table 19: Infectious diseases	%
Viral diseases	
Feline leukemia virus (FeLV)	36,8 %
Feline calicivirus (FCV)	21 %
Feline panleukopenia	15,8 %
Feline immunodeficiency virus (FIV)	15,9 %
Feline coronavirus (Feline Infectious Peritonitis, FIP)	10,5 %

Table 20: Cardiovascular diseases	%
Hypertrophic cardiomyopathy	63,6 %
Feline hypertension	36,4 %

Table 21: Hematology and imune-related disorders	%
Anemia	70 %
Generalized splenomegaly	20 %
Systemic anaphylaxis	10 %

Table 22: Neurology	%
Intracraneal diseases	
Hydrocephalus	10 %
Seizure disorders	10 %
Toxoplasmosis	10 %
Neuromuscular diseases	
Discospondilosis	30 %
Spinal trauma	10 %
Miscellaneous neurologic conditions	
Horner's syndrome	20 %
Feline hyperesthesia syndrome	10 %

Table 23: Musculoskeletal diseases	%
Fractures	67 %
Arthritis	22%
Neoplasia	11 %

Table 24: Oncology	%
Mammary tumors	55 %
Injection site sarcoma	30 %
Ceruminous adenocarcinoma	15 %

Table 25: Reproduction	%
Female	
Cystic endometrial hyperplasia-pyometra complex	62,5 %
Pregnancy diagnosis	12,5 %
Uterus unicornis	12,5 %
Male	
Cryptorchidism	12,5 %

Table 26: Behavior problems	%
Agression	75 %
Anxiety, fear and phobia	25 %

Table 27: Nutritional management of diseases	%
Critical care	
Esophagostomy feeding tube	100 %

Table 28: Toxicology	%
Household hazards	
Essential oils	100%

Research Institute in Semiochemistry and Applied Ethology (IRSEA)

IRSEA is a research institute in France dedicated to the study of animal's behavior, interactions and chemical communications. The IRSEA goal is centralized in comprehension studies on underlying mechanisms, but also in the development of methods that allow management of animal behavior disorders and welfare.

- Citology in cats: citological sampling, colorating and microscopic observations;
- Managing anesthesia in research dogs to test innibitor-effects of semiochemical against mosquitos;
- General activities in CECBA, the IRSEA clinical center of ethology and animal welfare: behavioral consultations;
- Histological and immunohistochemistry procedures;
- Necropsy of a cat with tissue sampling for histopathology;
- Managing anesthesia in research cats involved in the traineeship project;
- Participate in health management of animal population of dogs and cats (example: cat ophtalmic surgery, following of post-surgery, therapies, animals socialization).

Chapter II – Dental disease and pain in cats

1. Feline dental disease

1.1 Periodontal disease

Periodontal Disease (PD) is the most common oral disease in cats, divided in two clinical presentations, gingivitis and periodontitis (Clarke & Cameron, 1998; Harvey, 2005; Lyon, 2005; Bellows, 2010d; Perry & Tutt, 2015). It is characterized by bacteria-dental-plaque inflammation of the periodontium, due to interactions between the bacterial plaque and the host (Reichart *et al*., 1984; Gorrel *et al*., 1998; Gorrel, 2004b; Harvey, 2005; Girard *et al*., 2009).

Periodontium is the supporting apparatus of the tooth, which comprises the gingiva, the radicular cementum, the periodontal ligament and the alveolar bone (Figure 1) (Mitchell, 2002; Holmstrom, *et al*., 2007; Bellows, 2010a; DeBowes, 2010; Holmstrom *et al.,* 2013; Niemiec, 2013g; Reiter & Soltero-Riviera, 2014). The periodontal ligament relies on occlusal forces to actively maintain the periodontium, thus if forces are diminished or absent, the ligament atrophies and this phenomenon causes mobility and teeth loss (Mitchell, 2002; Surgeon, 2005; Niemiec, 2013g; Clarke & Caiafa, 2014).

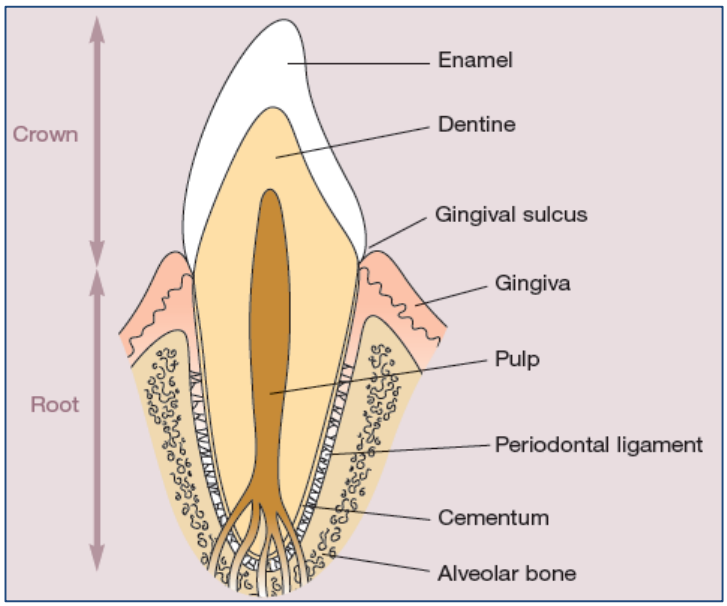


Figure 1: Diagram of a single-rooted tooth. The tooth is composed of two major parts: the crown, and the root. A central cavity within the tooth, the pulp, consists of nerves, blood vessels and connective tissues, which provides nutrition and sensation to the tooth. The pulp is surrounded and thus protected by dentine. The crown is covered in enamel and the root has an outer covering of cementum. The periodontal ligament supports and holds the tooth in the alveolar bone. The gingiva covers the alveolar process and surrounds the teeth. Gingiva can be divided into two regions: the free gingiva and the attached gingiva; the space created between the free gingiva and the tooth surface is termed the gingival sulcus (Orsini & Hennet, 1992; Clarke & Caiafa, 2014).

The factors that can predispose to the progression from gingivitis to periodontitis include malocclusions, age, animal health status, genetic, breed, diet, oral hygiene and mastication habits (DuPont, 1998). It has been considered that abrasive qualities of food have a calculus retarding effect and there are recently proper dental diets specifically designed for this effect (Watson, 1994; Clarke & Cameron, 1998; Reiter & Mendoza, 2002; Logan, 2006; Niemiec, 2013d; Perry & Tutt, 2015). PD can affect cats in every age, and a radiographic study reveals signs of periodontitis in cats older than 1 year of age (Lommer & Verstraete, 2001).

1.1.1 Etiology and pathogenesis

Bacterial plaque on the tooth surfaces is the etiological factor, which is thought to induce the host inflammatory process (Haake, 2002; Robinson, 2002; Gorrel, 2004b; Lobprise, 2007; Niemiec, 2008b; Bellows, 2010d). Plaque formation on the tooth surface is divided into three major steps (Niemiec, 2013b):

The first step is the formation of pellicle, which starts within minutes of teeth scaling and polishing (Bellows, 2010d). In this organic pellicle salivary components such as glycoproteins, proline-rich proteins, statherin and fibronectin, promote bacteria adherence during first hours (Bernimoulin, 2003).

The second step is the initial adhesion and attachment of bacteria, starting with the early colonizers including *Actinomyces* and *Streptococcus* that bind directly to the pellicle, and then the secondary colonizers including *Porphyromonas*, *Prevotella*, *Peptostreptococcus*, *Fusobacterium* will bind to the early colonizers (Bernimoulin, 2003; Bellows, 2010d; Niemiec, 2013b).

The third step is the colonization and maturation of bacterial plaque, when the attached microorganisms proliferate and give rise to the microcolonies that in turn constitute the biofilm (Robinson, 2002; Bernimoulin, 2003; Bellows, 2010d; Niemiec, 2013b).

Dental calculus is essentially bacterial plaque that has become calcified by saliva minerals (Niemiec, 2013b). Moreover, despite the fact that calculus is not inherently pathogenic, it is coated with a thin layer of plaque, which keeps plaque in close association with the gingiva perpetuating periodontal inflammation (Hinrichs, 2002; Bellows, 2004b; Gorrel, 2004b; Niemiec, 2008b; Bellows, 2010d; Niemiec, 2013b; Perry & Tutt, 2015).

Plaque and calculus are indexed and recorded according to the classifications presented (Table 29 and 30). Plaque is evaluated by using a disclosing solution placed onto the crown surface and rinsed with water (Löe, 1967; Gorrel, 2004b; Hennet *et al*., 2006; Clarke & Caiafa, 2014; Perry & Tutt, 2015). Calculus deposits can be grossly observed without disclosing agents (Bellows, 2010b; Clarke & Caiafa, 2014).

Table 29: Measure of calculus on the tooth surface. Adapted from Buikstra & Ubelaker, (1994), Greene *et al*., (2005), Bellows (2010), Niemiec (2013) and Clarke & Caiafa (2014)

Calculus index (CI)	Degree of calculus deposit	Description
0	Absent calculus	No observable calculus
1	Minimal calculus	Supragingival calculus covering less than one-third of the buccal surface of the tooth
2	Moderate calculus	Calculus covering between one-third and two-thirds of the buccal surface, with minimal subgingival calculus
3	Heavy calculus	Calculus covering greater than two-thirds of the buccal tooth surface, and extending subgingivally

Table 30: Plaque index. Adapted from modification of Turesky by Boyce & Logan (1994)

Plaque index (PI)	Description
0	No plaque
1	Thin film along gingival margin covering <1/3 of buccal tooth surface
2	Moderate accumulation of plaque covering 1/3 to 2/3 of buccal tooth surface
3	Abundant plaque covering >2/3 of buccal tooth surface

1.1.2 Clinical presentation: gingivitis and periodontitis

Periodontal Disease (PD) is clinically described in two stages: gingivitis and periodontitis (Harvey, 2005; Bellows, 2010d; Niemiec, 2013e). Gingivitis is the beginning stage of the disease and is characterized by inflammation of the gingiva (Figure 2), preventable with plaque control and reversible with treatment (Lobprise, 2007; Niemiec, 2013c; Perry & Tutt, 2015). Periodontitis is the inflammation of the periodontium (Figure 3), resulting in progressive destruction of the periodontal ligament, alveolar bone, and cementum, if not treated (Niemiec, 2013e; Perry & Tutt, 2015). It is irreversible unless guided tissue regeneration techniques are utilized (DeBowes, 2010; Niemiec & Furman, 2013; Requicha, *et al*., 2014).

The main difference between gingivitis and periodontitis is the presence of attachment loss (Niemiec, 2013e). To classify and diagnose both conditions, several parameters will be

discussed in detail after (Novak, 2002; DuPont & DeBowes, 2009; Niemiec, 2013e). Gingivitis followed by periodontitis, can lead to chronic oral infection, bacteraemia, pain and ultimately tooth loss (Perry & Tutt, 2015).

Figure 2: Clinical appearance of gingivitis in a cat. It is possible to identify the presence of marginal gingivitis, in mandibular teeth 408 and 409. The inflammation in 407 is extending onto the attached gingiva, however has not crossed the mucogingival junction. Perry & Tutt (2015).

Figure 3: Clinical appearance of periodontitis in a cat. It is possible to identify gingival recession and alveolar bone loss in right mandibular first molar (409) revealed furcation exposure (green arrow), corresponding to the presence of periodontitis. Perry & Tutt (2015).

1.1.3 Periodontal disease stages

Periodontal disease is classified according to the American Veterinary Dental College (AVDC) accepted staging of the disease (PD) (Table 31) (AVDC, 1988c). Each tooth must be evaluated individually and a whole mouth score for PD is an estimate at best (Bellows, 2010d; Niemiec, 2013e).

Table 31: Classification in stages of periodontal disease. Adapted from (AVDC) (1988), Bellows (2010), Niemiec (2013) and Perry & Tutt (2015)

Stage of periodontal disease (PD)	Description	Attachment loss	Furcation Exposure Index
0	Healthy	0	0
1	Gingivitis	0	0
2	Early Periodontitis	Attachment loss <25%	F1
3	Moderate Periodontitis	Attachment loss 25 to 50%	F2
4	Advanced Periodontitis	Attachment loss >50%	F3

Legend: About F1, F2 and F3, please refer to the Table 34.

1.1.4 Diagnosis

To successfully evaluate the periodontium, given that a complete periodontium evaluation requires periodontal probing and dental radiographic examination (that integrate the clinical examination, but not replace it), cats must be anesthetized (Mills, 1992; DuPont & DeBowes, 2009; Holmstrom *et al*., 2013; Niemiec, 2013e,f; Clarke & Caiafa, 2014; Perry & Tutt, 2015).

The PD specificities along with clinical signs are assessed and abnormalities are recorded on a specific dental chart in each tooth for all patients (Gorrel, 2004b; Bellows, 2010b,d). A dental chart utilize a dentition diagram that allows to note the information beside their site. This way, alterations are noted as a fast, easy and concise way (San Román *et al*., 1998). In this document, for each tooth, is noted the gingival index, periodontal probing depth, attachment loss, furcation exposure, mobility and missing teeth (Annex I) (Gorrel, 2004b; Bellows, 2010b,d).

1.1.5 Gingival index

The gingiva is an anatomical structure that covers the alveolar bone, thus conferring protection to periodontal structures, and is separated from the alveolar mucosa by the mucogingival junction (Perry & Tutt, 2015).

In order to standardize gingival evaluations, gingival indices have been developed. The gingival index (GI) concerns only qualitative changes in the gingival soft tissue (Löe, 1967; Niemiec, 2013c).

GI is determined with a periodontal probe applied carefully bellow the gingiva, and during this procedure, hemorrhage may occur whose termed "bleeding on probing" (BOP) (Löe, 1967; Gorrel *et al*., 1998; Bellows, 2010d; Clarke & Caiafa, 2014). GI is also evaluated depending the anatomical extension of gingivitis (Table 32) (Löe, 1967).

Table 32: Degree of gingivitis based in gingival index. Adapted from Löe (1967)

Gingival index (GI)	Degree of gingivitis	Description
0	Healthy gingiva	Normal gingiva
1	Mild inflammation	Slight color change and edema, at the gingival margin only; no BOP
2	Moderate inflammation	Redness, edema and glazing, of the gingival margin; BOP
3	Severe inflammation	Marked redness and edema as well as ulceration; Tendency for spontaneous bleeding

1.1.6 Periodontal probing depth

A periodontal probe is the most important instrument used in dentistry, both human and veterinary (Listgarten, 1980; Clarke & Caiafa, 2014). In addition to its traditional role in estimating gingival sulcus depth in millimeters (mm), it is also used to quantify gingival inflammation (Listgarten, 1980; Clarke & Caiafa, 2014). The gingival sulcus depth is measured with a periodontal probe from the cementoenamel junction (CEJ – where the enamel of the crown meets the cementum of the root) to the current gingival attachment (Figure 4) (Robinson, 2002; Niemiec, 2013e).

Otherwise, in orally healthy cats the gingival sulcus is V-shaped, barely allowing penetration with a periodontal probe (Haake, 2002; Clarke & Caiafa, 2014). Healthy cats present probing depths of gingival sulcus, between 0 and 0.5 to 1 mm (Bellows, 2010a; Holmstrom, *et al*., 2013; Niemiec, 2013g). However, once a bacterial population is established within the oral cavity, the gingival sulcus becomes deeper, showing probing depths deeper than 1 mm and the presence of a periodontal pocket (Robinson, 2002; Bellows, 2010c,d; Clarke & Caiafa, 2014; Perry & Tutt, 2015).

