PAULO VINÍCIUS TERTULIANO MARINHO

Comparação biomecânica *ex vivo* da estabilização vertebral cervical caudal de cães conferida por meio de pinos bicorticais e polimetilmetacrilato ou parafusos poliaxiais monocorticais associados ou não a distrator intersomático

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1. Fusão vertebral. 2. Parafusos ósseos. 3. Biomecânica. 4. Cães. I. Título.

RESUMO

MARINHO, Paulo Vinícius Tertuliano. **Comparação biomecânica ex vivo da estabilização vertebral cervical caudal de cães conferida por meio de pinos bicorticais e polimetilmetacrilato ou parafusos poliaxiais monocorticais associados ou não a distrator intersomático**. 2017. 155 f. Tese (Doutorado em Clínica Cirúrgica Veterinária) – Faculdade de Medicina Veterinária e Zootecnia, Universidade de São Paulo, São Paulo, 2017.

O objetivo deste estudo foi comparar as propriedades biomecânicas da estabilização vertebral cervical caudal de cães *ex vivo* por meio de pinos bicorticais com polimetilmetacrilato (PMMA) e parafusos poliaxiais monocorticais associados ou não a distrator intersomático. Foram utilizados dez segmentos de colunas vertebrais (C2-T3), coletadas de cadáveres caninos maduros (25-35 kg) que constituíram quatro grupos experimentais, cada um representado por dez espécimes em que o espaço intervertebral entre C6 e C7 representou a unidade vertebral motora (UVM) tratada e C4-C5 e C5-C6 as UVM adjacentes. Os grupos foram divididos segundo a condição avaliada: grupo colunas intactas (Intactas), grupo parafusos poliaxiais monocorticais com distrator intersomático (Poliaxial-C-Distrator); grupo parafusos poliaxiais monocorticais sem distrator intersomático (Poliaxial-S-Distrator) e grupo pinos bicorticais com PMMA (Pin-PMMA). Todos os implantes foram aplicados no corpo vertebral ventral. Os espécimes foram fixados na máquina de ensaios mecânicos em uma posição neutra, livre da ação de forças. Em seguida, foram submetidas a movimentos de extensão e flexão ventral por meio da aplicação de torque de ± 2 Nm. O teste biomecânico foi realizado sequencialmente nas colunas vertebrais intactas, no grupo Poliaxial-C-Distrator, no Poliaxial-S-Distrator e no Pin-PMMA. A diferença angular entre as vértebras antes e após a aplicação da carga foi calculada por meio de fotogoniometria após três repetições realizadas para cada movimento (flexão e extensão) em todos os grupos. A rigidez porcentual referente à diferença angular à flexão, extensão e flexão-extensão foi calculada e comparada entre os grupos. A rigidez à flexão entre C6 e C7 para os grupos Poliaxial-C-Distrator, Poliaxial-S-Distrator e Pin-PMMA foi, respectivamente, 72%, 59,88% e 68,58% maior que a rigidez das colunas intactas, sendo essa diferença estatisticamente significativa; à extensão, a rigidez entre C6 e C7 estabilizadas com Poliaxial-C-Distrator, Poliaxial-S-Distrator e Pin-PMMA foi, respectivamente, 92,51%, 89,61% e 90,98% maior que a rigidez das colunas intactas, diferindo significativamente. A rigidez à amplitude de movimento flexão-extensão entre C6 e C7 nos grupos Poliaxial-C-Distrator, Poliaxial-S-Distrator e Pin-PMMA foi, respectivamente, 80,77%, 72,74% e 78,27% maior que a rigidez das colunas intactas, o que diferiu significativamente. Quando a comparação foi realizada entre os tratamentos, não houve diferença significativa na rigidez entre C6 e C7. Não houve incremento significativo da amplitude de movimento das vértebras adjacentes após a estabilização, independentemente do tratamento utilizado. Em conclusão, a fixação monocortical com parafusos poliaxiais foi comparável à estabilização realizada com pinos bicorticais e PMMA. A associação do distrator intervertebral não promoveu aumento da rigidez à fixação com parafusos poliaxiais.