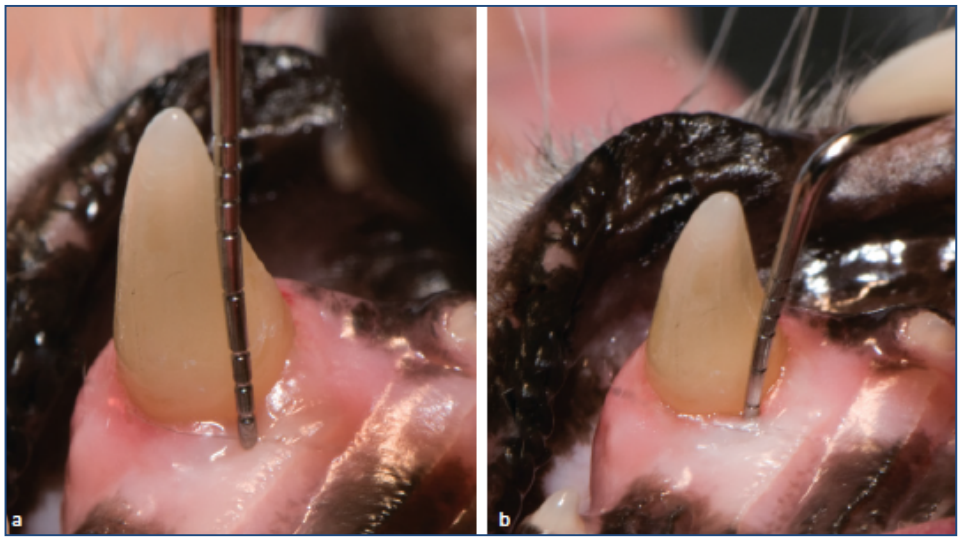


Figure 4: Periodontal probing in the left maxillary canine tooth (204) of a cat. a) Periodontal probe with millimeter markings before insertion. b) Periodontal probing depth palatal of 3 mm showing signs of attachment loss. Bellows (2010a).

1.1.7 Attachment loss

The hallmark sign of periodontitis is attachment loss, characterized by destruction of periodontal tissues (Beck & Arbes, 2002; Niemiec, 2013e). These can have two clinical presentations: 1) the apical migration results in gingival recession where consequently tooth roots become exposed; 2) the gingiva remains at the same height and the area of attachment moves apically, thus creating a periodontal pocket (Bellows, 2010c,d; Perry & Tutt, 2015).

Attachment loss can be assessed accurately by clinically measuring the distance between the cementoenamel junction to the current gingival attachment with a periodontal probe or radiographically (Lommer & Verstraete, 2001). This may also allow to evaluate the distance of the alveolar margin from the cementoenamel junction in relation to the length of the root, which is useful to ascertain periodontitis severity (Table 33) (Bellows, 2004b, Niemiec, 2013e).

Table 33: Detailed description about degrees of attachment loss. Adapted from Bellows (2010) and Niemiec (2013)

Degrees of attachment loss (AL)	Description
0	Normal periodontium
1	Gingivitis only, without attachment loss
2	Attachment loss is less than 25%
3	Attachment loss between 25 and 50%
4	Attachment loss greater than 50%

1.1.8 Furcation index

Furcation exposure (F) results from bone loss at the root junction of multirooted teeth, due to advanced periodontal disease and it is measured with a Nabers probe or explorer probe (Clarke & Cameron, 1998; Bellows, 2010e; Clarke & Caiafa, 2014). The stage of furcation exposure is also recorded on the dental chart (Table 34) (AVDC, 1988c).

Table 34: Classification in stages of furcation exposure. Adapted from Bellows (2010) and Niemiec (2013)

Stages of furcation index (F)	Description
0	No furcation exposure
1	A probe can just detect an entrance to the furcation
2	A probe can enter the furcation, but does not exit the other side
3	A probe can easily pass from side to side

1.1.9 Mobility index

Tooth mobility (M) is mainly caused by loss of supporting structures such as periodontal ligament and bone (Clarke & Caiafa, 2014). However, there are other systemic and non-systemic causes of tooth mobility, such as neoplasia, osteomyelitis, root fractures and hyperparatiroidism ("rubber jaw") (Niemiec, 2013e). Clinicians should consider these differential diagnoses when mobile teeth are encountered at initial presentation (Niemiec, 2013e). Teeth may be absent (missing teeth), in late stage periodontal disease, either because they exfoliated or they were extracted (DeBowes, 2010; Niemiec, 2013e).

The American Veterinary Dental College (AVDC) accepted definition and nomenclature of mobility indices are well described (Table 35) (AVDC, 1988c).

Table 35: Classification in stages of tooth mobility. Adapted from AVDC (2016)

Tooth mobility index (M)	Description
0	Normal physiologic mobility < 0.2 mm
1	Mobility increased in any direction except axial over a distance of 0.2 to 0.5 mm
2	Mobility increased in any direction except axial over a distance of 0.5 to 1 mm
3	Mobility is increased in any direction except axial over a distance > 1mm or any axial movement

1.2 Tooth fracture

1.2.1 Etiology and pathogenesis

Fractured teeth are a direct result of external traumatic forces applied to the tooth caused by motor vehicle accidents, fights with other cats, high-rise cats injuries or simply during playful activity (Bellows, 2010d; Soukup & Snyder, 2014).

Due to their role in apprehension and defense, canine teeth are more vulnerable to fractures, particularly the maxillary ones (Bellows, 2010d; Soukup & Snyder, 2014; Soukup *et al*., 2015). The presence of fractures can cause pain, as well as diminished mouth function, thereby affecting the cat's life quality (Holmstrom *et al*., 2013; Soukup *et al*., 2015).

1.2.2 Diagnosis and classification

The majority of cats with fractured teeth will not show any signs of discomfort, even though animals experience pain similar to humans (Bellows, 2010f).

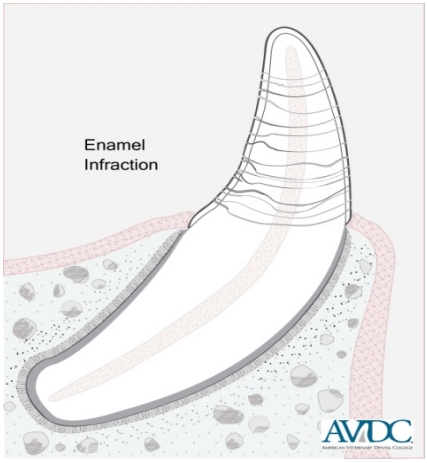
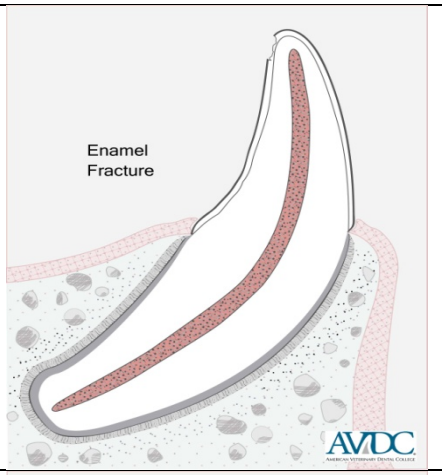
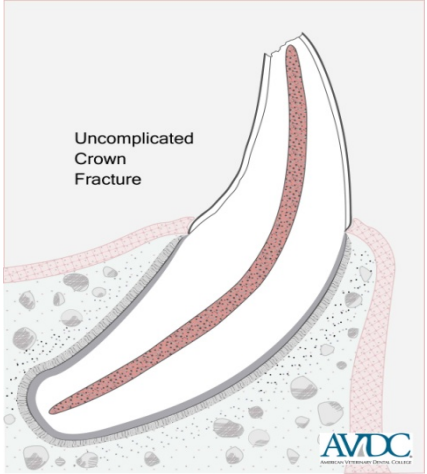
When there is a dentoalveolar injury a tooth fracture can be present, above the gingival margin: crown fracture, bellow the gingival margin: crown-root fracture; or if the tooth presents mobility with radiographic signs of root fracture, it is called root fracture (Andreasen *et al*., 2012; Soukup & Snyder, 2014).

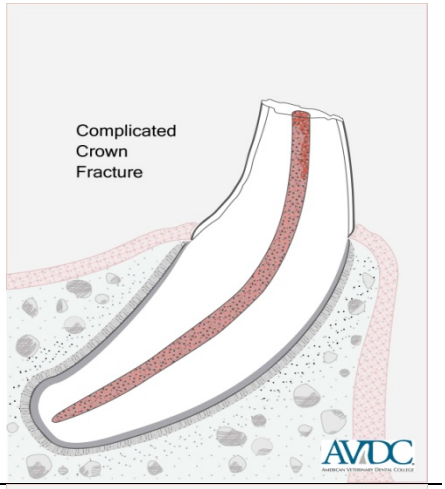
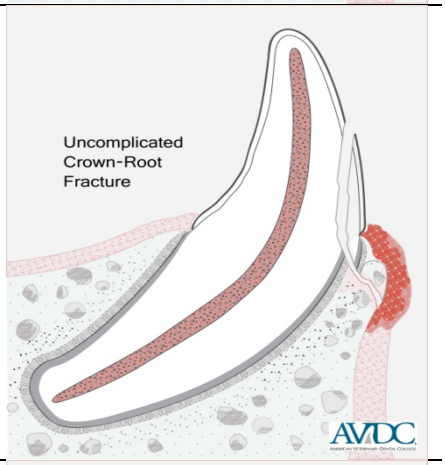
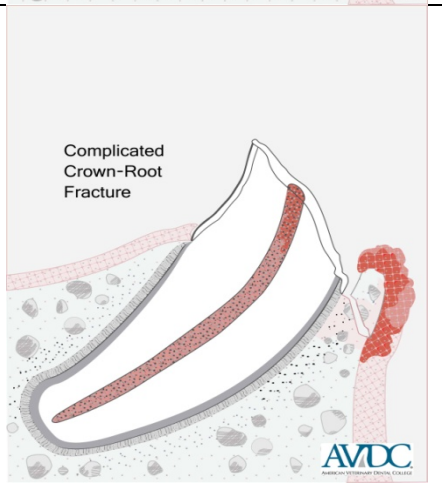
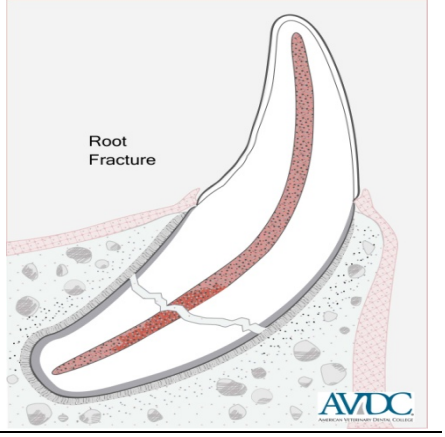
The American Veterinary Dental College (AVDC) classified tooth fractures in seven different types according to their presentations (Table 36) (AVDC, 1988b).

1.2.3 Clinical signs

An enamel infraction is asymptomatic and may be an incidental finding on oral examination (Soukup & Snyder, 2014). It does not lead to any negative consequences because it does not affect the dentin (Bellows, 2004a). However, it should be monitored for possible crack propagation (Soukup & Snyder, 2014). An enamel fracture seems not to be painful, because no dentinal tubules are exposed and there is no compromising of the pulp (Soukup & Snyder, 2014). Uncomplicated crown fracture (UCF) can compromise the dentin, because feline enamel in some locations may extend no more than 0.1 mm in depth, and due to exposure of nerve fibers within dentinal tubules, UCF causes pain (Crossley, 1995; Niemiec, 2008a; DuPont, 2010; Bellows, 2010d).

Table 36: Tooth fracture classification. Adapted from AVDC (1988a)

Tooth fracture classification (T/FX)	**Description**	**Image**
T/FX/EI Enamel infraction	Incomplete fracture of the enamel without loss of tooth substance	
T/FX/EF Enamel fracture	Fracture with loss of crown substance confined to the enamel	
T/FX/UCF Uncomplicated crown fracture	Fracture of the crown that does not expose the pulp	

T/FX/CCF Complicated crown fracture	Fracture of the crown that exposes the pulp	
T/FX/UCRF Uncomplicated crown-root fracture	Fracture of the crown and root that does not expose the pulp	
T/FX/CCRF Complicated crown-root fracture	Fracture of the crown and root that exposes the pulp	
T/FX/RF Root fracture	Fracture involving the root	

Complicated crown fracture (CCF) occurs easily in cats because the distance between the pulp chamber and the surface enamel is quite small, causing visible pulp exposure (moreover once the pulp chamber is exposed is called endodontic disease) (Holmstrom, 1992; Bellows, 2010d). That predisposes to pulpitis, and if not treated subsequent apical periodontitis may occur (Holmstrom, 1992; Bellows, 2010d; Soukup & Snyder, 2014). Uncomplicated and complicated crown-root fractures consequences are similar to those described for UCF and CCF and root fractures are often incidental findings on clinical examination (Crossley, 1995; Mitchell, 2002; Soukup & Snyder, 2014).

1.3 Tooth resorption

Tooth resorption (TR) is one of the most common dental diseases in cats (Verstraete, *et al*., 1996; Ingham *et al*., 2001; Reiter & Mendoza, 2002; Clarke & Caiafa, 2014). It occurs commonly in Burmese and Siamese cats under 12 months of age and Persian cats at younger ages, while in a number of other breeds it seems to be associated with increasing age (Wessum, *et al*., 1992; Lommer & Verstraete, 2000; Gorrel, 2015).

Several studies showed that TR affects 28 to 67% of cats and the prevalence varies with the characteristics of the population studied (Wessum *et al*., 1992; Verstraete *et al*., 1996; Lund *et al*., 1998; Scarlett *et al*., 1999; Lommer & Verstraete, 2000; Ingham *et al*., 2001; Mestrinho *et al*., 2013; Gorrel, 2015). Different methods used to diagnose TR can be clinical or radiographic (Wessum *et al*., 1992; Bellows, 2010d; Gorrel, 2015).

1.3.1 Etiology and pathogenesis

The etiology of TR is not clear (Scarlett *et al*., 1999; Gorrel, 2015). It seems that there are two different types of resorption, with different etiologies: resorption type 1 (inflammatory and associated with periodontal disease) and resorption type 2 (truly idiopathic) (Reiter *et al*., 2005; Gorrel, 2015).

TR occurs due to tooth destruction by odontoclasts (clastic multinucleated cells) that resorb the dental hard tissues (cementum and dentine) (Okuda & Harvey, 1992; Scarlett *et al*., 1999). This destruction can start on the wall of the pulp chamber (internal resorption) or in the external surface of the root (external resorption) (Reiter *et al*., 2005; Bellows, 2010d; Gorrel, 2015). The process of external tooth resorption starts in the cementum and progresses to involve the dentine of the crown and when the process extends through the crown dentine, reaches the enamel, that is either resorbed or it fractures off and a defect becomes clinically

evident (Gorrel, 2004a; Reiter *et al*., 2005). The internal resorption occurs due to a disorder of the pulp tissue (Okuda & Harvey, 1992; Gorrel, 2004a; Reiter *et al*., 2005; Bellows, 2010d).

1.3.2 Diagnosis

Clinically, tooth resorption presents as a highly vascular and inflamed granulation tissue at the gingival margin commonly on the cementoenamel junction, that may be painful and bleed easily when probed with a dental instrument (Figure 5) (Lommer & Verstraete, 2000; Reiter & Mendoza, 2002; Harvey *et al*., 2004; Reiter *et al*., 2005; Clarke & Caiafa, 2014; Gorrel, 2015). Visual inspection and tactile examination with a dental explorer will identify only end-stage lesions when they become evident in the crown (Gorrel, 2004a; Gorrel, 2015).