Palavras-chave: Fusão vertebral. Parafusos ósseos. Biomecânica. Cães.

ABSTRACT

MARINHO, Paulo Vinícius Tertuliano. ***Ex vivo* biomechanical evaluation of caudal cervical vertebral stabilization by use of bicortical pins with polymethylmethacrylate or monocortical polyaxial screws and connecting rods associated or not with intersomatic distractor in dogs.** 2017. 155f. Tese (Doutorado em Clínica Cirúrgica Veterinária) – Faculdade de Medicina Veterinária e Zootecnia, Universidade de São Paulo, São Paulo, 2017.

The purpose of this study was to compare the *ex vivo* biomechanical properties of caudal cervical vertebral stabilization in dogs by use of bicortical pins with polymethylmethacrylate or monocortical polyaxial screws and connecting rods associated or not with intersomatic distractor. Ten cervical spinal columns (C2-T3), harvested from ten adult canine cadavers (body weight ranging from 25 to 35 kg) were used, constituting four experimental groups, each represented by 10 specimens. The intervertebral space between C6 and C7 was considered the motor vertebral unit (UVM) that was treated and C4-C5 and C5-C6 were considered the adjacent UVMs. Groups were divided according to the assessed condition: intact cervical spine group (Intact Group); monocortical polyaxial screw with intersomatic distractor (Polyaxial-C-Distractor Group); monocortical polyaxial screw without intersomatic distractor (Polyaxial-S-Distractor Group) and bicortical pins/polymethylmethacrylate (PMMA) group (Pin-PMMA Group). All implants were applied to the vertebral bodies. All constructs were fixed to a testing machine in a neutral position (free of all testing forces). Afterwards, they were submitted to ventral extension and flexion tests with appliance of a 2 Nm torque. All biomechanical tests were performed sequentially on the intact group, then on Polyaxial-C-Distractor Group, Polyaxial-S-Distractor Group and Pin-PMMA Group. The angular difference between the vertebrae before and after load appliance was measured by photogoniometry after three cycles of each movement (flexion and extension) in all groups. Subsequently, range of motion to flexion, extension and flexion-extension in the intervertebral spaces was measured and compared between the groups. Stiffness to flexion between C6 and C7 in Polyaxial-C-Distractor, Polyaxial-S-Distractor and Pin-PMMA groups was 72%, 59.88% and 68.58% significantly greater than that of the intact group, while stiffness to extension was 92.51%, 89.61% and 90.98% statistically greater, respectively. Stiffness to range of motion in flexion-extension was 80.77%, 72.74% and 78.27% for Polyaxial-C-Distractor, Polyaxial-S-Distractor and Pin-PMMA groups, respectively, which differed significantly from stiffness of intact group. Comparison between treatments was not significantly different as to stiffness between C6 and C7. There was no significant increase in the range of motion of the adjacent vertebrae after stabilization, regardless of the treatment used. In conclusion, monocortical stabilization with polyaxial screws proved to be comparable to the stabilization performed with bicortical pins/PMMA constructs, a consecrated technique. Association of intervertebral distractor did not increase stiffness of the polyaxial screws constructs.

Key-words: Vertebral fusion. Bone screws. Biomechanics. Dogs.

1 INTRODUÇÃO

Diversos métodos de distração-estabilização vertebral têm sido utilizados no tratamento da espondilomielopatia cervical (BRUECKER; SEIM; BLASS, 1989; DIXON; TOMLINSON; KRAUS, 1996; FITCH et al., 2000; STURGES; LECOUTEUR, 2003; KOEHLER et al., 2005; VOSS; STEFFEN; MONTAVON, 2006; DA COSTA, 2010). Uma vez que o uso desses implantes permite aumentar o diâmetro do canal vertebral e reduzir os efeitos da protrusão do ânulo fibroso dorsal, hipertrofia ligamentar e inflamação ou deformidade das facetas articulares, produz descompressão indireta e elimina o componente dinâmico da compressão medular (SOLANO et al., 2015).