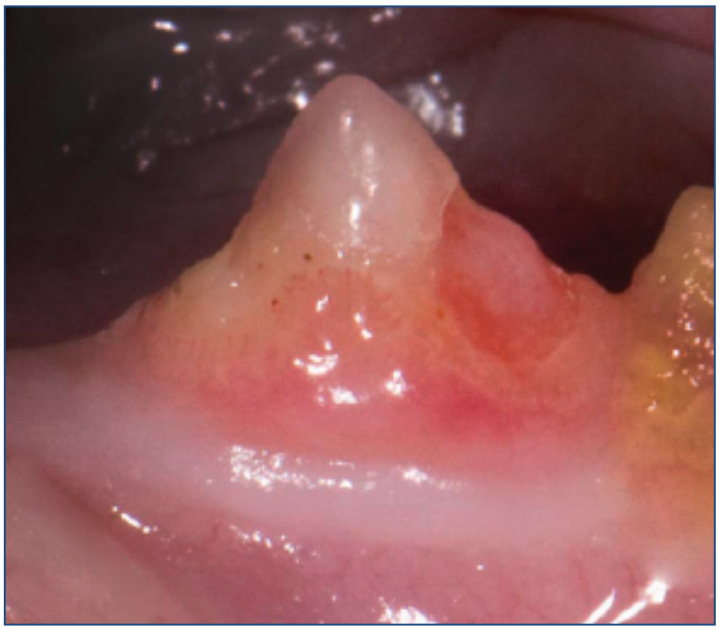
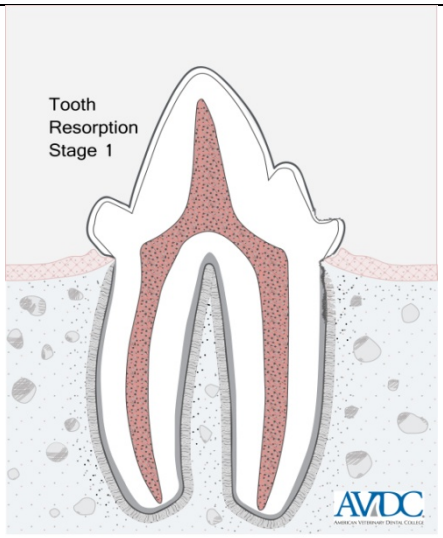
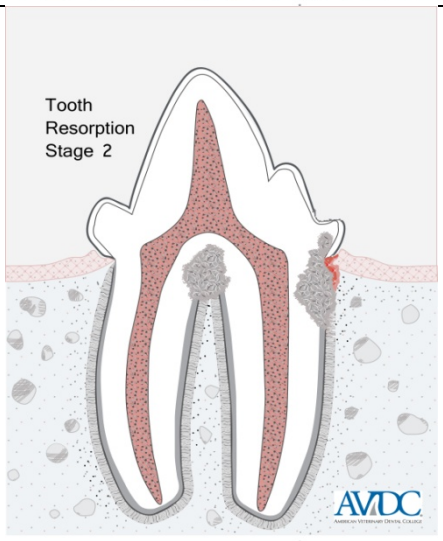
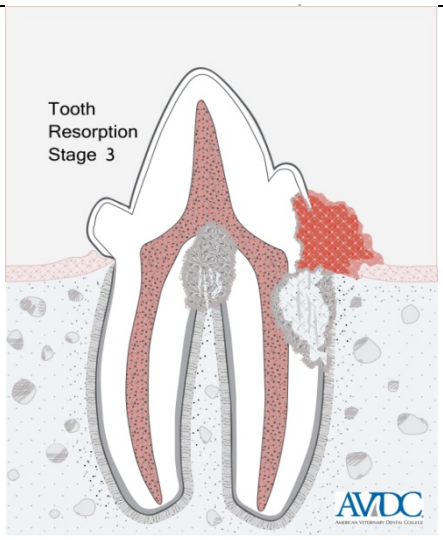


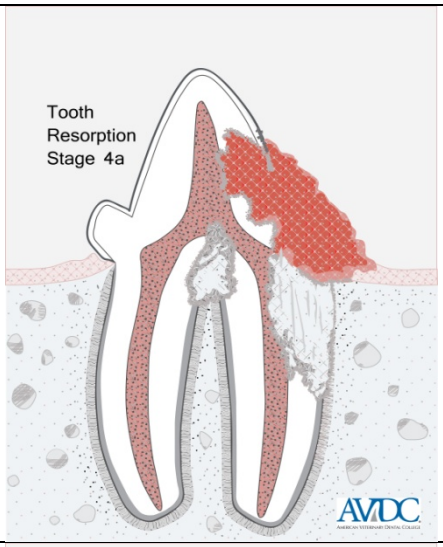
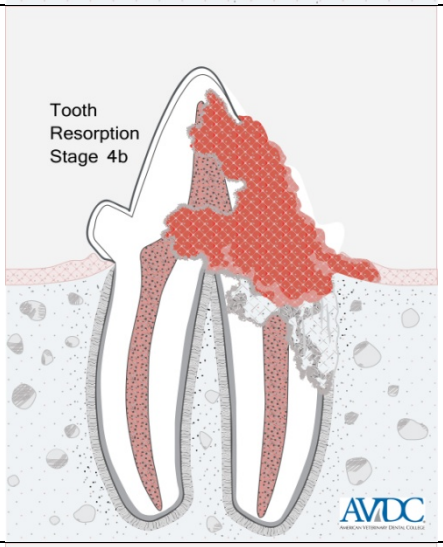
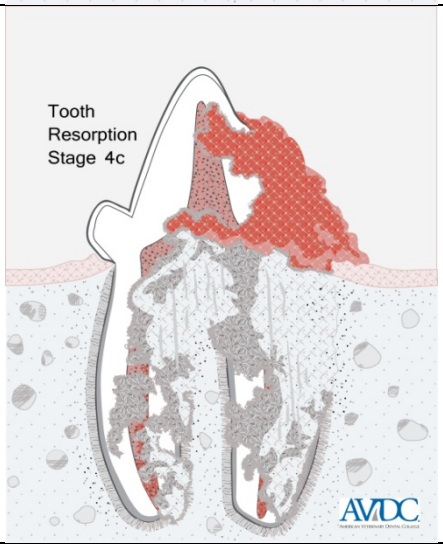
Figure 5: Presentation of feline tooth resorption. Observe a hyperplasic soft lesion above gingiva and TR at the mandibular third premolar tooth (307), the teeth most commonly affected by TR type 1 (see Table 38). Bellows (2010c,d); Mestrinho *et al*.,(2013).

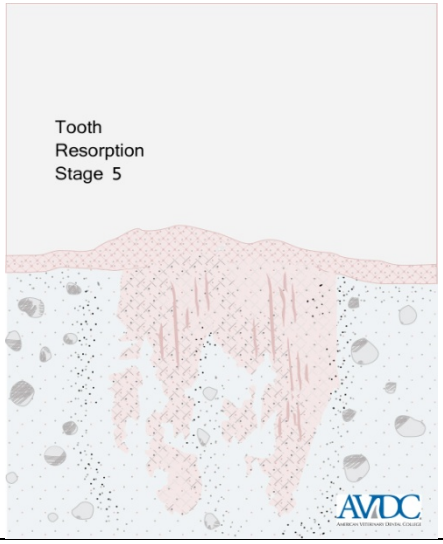
Radiographs will identify tooth resorption lesions localized on the root surfaces as radiotransparent areas in the affected teeth within the alveolar bone, and will also add the possibility to identify early stage lesions and classified them according to stages of TR (AVDC, 1988d; Wessum *et al*., 1992; Lommer & Verstraete, 2000; Gorrel, 2004a; Gorrel 2015).

Tooth resorption is classified by the American Veterinary Dental College (AVDC) based on radiographically appearance, staged according to hard dental tissue destruction and pulp involvement (Tables 37 and 38) (AVDC, 1988d; DuPont & DeBowes, 2002; DuPont, 2005; Bellows, 2010d,e; Clarke & Caiafa, 2014; Farcas *et al*., 2014; Gorrel, 2015).

Table 37: Complete description of the stages in tooth resorption lesions. Adapted from AVDC (1988d)

Stages of tooth resorption (TR)	Description	Image
Stage 1 (TR 1)	Mild dental hard tissue loss, cementum or cementum and enamel	
Stage 2 (TR 2)	Moderate dental hard tissue loss, cementum or cementum and enamel with loss of dentin that does not extend to the pulp cavity	
Stage 3 (TR 3)	Deep dental hard tissue loss, cementum or cementum and enamel with loss of dentin that extends to the pulp cavity Most of the tooth retains its integrity	
Stage 4 (TR 4)	Extensive dental hard tissue loss, cementum or cementum and enamel with loss of dentin that extends to the pulp cavity	

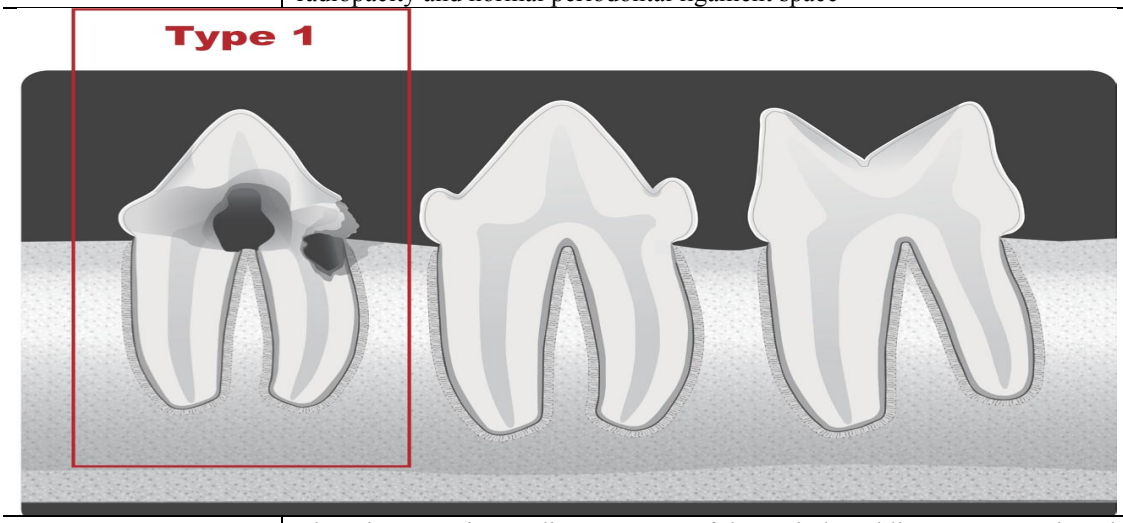
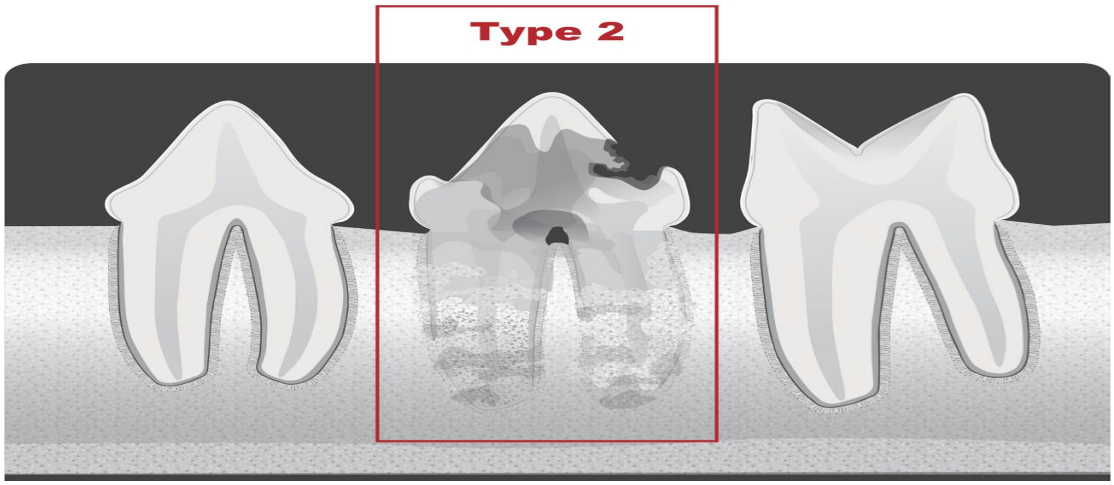
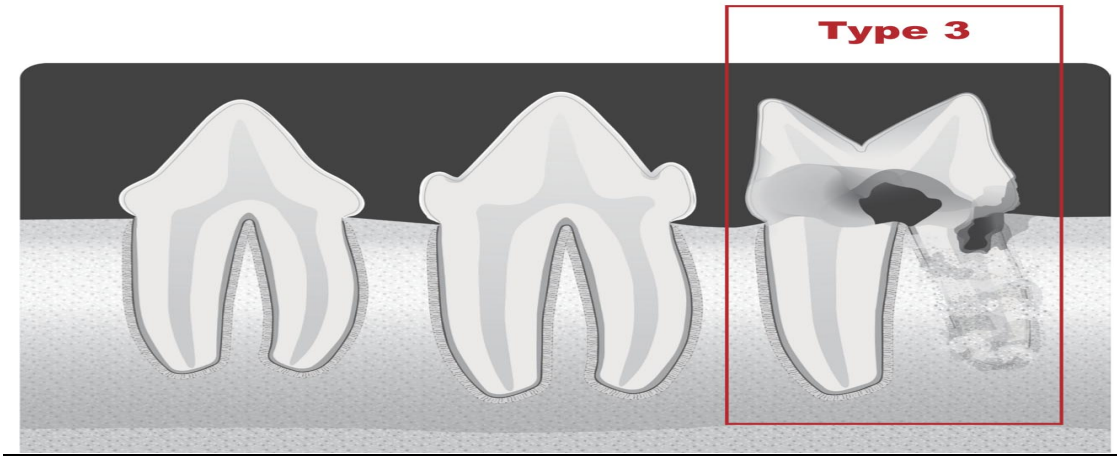
Most of the tooth has lost its integrity	
TR 4 a) Crown and root are equally affected	
TR 4 b) Crown is more severely affected than the root	
TR 4 c) Root is more severely affected than the crown	

Stage 5 (TR 5)	Remnants of dental hard tissue are visible only as irregular radiopacities Gingival covering is complete	

Tooth resorption in cats, may be described as an area of missing tooth substance (Bellows, 2010d). In TR 5 the crown is completely loss and the tooth may appear clinically absent, although the root remnants can be observed radiographically (Clarke & Caiafa, 2014).

TR have been classified in different types due to the presence or the absence of the intact periodontal ligament (Table 38) (Girard, *et al*., 2008; Bellows, 2010d; Clarke & Caiafa, 2014; Gorrel, 2015).

Table 38: Radiographic appearances of tooth resorption types. Adapted from AVDC (1988d)

Types of tooth resorption (T)	Description
Type 1 (T1)	A focal or multifocal radiotransparency is present in the tooth with otherwise normal radiopacity and normal periodontal ligament space
	
Type 2 (T2)	There is narrowing or disappearance of the periodontal ligament space in at least some areas and decreased radiopacity of part of the tooth
	
Type 3 (T3)	Features of both type 1 and type 2 are present in the same tooth. A tooth with this appearance has areas of normal and narrow or lost periodontal ligament space, and there is focal or multifocal radiotransparency in the tooth and decreased radiopacity in other areas of the tooth
	

1.4 General oral and dental disease clinical signs associated to oral pain

1.4.1 Halitosis

Halitosis is an unpleasant, abnormal odor of the breath (Mitchell, 2002; Robinson, 2002; Holmstrom *et al*., 2007). It may be a sign of an oral disease (Holmstrom *et al*., 2013; Niemiec, 2013e; Clarke & Caiafa, 2014). In the most majority of the cases, the same microorganisms that cause gingivitis and periodontitis cause it. The degree of halitosis is positively correlated to the level of periodontal inflammation (Yaegaki & Sanada, 1992). However, it can also be present in cats with resorptive lesions, due to the presence of tissue inflammation (Lee *et al*., 2003; DuPont, 2005).

1.4.2 Hypersalivation

Signs of endodontic pain include drooling on the injured side with hypersalivation being present, due to the fact that pain causes increased salivation (Holmstrom *et al*., 2007; Clarke & Caiafa, 2014). Patients affected with tooth resorption may show hypersalivation due to painful inflammation of surrounding soft tissues (Bellows, 2004b; Bellows, 2010d).

1.4.3 Mouth discomfort

Cats may not show obvious signs of pain and discomfort associated with oral disease (DuPont, 1988; Vogt *et al*., 2010; Clarke & Caiafa, 2014; Gorrel, 2015).

Oral diseases are common in cats, many of them causing discomfort and intense pain, such as periodontal disease, some stages of tooth resorption, malocclusion, fractured teeth and gingivostomatitis (Gorrel *et al*., 1988; Gorrel, 2004a; Hellyer *et al*., 2007; Quimby *et al*., 2008; Pittari *et al*., 2009; Bellows, 2010g; Robertson & Lascelles, 2010). However, a majority of cats with fractured teeth do not show any signs, and many of resorptive lesions cause no clinical signs (Bellows, 2010f; DuPont, 2005). Until now, much of the information about discomfort and local consequences in cats comes from looking at human beings as a model (DuPont, 2005; Niemiec, 2008b; Perry & Tutt, 2015).

1.4.4 Difficulty in holding food and several attempts in arresting food

To complete the oral examination, the clinical history comprised by the tutor's observation of eating behaviors will elucidate dental problems (Logan, 2006; Pittari *et al*.,

2009). Their overwhelming effects on tooth function and associated discomfort may lead to behavior changes in eating habits (Merola & Mills, 2016a).

2. Pain

2.1 Pathophisiology

The pain pathway is a complex process, which starts when a noxious stimulus activates the afferent nerve endings that convert this stimulus in electric energy (Taylor & Robertson, 2004; Woolf, 2011). Afferent neural impulses from the oral cavity are transmitted via the trigeminal afferent nerves to synapse with neurons located in the nucleus caudalis of the medulla, resulting in the perception of pain by the brain (Beckman, 2006; Beckman, 2013a,b).

2.2 Innervation of the oral cavity

Sensory innervation is provided by the trigeminal nerve (cranial nerve V), which divides into three branches: ophthalmic, maxillary and mandibular. The two most important branches in dentistry are the maxillary and the mandibular ones that leave the cranium through different foramina (De Vries & Putter, 2015). The pharynx and the base of the tongue are innervated by the glossopharyngeal and vagus nerves (cranial nerves IX and X, respectively) (De Vries & Putter, 2015).

The maxillary nerve enters in the infraorbital canal through the infraorbital foramen where it becomes the infraorbital nerve; The mandibular nerve enters to the mandibular canal in the mandibular foramen on the medial aspect of the mandible, where it becomes the inferior alveolar nerve; In the mental foramen the inferior alveolar nerves divides into the mental nerves, which emerge through the mental foramina on the laterorostral aspect of the mandible (Charlier, 2013; De Vries & Putter, 2015).

The infraorbital nerve releases branches of nerves, of which the caudal superior alveolar supply sensory innervations to the maxillary molar and possibly distal root of the fourth premolar; the middle superior alveolar branches innervate the fourth premolar (108/208); the rostral superior alveolar branch, before exiting the canal innervates the ipsilateral rostral premolars, canine and incisors; the branches of the infraorbital nerve that extend beyond the infraorbital canal innervate the soft tissue structures of the dorsal and lateral maxilla and upper lip (Charlier, 2013; De Vries & Putter, 2015).

The inferior alveolar nerve supplies sensory innervations to the ipsilateral mandibular teeth and their associated structures; rostrally to the mandibular third premolar (307/407) it divides into the mental nerves, innervating the chin, lip, rostral buccal mucosa and gingiva (Charlier, 2013; De Vries & Putter, 2015).

2.3 Sensibility of the teeth

The teeth possess a very important innervation system, innervated by branches of the maxillary and mandibular nerves (Charlier, 2013; De Vries & Putter, 2015; Perry & Tutt, 2015).

The pulp cavity is the central cavity of the tooth, consisting by the pulp chamber in the teeth crown and root canal in the root, containing blood vessels, nerves, lymph vessels and odontoblasts (DuPont & DeBowes, 2009). The pulp chamber of the cat lies very close to the enamel surface, so any fracture in a cat's tooth requires endodontic or exodontic treatment (Charlier, 2013).

Dentin is the living tissue that comprises the bulk of the tooth surrounding the pulp cavity and covered by cementum and enamel (Logan, 2006; Charlier, 2013). Dentin is a porous structure containing dentinal tubules, which extend from the dentin-cementum or dentin-enamel surfaces of the tooth, to the pulp and are responsible for transmission of painful stimuli if the dentin is exposed (Charlier, 2013).

2.4 Recognition and assessment of pain in cats

Cats in nature are both a predator and prey (Landsberg & Ley, 2012). Like their wild ancestors (*Felis lybica*), they avoid showing outward signs of pain and illness as a protective mechanism (Rodan, 2012; Rodan & Sparkes, 2012). Unfortunately this important survival adaptation occurs also in domestic cats, often delaying illness recognition (Bellows, 2010f; Rodan, 2013).

In this case of nonverbal animals, pain is defined regarding the behavioral reaction to that sensation (Lamont *et al*., 2000). Behavioral changes associated with pain in cats can be very subtle, that is why managing pain effectively requires looking for its signs and asking the right questions (Tobias *et al*., 2006; Hellyer *et al*., 2007; Aguiar *et al*., 2015).

Pain evaluation for patients with periodontal disease should utilize oral palpation of affected tissue and behavioral observation with recourse to pain scales, which provide written

documentation of pain behaviors (Beckman, 2013b). The veterinarians should develop standard operating procedures to prevent pain, including prevention of dental diseases (Rodan, 2012; Epstein *et al*., 2015). It is commonly assumed that animals experience pain even if they cannot exactly perceive or communicate it in the same way people do, however ignoring pain simply because there is difficulty measuring it, condemns animal patients to undue suffering (Hellyer *et al*., 2007).

The patient's behavior is the key to recognize and assess pain, considered the aspects of maintenance of normal behaviors, loss of normal behaviors and development of new behaviors, because animals are non verbal and cannot self-report the presence of pain (Epstein *et al*., 2015).

Some dental conditions are painful for cats, but there is a lack of studies concerning this issue. Having this in mind, the purpose of the present study is to demonstrate that some conditions are in fact painful in cats, and also to investigate if a pain scale is adequate to evaluate that type of pain and its intensity (Vogt *et al*., 2010; WSAVA, 2014). In periodontal disease the cementum destruction resulting in root exposure creates sensitivity (Beckman, 2013b). Tooth resorption can be difficult to detect, with cats often masking signs of oral discomfort or pain, but once dentin destruction has progressed to pulpal exposure, then discomfort or pain can be present (DuPont, 2005; Bellows, 2010g; Clarke & Caiafa, 2014; Gorrel, 2015). Marked gingivitis occurs in cats, and is clinically characterized by erythematous and swollen gums and potentially intense oral discomfort (Quimby *et al*., 2008; Rolim *et al*., 2016).

Avoiding treatment of painful dental conditions such as odontoclastic resorptive lesions, periodontal disease or broken teeth leads the cat to be thin, drop their food, chew on one side, eat more slowly, eat less or show less interest in food which diminished their quality and quantity of life (Pittari *et al*., 2009; Vogt *et al*., 2010).

2.5 Pain scales

There is presently no gold standard method for assessing pain in animals, although a pain score is considered the fourth vital sign, after temperature, pulse and breathing (Hellyer *et al*., 2007; Epstein *et al*., 2015). The Guidelines Task Force strongly recommends using pain scoring tools both for acute and chronic pain (Clarke & Bennet, 2006; Hellyer *et al*., 2007; Lascelles *et al*., 2012; Matthews *et al*., 2014). Behavioral responses to pain vary greatly

between species, and these differences may be linked to an animal's survival mechanisms (Lamont, 2002; Hellyer *et al*., 2007; Epstein *et al*., 2015). Therefore, pain assessment tools must be species specific (Paul-Murphy *et al*., 2004; Hellyer *et al*., 2007; Benito *et al*., 2013; Epstein *et al*., 2015).

Different tools have been used to detect pain in cats (Merola & Mills, 2016b). The main recommendations are that: a) tools must include documented levels of validity, reliability, and sensitivity from high quality, evidence-based studies; b) acute and chronic pain scales are not interchangeable, and c) canine and feline pain scales are not interchangeable (Matthews, 2000; Hellyer *et al*., 2007; Merola & Mills, 2016b). The American Animal Hospital Association/American Association of Feline Practitioners (AAHA/AAFP) pain management guidelines recently recommend two pain scales for cats: a) the Feline Acute Pain Scale from Colorado State University Veterinary Teaching Hospital (CSUVTH); b) the Universidade Estadual Paulista-Botucatu (UNESP-Botucatu) pain scale (Epstein *et al*., 2015).

The feline acute pain scale from CSUVTH is often used in veterinary practice, namely on this study, and it is also recommended by the International Veterinary Academy of Pain Management (Hellyer *et al*., 2006; Brondani *et al*., 2011; Brondani *et al*., 2013; Epstein *et al*., 2015; Mathews *et al*., 2014; Merola & Mills, 2016a,b). Behavior alterations are bettered assessed and scored using either a descriptive, numerical rating or visual analogue scale (Mathews *et al*., 2014). Moreover, the Feline Acute Pain Scale of CSUVTH evaluates the psychological and behavioral indicators of pain and response to palpation (Epstein *et al*., 2015). It is arguable whether, a tool based on non-interacting observations only would be preferable to minimize suffering, however, interacting with the painful animal can be important when detecting pain (Lascelles *et al*., 1999; Epstein *et al*., 2015). This is, to the best of our knowledge the first study in the literature that correlates feline oral diseases with pain and its intensity.

3. Aims of the Study

This study has been developed with two main aims:

- To evaluate if feline dental diseases are a cause of pain and if their severity correlates to pain score;

- To evaluate if the feline acute pain scale of the Colorado State University Veterinary Teaching Hospital (CSUVTH) is adequate to identify pain caused by dental disease in cats.

4. Material and Methods

4.1 Internship location

The collection of data was conducted between August of 2015 and January of 2016 in the Hospital do Gato (Lisbon, Portugal). The statistical analysis and the writing of the thesis were conducted in the Institut de Recherche en Sémiochimie et Ethologie Appliquée (IRSEA – Apt, France) during an ERASMUS+ program between March and August of 2016.

4.2 Population description

The studied population was composed by 53 domestic cats (*Felis catus)* attended to clinical examinations and surgical procedures in the Hospital Vivemos o Gato *vulgo* Hospital do Gato (Lisbon) during the period of this study.

Cats' breeds distributed in a non-statistical way included 41 Domestic Short Hair, 6 Norwegian Forest, 4 Persian, 1 Turkish Angora and 1 Burmese. The population life style varied between *indoor* and/or *outdoor*.

Inclusion criteria: all the cats for which it was possible to evaluate the selected parameters were included;
Non inclusion criteria: (i) cats presenting with pain scale level 4 not due to dental severe disease, (ii) impossibility to fill the dental chart and (iii) impossibility to assess the level of pain.

4.3 Study protocol

4.3.1. Oral examination

The first step of the process of oral examination was a review of current oral problem(s). Patient history was an important part of the assessment process, and included:

- Patient's signalment;
- Present and past medical information;
- Vaccination status;
- Amount of time spent indoors and outdoors;
- Type of food.

Questions to the owner regarding clinical signs related to oral disease in the cat included:

- Ever having noticed some discomfort in the mouth;
- Halitosis;
- Hypersalivation;
- Difficulty in holding food;
- Several attempts in arresting food;
- Any past dental procedures;
- Past and current dental homecare program.

4.3.2. General and extraoral physical examination

The second step was a general and extraoral physical examination, including:

- Complete clinical examination of all body systems to rule out systemic disease;
- Skin examination;
- Comparison of the left and the right side of the head and face for symmetry;
- Face palpation;
- Nares observation;
- Mandibular salivary glands palpation;
- Mandibular lymph nodes palpation;
- Muscles of mastication palpation;
- Temporomandibular joint function examination.

4.3.3. Intraoral examination

The third step of the process of oral examination was an intraoral examination of the conscious cat. To have an initial inspection of teeth, the head was holded by steady in one hand with the mouth closed and the rostral portion of lips was pulled caudally to observe:

- Occlusion;
- Missing, extra, or malpositioned teeth;
- Fractured teeth.

To evaluate the temporomandibular joint movement and inspect more intraoral structures, the cat's mouth was opened. The cat's mouth was opened by placing one hand on top of the cat's head with the thumb and forefinger lightly pressing just behind the lip

commissures. The lips were pulled caudally to reveal the premolars. To pull the lower jaw ventrally, the head was tilt backward, while applied the forefinger of the opposite hand was applied in the mandibular incisor area.

Intraoral hard and soft tissues were inspected:

- Cat's breath;
- Dentition;
- Lips;
- Oral mucosa and gingiva;
- Tongue;
- Hard palate;
- Salivary gland openings;
- Oropharynx;
- Calculus accumulation.

4.3.4. Filling of the feline acute pain scale

The fourth step of the process of oral examination was filling the feline acute pain scale of the CSUVTH according to the cats' response to mouth inspection (see Annex II):

- Observation of the figure that was more adequate to the cat;
- For each cat the "psychological & behavioral" section was read in detail and the sentences more adequate to the cat was ticked;
- For each cat the "response to palpation" section was read in detail and the sentences more adequate to the cat was ticked;
- A note was taken regarding the "body tension" degree.

4.3.5. Filling of the dental chart

The fifth step of the process of oral examination was an extraoral and intraoral examination under anesthesia, and record observations on the dental chart (Annex I). The anesthetic protocol (Annex III) was dependent on several factors such as: age, health status and type of surgery procedure.

A similar examination to that performed in the conscious patient was repeated in the anaesthetized patient, although in much greater detail. The examination included:

- Close evaluation of the soft tissues including the tongue, gingiva, mucosa and oropharyngeal areas;
- Evaluation of hard tissues, including maxilla and mandible;
- Evaluation of the dentition as a whole and then individually;
- Occlusion;
- Missing, extra, or malpositioned teeth;
- Fractured, discolored or resorbed teeth;

A periodontal probe (presented on Figure 4) was used to evaluate:

- Gingival index;
- Calculus index.

Assessment of periodontal disease, using a periodontal probe included evaluation of:

- Gingival sulcus depth in each tooth;
- Gingival recession or hyperplasia;
- Furcation involvement.

Assessment of tooth resorption using a probe included evaluation of:

- Observed lesions found to be hemorrhagic beneath hyperplasic gingival adjacent to a surface enamel defect.

Fractured teeth were assessed by:

- Visual inspection.

4.4 Studied Parameters

Parameters concerning cats' dental condition were divided in 2 groups in a total of 11 assessed parameters: 6 primary dental parameters and 5 secondary dental parameters. The secondary dental parameters were renamed for statistical analyses, as they were previously reported as *General oral-dental disease clinical signs associated to oral pain.*

The distinction into primary and secondary was based on the fact that primary dental parameters are already classified and recognized in Veterinary Dentistry (AVDC, Nomenclature), while secondary dental parameters are evaluated by visual observation and thus more prone to observer subjectivity.

4.4.1 Parameters description and classification

4.4.1.1 Demographic parameters

In the dental chart, the demographic parameters described in Table 39, were registered for each cat. Age was classified as a linear date in months; sex was divided in 0: female and 1: male; type of food was classified due to the cat's preference for the aliment as 1: wet, 2: dry, 3: wet and dry.

Table 39: The demographic parameters

Age
Sex
Type of Food

4.4.1.2 Primary dental parameters

Periodontal Disease: According to periodontal disease (PD), the different clinical presentations (Lobprise, 2007; Bellows, 2010d; DeBowes, 2010; Niemiec, 2013c,e; Perry & Tutt, 2015) were re-numbered for statistical differentiation:

- PD 0: Healthy cats
- PD 1: Gingivitis
- PD 2: Periodontitis (included PD 2 + PD 3 + PD 4)

Gingival Index (GI): the description by Löe (1967) was utilized:

- GI 0: Healthy gingiva with normal color
- GI 1: Mild inflammation with some color change and edema at the gingival margin only; no bleeding on probing (BOP)
- GI 2: Moderate inflammation, presented with redness and edema of the gingival margin; no BOP
- GI 3: Severe inflammation with marked redness and edema as well as ulceration; tendency for spontaneous bleeding

Calculus Index (CI): was classified according to veterinary dentistry classification (Bellows, 2010d; Niemiec, 2013a; Clarke & Caiafa, 2014) used by veterinary dental clinicians:

- CI 0: No observable calculus

- CI 1: Minimal calculus with supragingival calculus covering <1/3 of the buccal surface of the tooth
- CI 2: Moderate calculus, covering 1/3 – 2/3 of the buccal surface, with minimal subgingival calculus
- CI 3: Heavy calculus, covering > 2/3 of the buccal tooth surface, and extending subgingivally

Tooth Resorption (TR): was diagnosed clinically (Gorrel, 2015) in each teeth and was numbered for statistical analysis as: absence (TR 0) or presence (TR 1).