Dentre os implantes descritos na literatura destaca-se a combinação de pinos bicorticais associados com o polimetilmetacrilato (PMMA) nos corpos vertebrais (BRUECKER; SEIM; BLASS, 1989; KOEHLER et al., 2005), que têm sido associados a uma taxa inaceitável de penetração do canal vertebral e forame intervertebral (CORLAZZOLI, 2008). Entretanto, os relatos clínicos e os estudos biomecânicos do uso de construções envolvendo parafusos monocorticais na coluna cervical sugerem que a construção com parafusos/PMMA ou placas bloqueadas é eficaz na estabilização da coluna vertebral de cães com espondilomielopatia cervical (BLASS et al., 1988; ELLISON et al., 1988; BRUECKER; SEIM; BLASS, 1989; VOSS; STEFFEN; MONTAVON, 2006; BERGMAN et al., 2008; SHAMIR; CHAI; LOEB, 2008; TROTTER, 2009; AGNELLO et al., 2010; STEFFEN; VOSS; MORGAN, 2011; HETTLICH et al., 2013; HETTLICH et al., 2014; SOLANO et al., 2015; HETTLICH; FOSGATE; LITSKY, 2017). Enquanto a fixação com parafusos monocorticais e PMMA permite uma aplicação mais versátil, as placas bloqueadas oferecem um implante de baixo perfil sem a possibilidade dos efeitos adversos locais da aplicação do PMMA (HETTLICH; FOSGATE; LITSKY, 2017). A adição de um espaçador intersomático nessas construções aumenta a rigidez significativamente (HETTLICH et al., 2014; HETTLICH; FOSGATE; LITSKY, 2017).

Os parafusos pediculares, sejam monoaxiais ou poliaxiais, têm sido cada vez mais utilizados na estabilização vertebral de cães. A grande vantagem de sua utilização relaciona-se a uma estabilidade angular que se assemelha àquela conferida pelas placas bloqueadas, com baixo perfil do implante e com a versatilidade de aplicação conferida pelas construções com PMMA, especialmente

os parafusos poliaxiais (MORGENSTERN et al., 2003; KOLLER et al., 2008a; KOLLER et al., 2008b; KOLLER et al., 2009; ABUMI; ITO; SUDO, 2012; KOKTEKIR et al., 2015). Na literatura veterinária, os parafusos pediculares têm sido avaliados biomecanicamente em cadáveres caninos (MEIJ et al., 2007) e *in vivo* (SMOLDERS et al., 2012; FITZPATRICK, 2014; TELLEGEN et al., 2015) apenas para estabilização da coluna lombossacra após cirurgia descompressiva, promovendo estabilidade vertebral eficiente (MEIJ et al., 2007; SMOLDERS et al., 2012; ZYND et al., 2014). Já em seres humanos, o uso é rotineiro no tratamento de diversas afecções que causam instabilidade vertebral ou quando se requer fusão vertebral, tanto na coluna cervical, na torácica ou na lombar (YAHIRO, 1994; BOOS; WEBB, 1997; MORGENSTERN et al., 2003; KOLLER et al., 2008a; KOLLER et al., 2008b; KOLLER et al., 2009; ABUMI; ITO; SUDO, 2012; KOKTEKIR et al., 2015).

Na literatura revisada, não foi identificado estudo biomecânico referente ao uso de parafusos poliaxiais monocorticais na estabilização ventral da coluna vertebral cervical de cães, o que motivou a realização deste trabalho. Objetivou-se, portanto, comparar biomecanicamente a estabilidade vertebral cervical caudal conferida por meio de pinos bicorticais/PMMA ou parafusos poliaxiais monocorticais associados ou não a distrator intersomático.

9 CONCLUSÕES

Com base nos resultados encontrados no referido estudo, conclui-se que:

- 1) A fixação monocortical com parafusos poliaxiais associadas ou não a distrator intersomático mostrou-se eficaz e comparável à estabilização realizada com pinos bicorticais e PMMA;
- 2) A associação de um distrator intervertebral cônico não promoveu aumento da rigidez à fixação com parafusos poliaxiais e barras conectoras;
- 3) Nas condições estudadas, não houve incremento da mobilidade na UVM adjacentes craniais após a estabilização vertebral de C6-C7.