Tooth Fracture (FX): was diagnosed clinically and classified according to absence (FX 0) or presence (FX 1).

Missing Teeth (MT): is a quantitative variable that was measured by counting the number of absent teeth and registering it in the dental chart (Table 40).

Table 40: Primary dental parameters

Periodontal Disease
Gingival Index
Calculus Index
Tooth Resorption
Tooth Fracture
Missing Teeth

4.4.1.3 Secondary dental parameters

To evaluate dental disease pain, the tutor's were asked regarding routinely clinical signs in cats (Table 41). These parameters were classified as 0: absence and 1: presence.

Table 41: Presentation about the secondary dental parameters

Halitosis
Hypersalivation
Mouth discomfort
Difficulty holding food
Several attemps arresting food

4.4.1.4 Pain parameter

Pain parameter was evaluated by the author using the Feline Acute Pain Scale of Colorado State University Veterinary Teaching Hospital (CSUVTH), taking into account the following aspects of each cat: image representing pain score, psychological and behavioral status, response to palpation, and finishing with the attribution of a grade due to body tension resulting in a numeric score for each cat (Table 42 and annex II).

Table 42: Description according to pain parameter

0: Absent pain
1: Weak pain
2: Mild pain
3: Moderate pain
4: Strong pain

4.5 Statistical analysis

Statistical analysis was performed using 9.4 SAS Software (SAS Institute, North-Carolina, United States). The Generalized Linear Mixed Model was used because the dependent variable did not follow a normal distribution. When the dependent variable had more than 2 groups, Glimmix or Genmod SAS procedures were employed. The post-hoc multiple means comparisons were carried out using lsmeans statement in proc Genmod and Glimmix using the adjustment of Tukey-Kramer. Comparison between dental parameters and pain, and dental and demographic parameters were carried out using the chi-square test, except when variables were continuous data. In this case, if continuous data were compared to other continuous data, they were analyzed using a logistic regression using the Logistic procedure of SAS 9.4 software. Moreover, this procedure also allows to obtain the odds ratio. The odds ratio is an indicator, which measures the risk at each level of the interacting covariate when the parameter to be explained takes the value 1. When the comparison was carried out between a continuous data and a qualitative data, the ANOVA test was. Statistical significance was based on a 5% ($p < 0.05$) significance level.

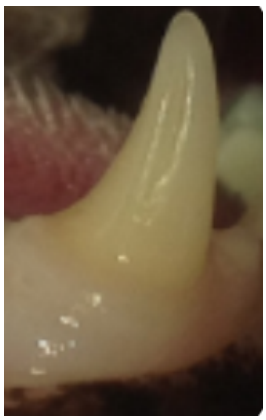
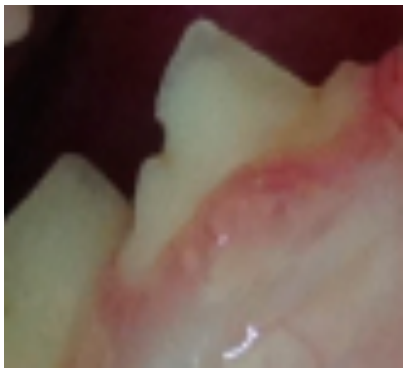
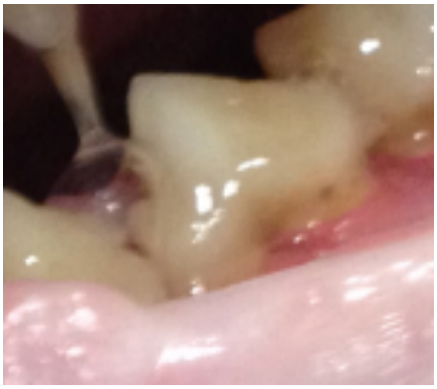
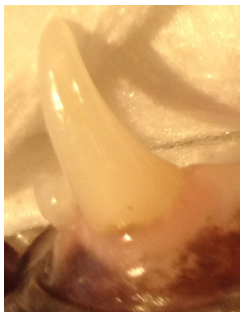
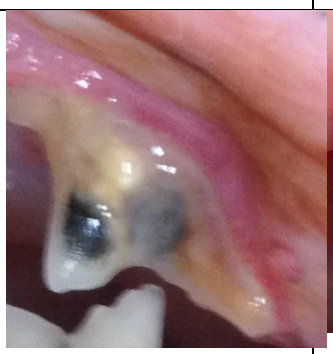
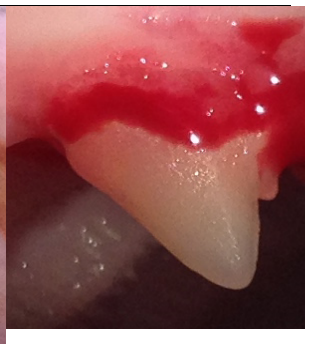
To resume, the statistical analysis allowed comparing dental parameters to pain and to demographic parameters. Moreover, the pain groups were also compared to the demographic parameter “type of food”.

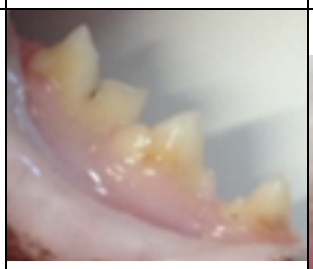
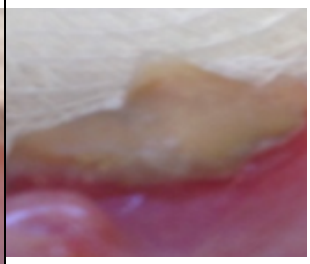
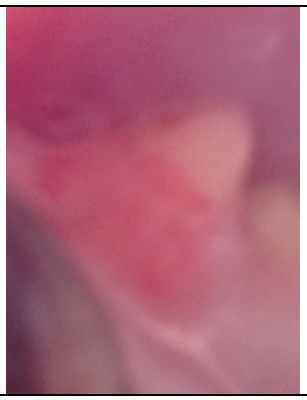
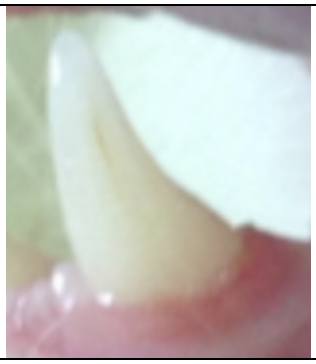
5. Results

5.1 Primary dental parameters original photography's

Photographs were taken during this study of each primary dental parameter, which was hence found and recorded (Table 43).

Table 43: Photograph description of primary dental parameters.

PD 0	PD 1	PD 2	
			
GI 0	**GI 1**	**GI 2**	**GI 3**
			

CI 0	CI 1	CI 2	CI 3
			
TR 0		**TR 1**	
			
FX 0		**FX 1**	
			

Legend: please refer to the sub-chapter “Parameters description and classification”.

5.2 Descriptive statistics

5.2.1 Demographic parameters

The study includes from younger cats presented to sterilization, as well as older cats presented to power scaling and teeth extraction being 8 years old the mean age. There were no differences in gender. And finally, most of the cats (60%) ate both wet and dry food (Table 44).

Table 44: Absolute frequency and percentage of cats according to demographic parameters

	Age		**Sex**		**Type of Food**		
53 cats	$\bar{x}$ 98 months (range: 4 – 192 months)		**Female**	**Male**	**Wet and dry**	**Wet**	**Dry**
		N	27	26	32	10	11
		%	51	49	60	19	21
		Kitten	**Junior**	**Prime**	**Mature**	**Senior**	**Geriatric**
		7 (13%)	11 (21%)	14 (26%)	5 (9%)	13 (25%)	3 (6%)

5.2.2 Dental parameters

Cats were divided in accordance to primary dental parameters. Regarding periodontal disease, 15 cats had PD0 (28%), 20 cats had PD1 (38%) and 18 cats had PD2 (34%). In what concerns the gingival index, sixteen cats had GI0 (30%), 15 cats had GI1 (28%), 14 cats had GI2 (27%) 8 cats had GI3 (15%). As to calculus index, sixteen cats had CI0 (30%), 14 cats had CI1 (26%), 11 cats had CI2 (21%) and 12 cats had CI3 (23%). The mean number of missing teeth was 3 (range from 0 to 25). The prevalence of TR was 25% (13 cats), and the prevalence of FX was 23% (12 cats) (Table 45).

Table 45: Absolute frequency and percentage of cats according to the selected way classification of primary dental parameters

	Periodontal disease (PD)			**Gingival index (GI)**				**Calculus index (CI)**				**Missing teeth (MT)**			**Tooth resorption (TR)**		**Tooth fracture (FX)**	
	0	**1**	**2**	**0**	**1**	**2**	**3**	**0**	**1**	**2**	**3**	**X**	**m**	**M**	**P**	**A**	**P**	**A**
N	15	20	18	16	15	14	8	16	14	11	12	3	0	25	13	40	12	41
%	28	38	34	30	28	27	15	30	26	21	23				25	75	23	77

P= presence, A= absence, X=mean, m= minimum, M=maximum

Cats were then divided in accordance to secondary dental parameters and the following data was found: 24 cats (45%) presented halitosis; 12 cats (23%) presented hypersalivation; 19 cats (36%) presented mouth discomfort; 23 cats (43%) presented difficulty in holding food; and 23 cats (43%) presented several attempts in arresting food (Table 46).

Table 46: Absolute frequency and percentage of cats according to secondary dental parameters classified as present (P) or absent (A) in the studied population

	Halitosis		**Hypersalivation**		**Mouth discomfort**		**Difficulty holding food**		**Several attempts**	
	P	**A**	**P**	**A**	**P**	**A**	**P**	**A**	**P**	**A**
N	24	29	12	41	19	34	23	30	23	30
%	45	55	23	77	36	64	43	57	43	57

P= presence, A= absence

5.2.3 Pain scale

Presence of pain in the studied cats was recorded according to the Feline Acute Pain Scale of Colorado State University Veterinary Teaching Hospital (CSUVTH). Twenty-two cats (41%) presented no pain (score 0), 11 cats (21%) had weak pain (score 1), 11 cats (21%) had mild pain (score 2), and 9 cats (17%) had moderate pain (score 3) (Table 47). The majority of the subjects presented pain with different degrees of intensity.

Table 47: Absolute frequency and percentage of cats according to pain scores

	Pain Scale			
	0: Absent	**1: Weak**	**2: Mild**	**3: Moderate**
N	22	11	11	9
%	41%	21%	21%	17%

5.3 Relationship between pain scale and primary dental parameters

There was a statistically significant correlation between missing teeth and pain score ($p < 0.0001$). Moreover, we observed a statistically trend between tooth resorption and pain score ($p = 0.0844$). The statistical correlations between the pain score and dental primary parameters are reported in Table 48.

Table 48: Statistic values of primary dental parameters according to pain score

Variables	**P - Value**
Periodontal Disease (PD)	0.1140
Gingival Index (GI)	0.6545
Calculus Index (CI)	0.2440
Tooth Resorption (TR)	0.0844
Tooth Fracture (FX)	0.2925
Missing Teeth (MT)	**< 0.0001**

No statistically correlations were observed between specific periodontal diseases (PD) and pain score groups (p = 0.1140) (Figure 6).

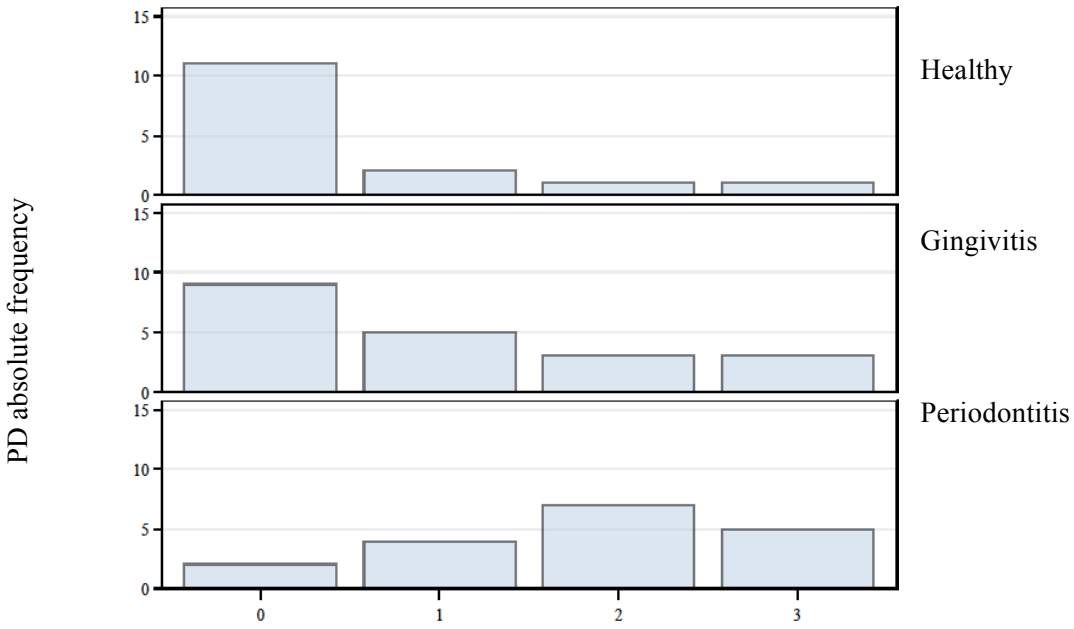


Figure 6: Graphic distribution of PD according to pain scores.

There was no statistically correlation between tooth resorption (TR) and pain score however a trend was observed (p = 0.0844), in which absence of pain was mostly found in the absence of TR (Figure 7).

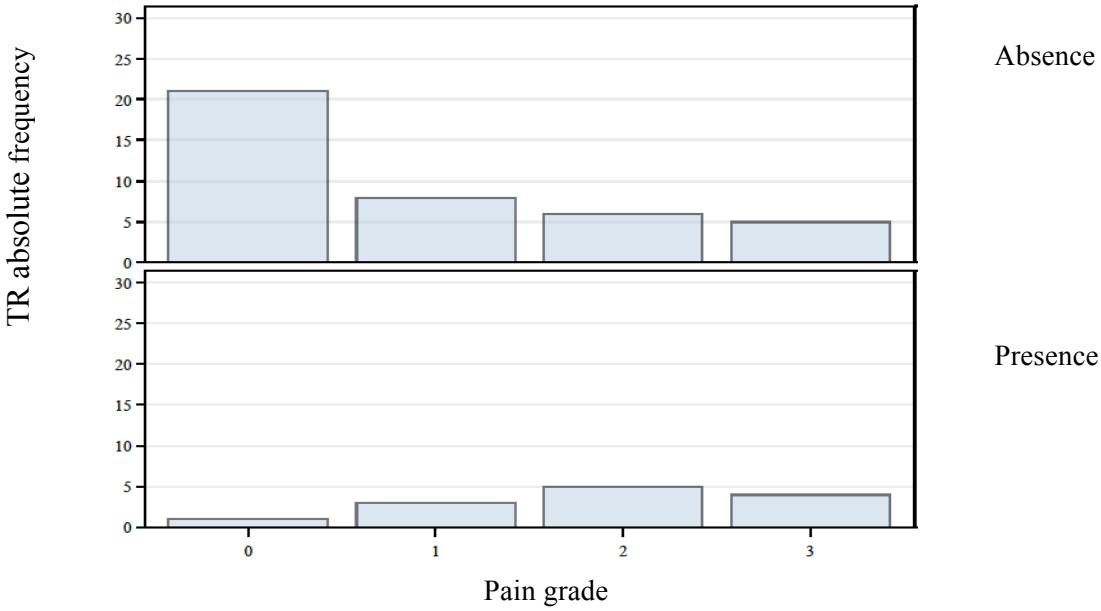


Figure 7: Graphic distribution of TR according to pain scores.

Tooth fracture (FX) was not statistically associated to different pain scores (p = 0.2925) (Figure 8).

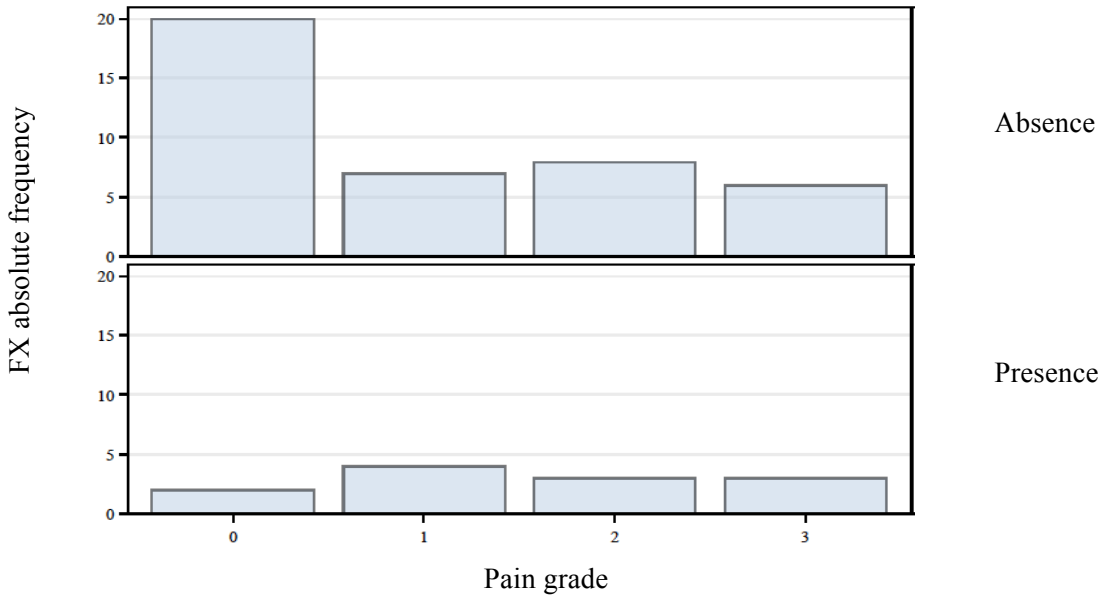


Figure 8: Graphic distribution of FX according to pain scores.

The number of missing teeth (MT) was statistically correlated with pain score ($p < 0.0001$). The results show that more absent teeth were associated with higher score since the pain scale (Figure 9).

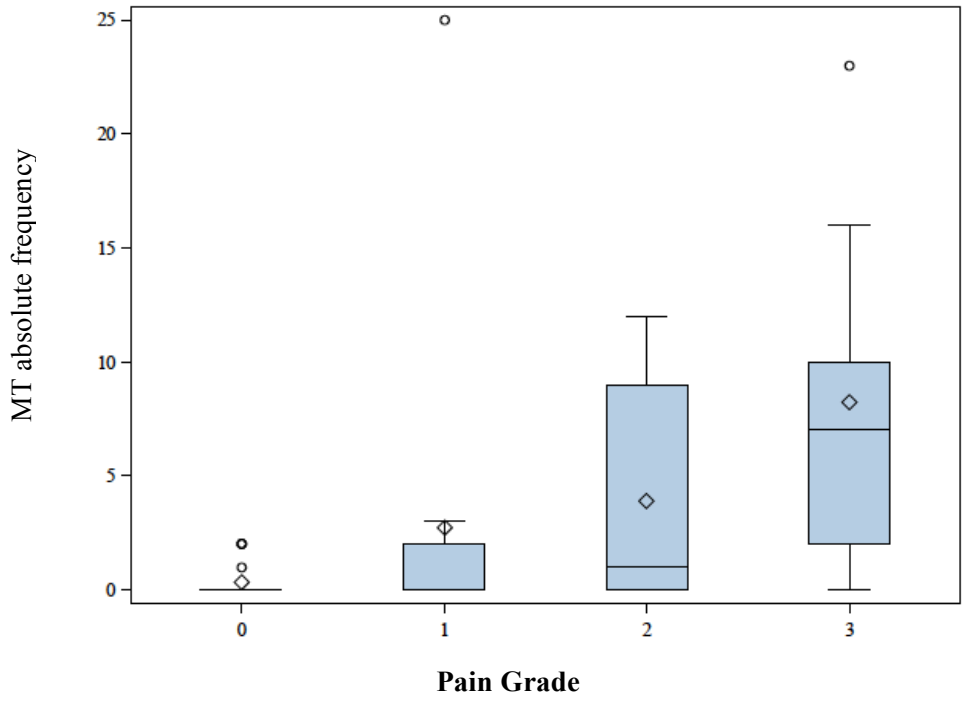


Figure 9: Graphic distribution of MT according to pain scores.

5.4 Correlation between pain scale and secondary dental parameters

All the secondary dental parameters were statistically associated to pain scores assessed according to the Feline Acute Pain Scale of CSUVTH. Statistical correlations between the presence of pain and secondary dental parameters are presented in Table 49.

Table 49: Secondary dental parameters according to pain scale

Variables	**P - Value**
Mouth discomfort	0.0239
Halitosis	0.0293
Hypersalivation	0.0055
Difficulty holding food	0.0013
Several attempts arresting food	0.0013

The presence of mouth discomfort (MD) was statistically correlated with the presence of pain ($p = 0.0239$). Further statistical analysis also allowed to assess that: when compared

with pain scale score 0, the risk for mouth discomfort was increasingly, 38 times higher (odds ratio 38.091), 75 times higher (odds ratio 75.028), and 135 times higher (odds ratio 135.054) to occur at pain scale scores 1, 2 and 3, respectively. The presence of mouth discomfort was directly correlated with the presence of pain (Figure 10).

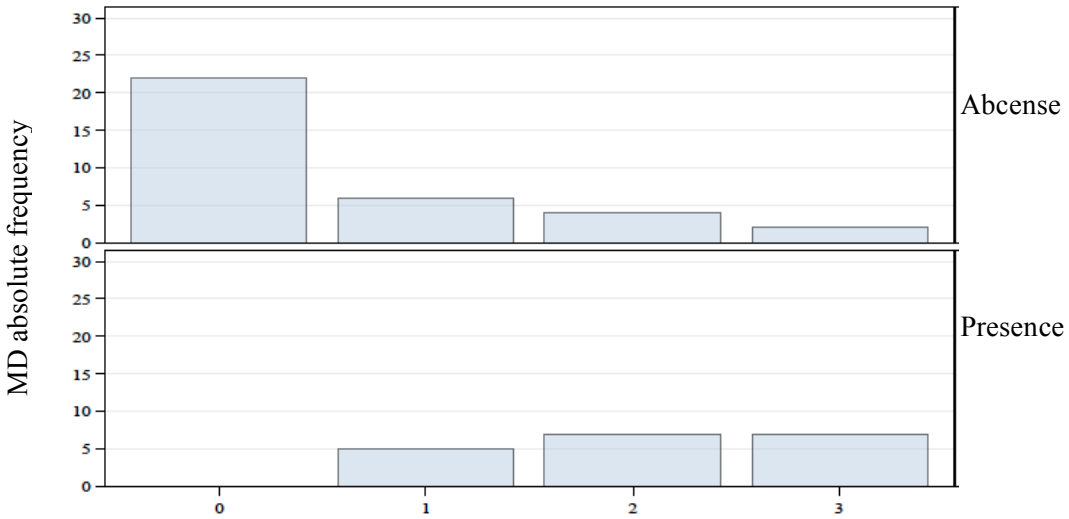


Figure 10: Graphic distribution of MD according to pain scores.

Furthermore, the presence of halitosis (Ha) was statistically correlated with the presence of pain ($p = 0.0293$). The statistical analysis also allowed to assess that: when compared with pain scale score 0, the risk for halitosis was 3 times higher (odds ratio 13.350), 4 times higher (odds ratio 19.225), and 27 times higher (odds ratio 272.827) to occur at pain scale scores 1, 2 and 3 respectively. The presence of halitosis was directly correlated with the presence of pain (Figure 11).

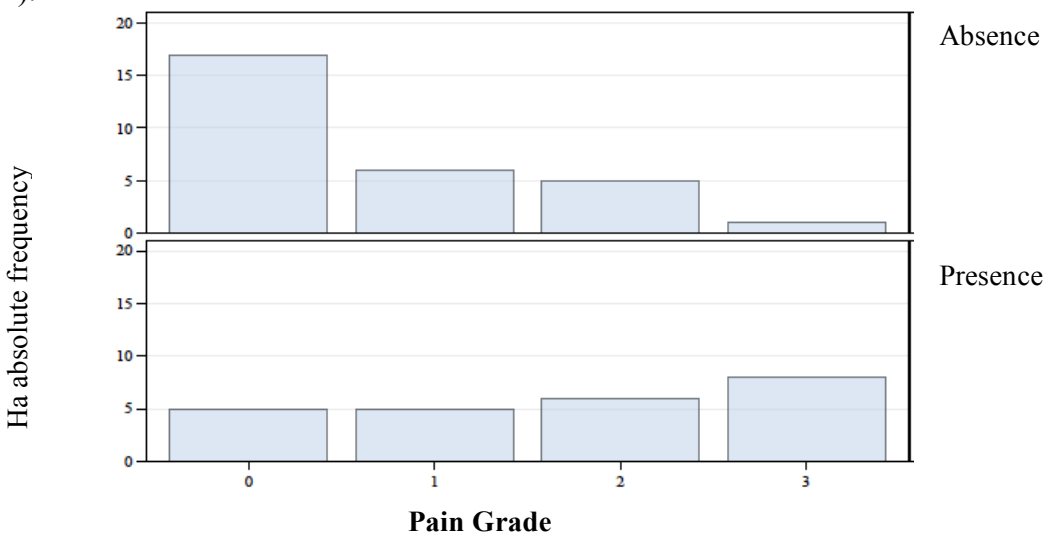


Figure 11: Graphic distribution of Ha according to pain scores.

Also, the presence of hypersalivation (Hy) was statistically correlated with the presence of pain (p = 0.0055). The statistical analysis also allowed assessing that: compared with pain scale score 0, the risk for hypersalivation was 2 times higher (odds ratio 120.188), 38 times higher (odds ratio 846.312), and 135 times higher (odds ratio >999.999) to occur at pain scale scores 1, 2 and 3 respectively. The presence of hypersalivation was directly correlated with the presence of pain (Figure 12).

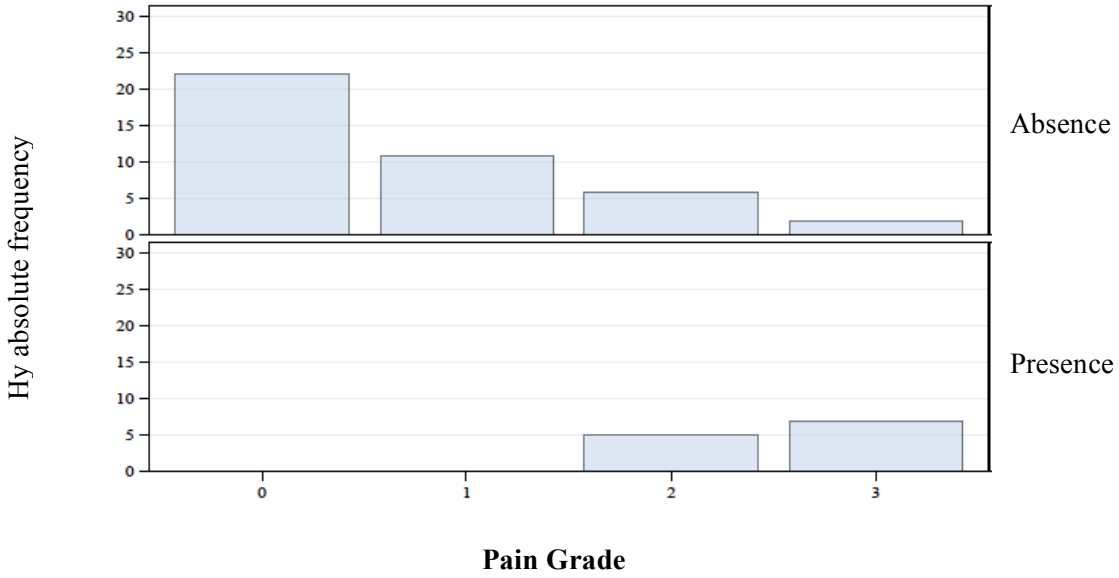


Figure 12: Graphic distribution of Hy according to pain scores.

Finally, difficulty in holding food (DHF) and the presence of several attempts in arresting food (SAAF) was statistically correlated with the presence of pain (p = 0.0013). The statistical analysis also allowed to assess that: when compared with pain scale score 0, the risk for difficulty in holding food and for several attempts in arresting food was 27 times higher (odds ratio 608.121), 315 times higher (odds ratio >999.999), and 855 times higher (odds ratio >999.999) to occur at pain scale scores 1, 2 and 3 respectively. Difficulty in holding food and the presence of several attempts in arresting food, were directly correlated with the presence of pain (Figure 13 and 14).

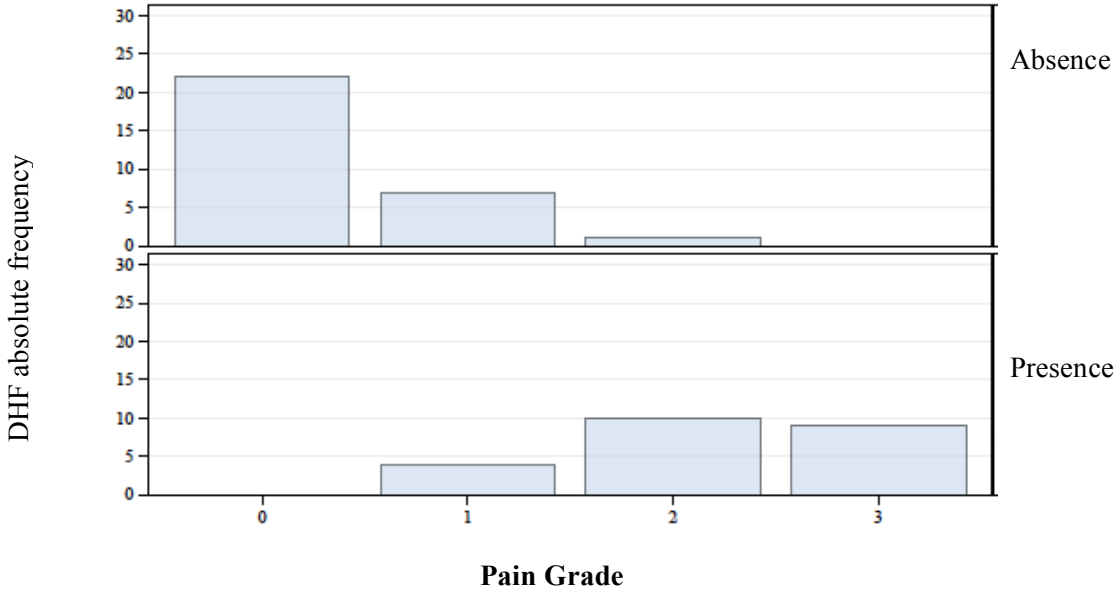


Figure 13: Graphic distribution of DHF according to pain scores.

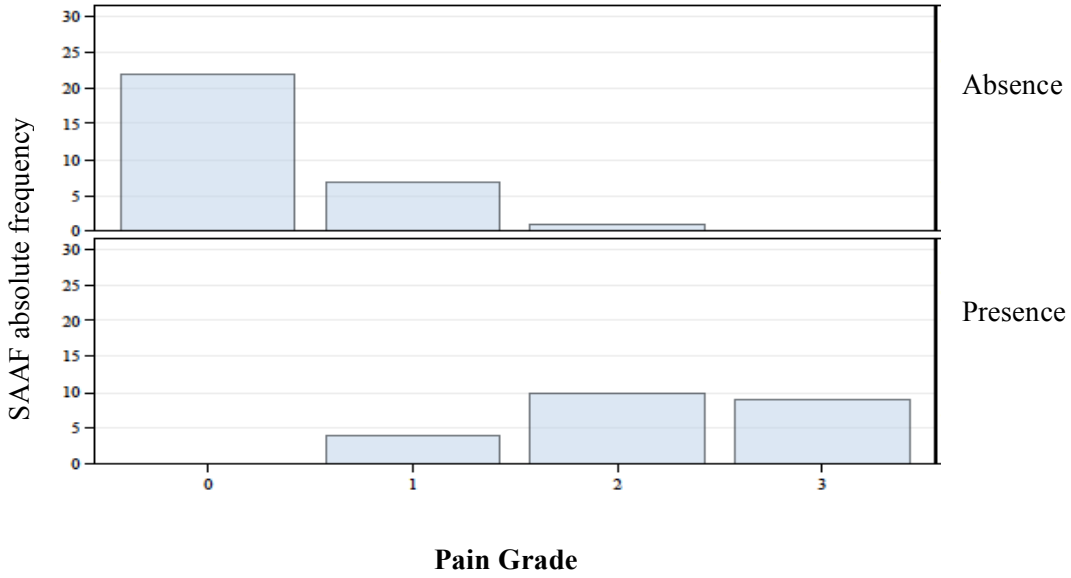


Figure 14: Graphic distribution of SAAF according to pain scores.

To conclude, the statistical analysis showed statistically significant correlations between all the secondary dental parameters included in the statistical analysis with pain scale groups, while regarding the primary dental parameters only the number of missing teeth was statistically correlated to the increase of pain (Table 50).

Table 50: Data statistically correlated with the feline acute pain scale of Colorado State University Veterinary Teaching Hospital ($\rho < 0.05$)

Variables	**P - value**
Missing teeth	< 0.0001
Discomfort in the mouth	0.0239
Halitosis	0.0293
Hypersalivation	0.0055
Difficulty in holding food	0.0013
Several attempts in arresting food	0.0013

5.5 Demographic and dental parameters

Correlations between dental parameters and demographic parameters are reported in the Table 51.

Table 51: Statistical comparisons between dental parameters and demographic parameters

	P - value		
Variables	**Age**	**Sex**	**Type of food**
Periodontal Disease	**0.0159**	0.7454	0.8956
Gingival Index	0.8407	0.5441	**< 0.0001**
Calculus Index	0.3079	0.3272	0.1223
Tooth Resorption	0.6060	0.6913	0.3984
Tooth Fracture	0.0661	0.9407	0.9120
Missing Teeth	**< 0.0001**	0.2301	**< 0.0001**
Discomfort Mouth	**0.0156**	0.1872	0.0922
Halitosis	**0.0056**	0.6696	0.9418
Hypersalivation	**0.0083**	0.0684	0.0942
Difficulty Holding Food	**0.0005**	**0.0201**	0.1456
Several Attempts Arresting Food	**0.0005**	**0.0201**	0.1456

The statistical analysis showed that Age was the demographic parameter more frequently associated with the presence of dental alterations. In fact, aged cats presented several dental alterations such as periodontal disease and missing teeth, and clinical signs such as discomfort in the mouth, halitosis, hypersalivation, difficulty in holding food and several attempts in arresting food.

5.5.1 Periodontal Disease

A statistically significant correlation was found between periodontal disease and age (p = 0.0159) (Figure 15). The results show that periodontal disease severity increases with the increasing age: $\bar{x}$ PD 0 = 44 months, $\bar{x}$ PD 1 = 67 months, $\bar{x}$ PD 2 = 117 months.

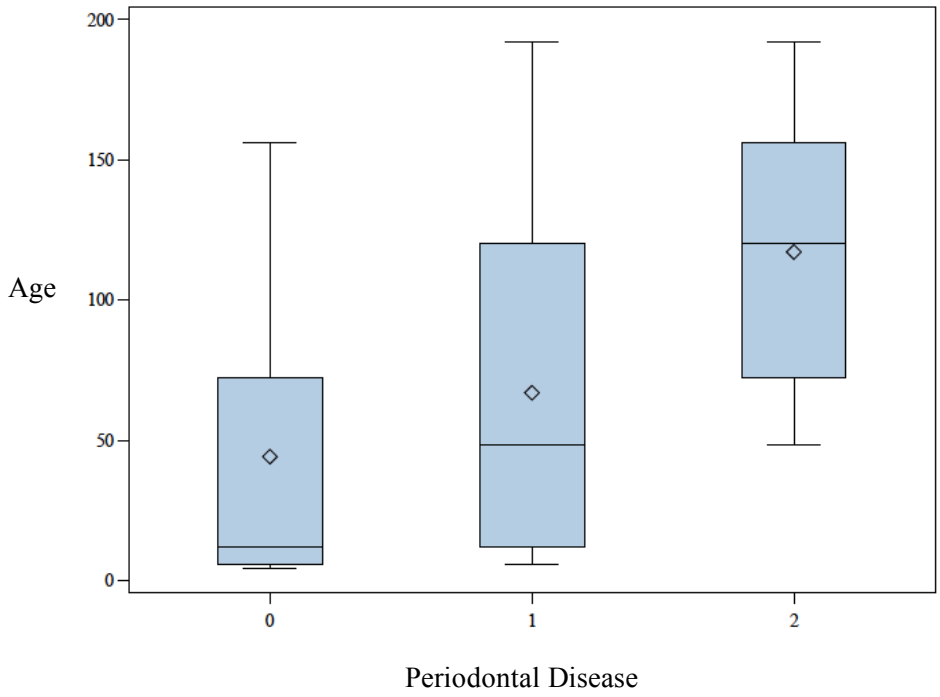


Figure 15: Graphic distribution of age according to PD.

5.5.2 Gingival Index

Gingival index (GI) was statistically correlated with type of food (p < 0.0001). The statistical significance was found between gingival index level 3 and type of food (p = 0.0025). The statistical analysis also allowed assessing that the risk for GI 3 occurrence with dry food was 0.067 times lower (odds ratio 0.067) than with wet food, and 0.022 times lower (odds ratio 0.022) with wet and dry food compared with wet food. Dry and, wet and dry foods were protector factors to GI 3 when compared with wet food alone (Figure 16).

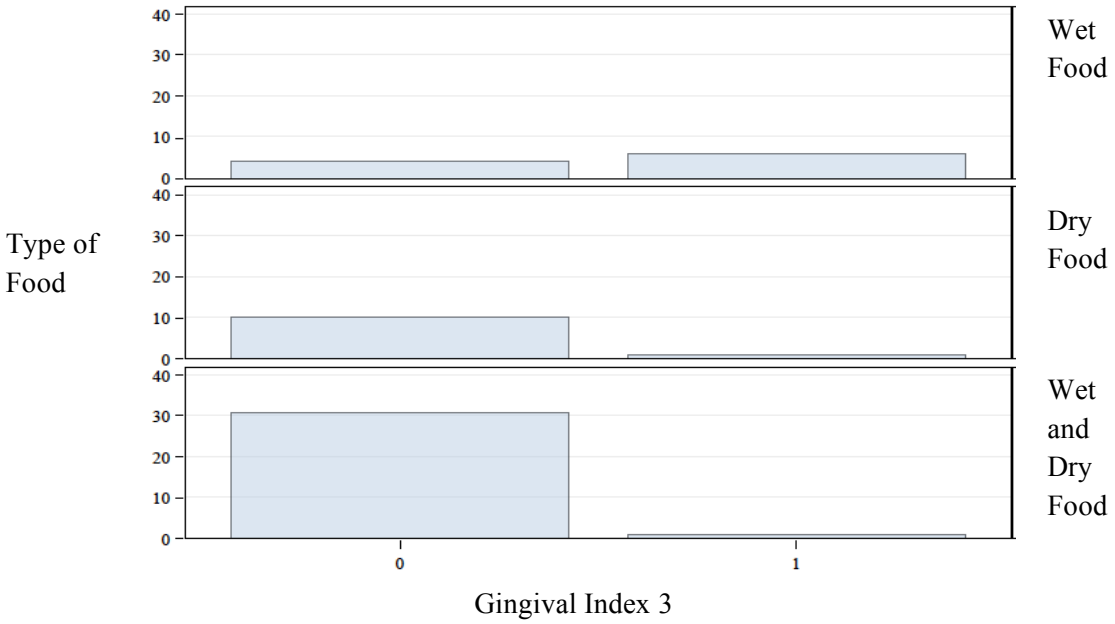


Figure 16: Graphic distribution of type of food according to GI 3.

5.5.3 Missing teeth

A statistical correlation between missing teeth and age ($p < 0.0001$) was found. An increase of missing teeth number was observed with increasing age (Figure 17).

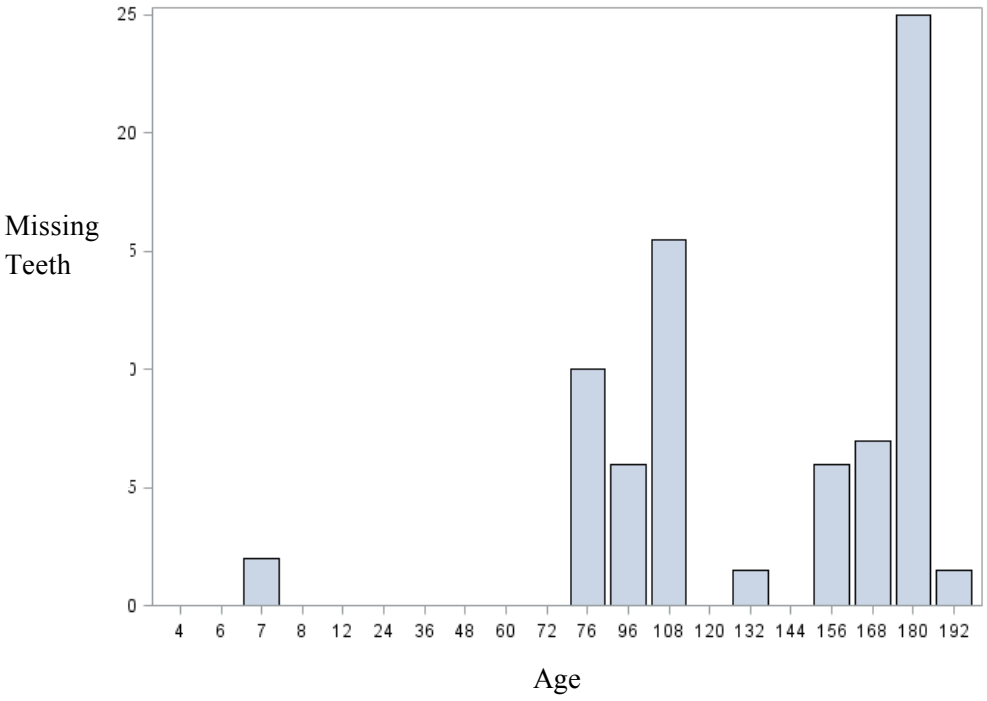


Figure 17: Graphic distribution of age in months according to MT.

Also according to the missing teeth, there was a significant correlation between missing teeth and type of food ($p < 0.0001$). Cats that ate wet and dry food had less number of missing teeth when compared with cats that eat solely wet or dry food.

5.5.4 Sex

A statistically significant difference was observed between sex and difficulty in holding food ($p = 0.0201$) and between sex and several attempts in arresting food ($p = 0.0201$). The risk for males to have difficulty in holding food and several attempts in arresting food was 0.253 times lower (odds ratio 0.253) when compared with females, showing that sex is a protector factor in both cases. This may mean that male cats are less likely to have difficulty in holding food and several attempts arresting food than female cats.

5.6 Type of food and pain scale

Concerning the comparison between the type of food and pain, based in the Feline Acute Pain Scale of CSUVTH, neither a statistically correlation nor a trend was observed ($p = 0.7243$).

6. Discussion

This study showed that all the secondary dental parameters included in the statistical analysis were statistically correlated to the pain scale groups of feline acute pain scale of CSUVTH. In our study, we included in the secondary parameters category those parameters based on observations carried out by the owners (discomfort in the mouth, halitosis, hypersalivation, difficulty in holding food, several attempts in arresting food). Thus, the statistical analysis showed that the feline acute pain scale of CSUVTH, that it is based on simple visual behavioral observations, seems to be adequate to evaluate pain conditions related to oral symptoms detected by owners' visual observations. On the contrary, regarding the primary dental parameters, only the number of missing teeth was statistically correlated to the pain scale groups. Primary parameters are those parameters measured by a deep clinical examination and based on precise scale categories (AVDC, 1988a). This general lack of statistical association seems to reveal that the Colorado Pain Scale is less adequate to evaluate pain conditions related to oral diseases assessed by precise and accurate clinical analyses, however is a promising readily-available tool in this setting.

Some dental diseases have been previous related in cats as a cause of discomfort (Gorrel *et al*., 1988; Gorrel, 2004a; Tobias *et al*., 2006; Hellyer *et al*., 2007; Quimby *et al*., 2008; Pittari *et al*., 2009; Bellows, 2010g; Robertson & Lascelles, 2010). The results are in agreement with these studies and, moreover, they also showed that mouth discomfort is associated to pain. The discomfort in the mouth occurs in presence of oral diseases with different etiologies, due to the important nervous system that innervates teeth and the whole oral cavity (Bellows, 2010g; Charlier, 2013; De Vries & Putter, 2015; Perry & Tutt, 2015).

Halitosis is a well-established sign of oral disease (Holmstrom *et al*., 2013; Niemiec, 2013e; Clarke & Caiafa, 2014). Our results showed that halitosis is not only a sign of oral disease, but it is also associated with the presence of oral pain as a consequence of the underlying oral disorder.

Our results concerning hypersalivation are in accordance with the literature. Previous studies reported that the hypersalivation could be a sign of dental disease and also a behavior linked to the oral pain (Bellows, 2004b; Bellows, 2010d; Clarke & Caiafa, 2014; Merola & Mills, 2016a). The pain felt by the cat in the oral cavity may relate to the inflammation of teeth

surrounding soft tissues and endodontic pain, due to the studied dental diseases (Holmstrom *et al*., 2007).

Even the difficulty in holding food and the necessity of several attempts in arresting food was correlated to pain. The presence of oral pain may have several consequences in food intake, leading sometimes to changes in eating behaviors (Logan, 2006; Pittari *et al*., 2009; Merola & Mills, 2016a). When the cat is eating and food falls from its mouth, it may thus be due to pain felt upon contact with an affected area in the teeth or mouth.

Regarding the primary dental parameters, only the number of missing teeth was statistically correlated to the increase of pain, and a trend was observed for tooth resorption.

The literature describes that the number of missing teeth is associated with a late stage in periodontal disease and a late stage in tooth resorption, and the present study shows that the missing teeth is also associated with pain in cats (Bellows, 2010a; DeBowes, 2010; Niemiec, 2013e; Clarke & Caiafa, 2014). These underlying causes of missing teeth could be also the causes of oral pain in cats with this dental condition.

Missing teeth can also be encountered in younger cats and is correlated with pain, meaning that the younger cats may also feel discomfort when the teeth are erupting (Rusbridge *et al*., 2010). It is described by the literature that cats presenting an intense gingivitis can have missing teeth, and the results of this study corroborate that hypothesis (Bellows, 2010d).

On the present study, the majority of tooth resorption lesions (TR) were diagnosed clinically, which means that the only diagnosed TR lesions were late stage lesions (Gorrel, 2015). This can explain the fact that although there was not statistically significant association, a trend was found between TR and pain scale group. As described in the literature and also in the author's opinion regarding the data presented in this work, TR may be accompanied by pain increase (Lommer & Verstraete, 2000; Reiter & Mendoza, 2002; Clarke & Caiafa, 2014; Gorrel, 2015).

As the literature describes almost all feline cuspid fracture expose the pulp chamber, however when the pulp is completely necrosed the pain decreases (Bellows, 2004b; Niemiec, 2005; Bellows, 2010d). Because it was not possible to determine the moment when the fracture occurred in the cats of the present study, and some cats presented fractures that did not affect the pulp in other teeth, the lack of statistically significant association to pain can be related

either to the fact that cats did not feel pain in the moment of the examination, or to the fact that the fractures were not complicated.

No statistically significant correlations were observed between periodontal disease, gingival index and calculus index with pain scale groups. It is authors' opinion that this result can be due to the fact that the feline acute pain scale tests in this study it is not totally adapted to evaluate the pain related to such specific dental pathological changes.

The age of the cats was statistically correlated with several dental parameters. The association between PD and age has been previously reported by various studies, which described that PD can affect cats in every age and the severity increases with increasing age (Gengler *et al*., 1995; Lommer & Verstraete, 2001). This can be explained due to the fact that periodontal disease is a progressive condition, which tends to aggravate if the initial cause is not treated. Also the number of missing teeth was associated to the increasing age, probably because the diseases that cause missing teeth are progressive and need time before to lead to the fall or destruction of the tooth (DuPont, 1998; Richards *et al*., 2005; Lobprise, 2007; Bellows, 2010d; DeBowes, 2010; Niemiec, 2013c,e; Perry & Tutt, 2015). Concerning the other primary parameters, TR deserves some explanations. According to the present results, age did not influence the prevalence of TR. Literature describes that the incidence of TR increase with increasing age (Wessum *et al*., 1992; Gorrel, 2015). In another study the age was not correlated with the incidence of TR in the purebred population (Girard *et al*., 2008). The results of our study are in accordance with the latter. This can be due to the fact that our studied population was composed by mixed and purebred cats, and by a large number of young cats.

All the dental secondary signs (as so the parameters perceived by the owners) were correlated with age. As explained before, the majority of oral diseases are progressive in time, so even their behavioral manifestations are more common and detectable with the increase of the age.

Sex was not correlated with dental pathological changes, except for the two parameters about the capacity in holding and arresting food, from which the females seems to be more affected. Periodontal disease has been previously shown no correlation to gender (DuPont, 1988; Verhaert & Wetter, 2004; Girard *et al*., 2009;). Regarding the relationship between TR and sex, several contradictory findings are present in literature. In the past, some authors reported that there may be a sex effect (Reiter & Mendoza, 2002), being males more affected (Wessum *et al*., 1992), or the females in other studies (Lund *et al*., 1998). More recent studies

showed that there is no association between sex and TR (Scarlett *et al*., 1999; Ingham, *et al*., 2001; Girard *et al*., 2008; Mestrinho *et al*., 2013 Gorrel, 2015). In the present study sex did not affect the prevalence of TR, which was in accordance with recent studies.

Regarding the type of food, we observed a statistically significant correlation with both the gingival index and the number of missing teeth. Interestingly, our results showed that cats who ate only wet food were those presenting a gingival index of score 3, when compared with cats that eat dry or wet and only dry food. This correlation may have two possible explanations. One is that the a cat presenting GI 3 could prefer wet food in order to reduce mouth discomfort while eating (Jennings *et al*., 2015; Rolim *et al*., 2016). The second explanation could be that these cats have a severe inflammation because they eat only wet food, described in the literature not to achive an efficient mechanical removal of dental plaque (Watson, 1994; Reiter & Mendoza, 2002; Logan, 2006; Niemiec, 2013d; Perry & Tutt, 2015). Regarding the influence of the type of food on the number of missing teeth, our results showed that an equilibrated diet composed by both dry and wet food is associated to those cats presented all or more teeth than cats eating only dry or only wet food. As previously described in the literature, dietary form and nutritional intake affect tooth, bone and mucosal integrity and tooth longevity (Logan, 2006). The statistical analysis also showed that no correlation was present between the type of food and the pain scale groups.

As far as we know, this is the first study that evaluates the efficacy of a pain scale in detecting pain due to oral disorders in cats. The most important finding is that the Colorado Pain Scale seems to be very accurate in detecting pain associated to overall oral disorders, which in this study have been identified by various parameters assessed by owners' observations. In the author's opinion, this aspect is very important, because our data seem show a strict correlation between a scale based on visual observations of pain manifestations and oral conditions assessed in the same manner, always observing the behavioral manifestations of an oral alteration. On the opposite, this scale seems less adapted to detected the pain caused by a precise oral condition, such as those pathologies assessed by a complete oral clinical evaluation and measured according to precise scoring grids (the conditions that here we included in the primary parameters category). As such, this scale shows a lack of efficacy if applied to precise oral diseases diagnosed with accurate clinical methods. The Colorado Pain scale has been conceived to detect acute pain in cats, while some of the dental changes presented in this study are chronic and progressive phenomena (Okuda & Harvey, 1992; Hellyer *et al*., 2006; Perry & Tutt, 2015).

Another important aspect confirmed by our study is that oral disorders are an important and common problem in cats, which should accurately be prevented and assessed to improve the oral health and welfare of cats (Lommer & Verstraete, 2001; Ray & Eubanks, 2009; Vogt *et al*., 2010; Perry & Tutt, 2015). The examination of the oral cavity in the aging cat should start with questioning the owner regarding signs of pain and oral-dental diseases, such as those parameters that are common clinical signs of oral-dental disease (Richards *et al*., 2005; Bellows, 2016a,b). Since the classic signs of aging noticed by cat owners are commonly behavioral, this correlation suggests that aged cats that during their life did not have proper oral care, inevitably will develop oral-dental disease (Pittari *et al*., 2009). Client education about diseases of the oral cavity is fundamental. In fact the bond between human-pet-veterinary is strengthened and the quality of cats life improved (Lommer & Verstraete, 2001; Pittari *et al*. 2009; Vogt *et al*., 2010). Toothbrushing is considered the gold standard in veterinary oral health home-care, being the single most effective mean of removing dental plaque (Gorrel, 2004c; Ray & Eubanks, 2009). Veterinary toothpastes are available with feline-friendly flavours.

7. Conclusion

Concluding, the Feline Acute Pain Scale of Colorado State University Veterinary Teaching Hospital seems to be very good in evaluating pain induced upon stimulus in the context of a general worsening of oral health in cats (secondary parameters), being detectable mostly by visual observations, as is the scale. This same subjectivity might be the cause of the lack of significant results when using this scale in evaluating pain due to precise feline oral diseases. The statistically significant association found between pain scores and the high severity associated number of missing teeth, as well as the trend regarding tooth resorption strengthens this hypothesis. Further studies should also focus in evaluating the accuracy of other scales conceived to measure pain in animals, and in standardizing the protocols needed to assess and score oral health in cats. This work allowed to definitely clarifying that cats with oral disease feel pain, and that it increases in a disease severity-dependent manner. Prevention of oral disorders is of the utmost importance to contribute to improved welfare and quality of life in cats.

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Annex I: Dental chart

The present dental chart was made based on pre-existing ones:

Name Age F M NF NM Weigh BCS:

Tutor Breed Date

Motive of consultation/internment/surgery

Medical history/dentary

Alimentation

☐ Dry food ☐ Wet food

Obs :

Ever noticed some discomfort in the mouth?

☐ Yes ☐ No

Obs :

Halitosis?

☐ Yes ☐ No

Obs :

Hypersalivation?

☐ Yes ☐ No

Obs :

Difficulty in holding food?

☐ Yes ☐ No

Obs :

Several attempts in arresting food?

☐ Yes ☐ No

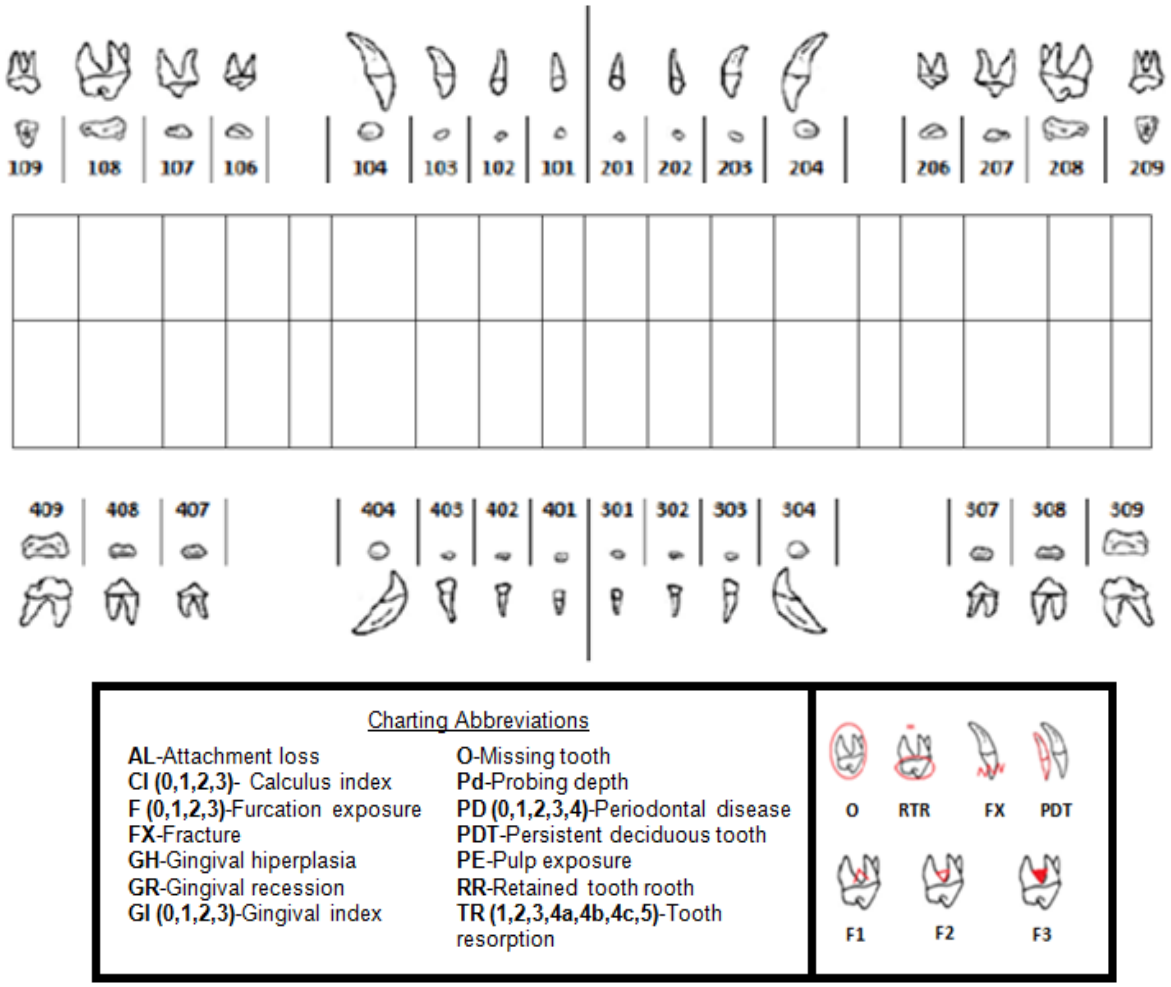

Figure 18: Dental chart with abbreviations. Adapted from Holmstrom *et al*. (2013). Courtesy of Prof. Doutor João Filipe Requicha.

Ancillary exams

Diagnostic

Treatment

Prognostic

Follow up

Annex II: Feline pain scale

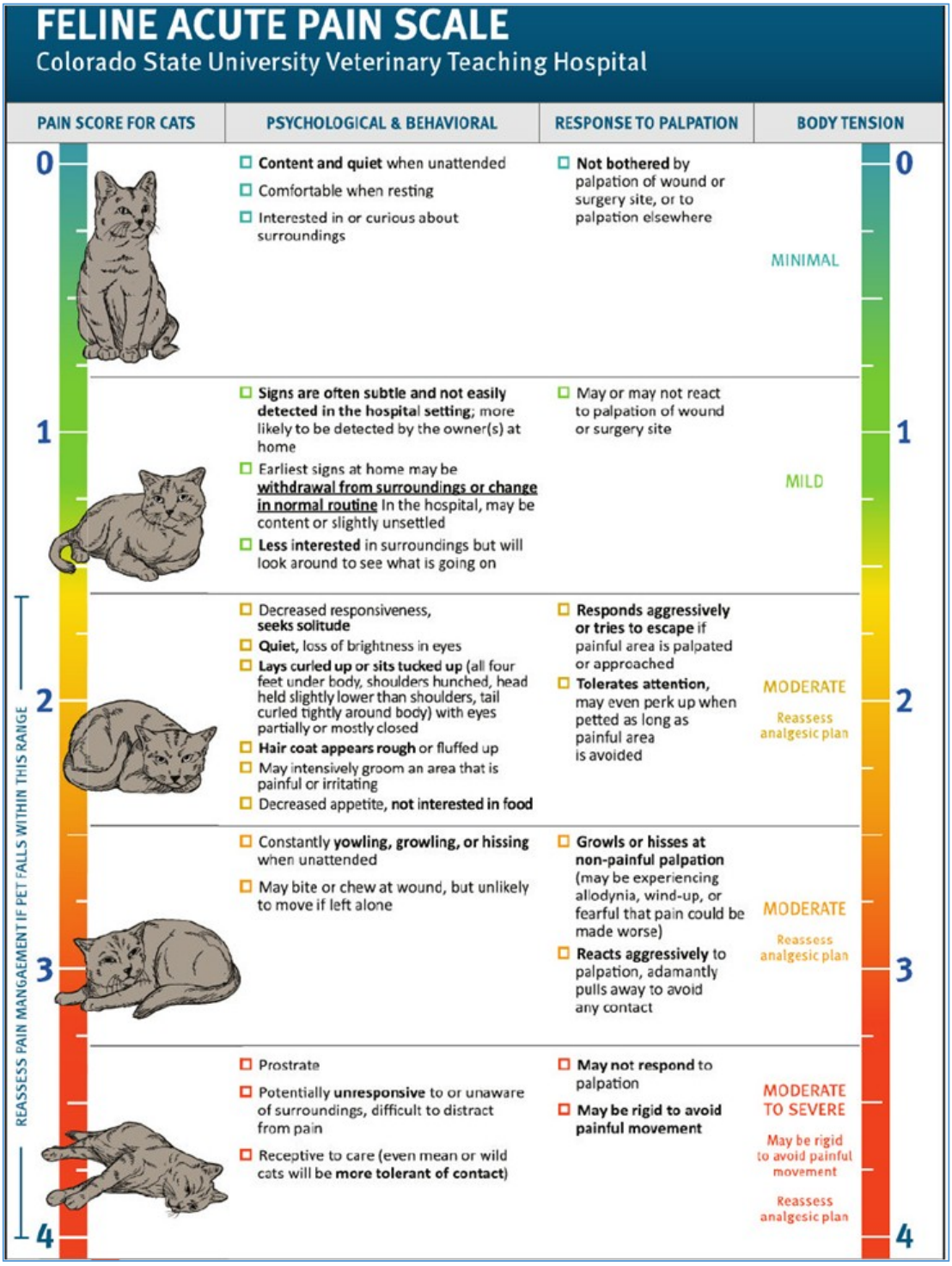

Figure 19: Feline Acute Pain Scale of Colorado State University Veterinary Teaching Hospital. This pain scale combines aspects of the numerical rating scale along with composite behavioral observation, and it has been shown to increase awareness of behavioral changes associated with pain (Hellyer et *al*., 2006; Mathews *et al*., 2014; Epstein *et al*., 2015).

Annex III: Anesthesic protocol

To the cats presented to Hospital do Gato during the period of this study, the presented anesthesic protocol was employed (Table 52).

Table 52: Agents and dosis for the anesthetic protocol. Adapted from: Garcia *et al*., (2015).

	Agents in young/healthy patients	**Agents in renal/cardiac insufficient patients**
Sedation and premedication	Midazolam 0.2 mg/kg IM + butorphanol 0.2 mg/kg IM; ketamine 5-10 mg/kg IM; buprenorphine 0.01 mg/kg IM	Butorphanol 0.2 mg/kg IM + midazolam 0.2 mg/kg IM
Induction	Isoflurane or Sevoflurane	Isoflurane or Sevoflurane
Maintenace	Isoflurane or Sevoflurane	Isoflurane or Sevoflurane

When dental extractions were necessary, the presented anesthesic protocol was employed (Table 53).

Table 53: Local dental blocks and dosis utilized in dental extractions. Adapted from Rochette (2005), Beckman (2013a) and Aguiar (2015)

Agents	**Nerve blocks**	**Area**
Lidocaine 0.25 mg/kg + bupivacaine 0.25 mg/kg	Mentonian	Mandibular arcade since 2nd premolar until interincisive junction
	Mandibular	Mandibular arcade
	Infraorbitary	Maxillary arcade
	Maxillary	Maxillary arcade

Annex IV: Future presentations

An article based on this research work is being prepared for submission in peer-review cientific journal.

An abstract was submitted and accepted for oral communication in the 26th European Veterinary Dental Forum, Málaga (Spain), May 18-21, 2017.