REFERÊNCIAS

- ABRAHÃO, G. S.; ROSA, R. C.; OKUBO, R.; SHIMANO, A. C. Influência do preparo do orifício piloto na ancoragem dos parafusos pediculares. *Acta. Ortop. Bras.*, v. 20, n. 5, p. 274-279, 2012.
- ABSHIRE, B. B.; MCLAIN, R. F.; VALDEVIT, A.; KAMBIC, H. E. Characteristics of pullout failure in conical and cylindrical pedicle screws after full insertion and back out. *Spine J.*, v. 1, n. 6, p. 408-414, nov.-dez. 2001.
- ABUMI, K.; ITO, M.; SUDO, H. Reconstruction of the subaxial cervical spine using pedicle screw instrumentation. *Spine (Phila. Pa. 1976)*, v. 37, n. 5, p. E349-E356, mar. 2012.
- ADAMO, P. F. Cervical arthroplasty in two dogs with disk-associated cervical spondylomyelopathy. *Small Animals/Exotic*, v. 239, n. 6, p. 208-217, 2011.
- _____. Cervical disc arthroplasty in dogs with disc associated wobbler syndrome - limitations and how to prevent possible complications. *Journal of Veterinary Internal Medicine*, v. 28, p. 1357, 2014a.
- _____; DA COSTA, R. C.; KROLL, R.; GIOVANNELLA, C.; PODELL, M.; BROFMAN, P. Cervical disc arthroplasty using the Adamo Spinal Disc® in 30 dogs affected by disc associated wobbler syndrome at single and multiple levels. *Journal of Veterinary Internal Medicine*, v. 28, p. 949, 2014b.
- _____; FORTERRE, F. Will There be a Role for Disc Prostheses in Small Animals? In: FINGEROTH, J. M.; THOMAS, W. B. (Eds.). *Advances in intervertebral disc disease in dogs and cats*. Oxford: Wiley Blackwell/ACVS Foundation, 2015, p. 294-309.
- _____; KOBAYASHI, H.; MARKEL, M.; VANDERBY JR., R. In vitro biomechanical comparison of cervical disk arthroplasty, ventral slot procedure, and smooth pins with polymethylmethacrylate fixation at treated and adjacent canine cervical motion units. *Veterinary Surgery*, v. 36, n. 8, p. 729-741, dez. 2007.
- ADREGA DA SILVA, C.; BERNARD, F.; BARDET, J. F. Caudal cervical arthrodesis using a distractable fusion cage in a dog. *Vet. Comp. Orthop. Traumatol.*, v. 23, n. 3, p. 209-213, 2010.
- AGHAYEV, K.; GONZALEZ-BLOHM, S. A.; DOULGERIS, J. J.; LEE, W. E. 3RD.; WADDELL, J. K.; VRIONIS, F. D. Feasibility and biomechanical performance of a novel transdiscal screw system for one level in non-spondylolisthetic lumbar fusion: an in vitro investigation. *The Spine Journal*, v. 14, n. 4, p. 705-713, abr. 2014.
- AGNELLO, K. A.; KAPATKIN, A. S.; GARCIA, T. C. et al. Intervertebral biomechanics of locking compression plate monocortical fixation of the canine cervical spine. *Veterinary Surgery*, v. 39, n. 8, p. 991-1000, dez. 2010.
- AMARITSAKUL, Y.; CHAO, C. K.; LIN, J. Multi-objective optimization design of spinal pedicle screws using neural networks and genetic algorithm: mathematical models

and mechanical validation. *Computational and Mathematical Methods in Medicine*, v. 2013, p. 462875, jul. 2013.

AMBATI, D. V.; WRIGHT, E.K. JR.; LEHMAN, R.A. JR.; KANG, D. G.; WAGNER, S. C.; DMITRIEV, A. E. Bilateral pedicle screw fixation provides superior biomechanical stability in transforaminal lumbar interbody fusion: a finite element study. *The Spine Journal*, v. 15, n. 8, p. 1812-1822, ago. 2015.

ARMSTRONG, J.; DA COSTA, R. C.; MARTIN-VAQUERO, P. Cervical Vertebral Trabecular Bone Mineral Density in Great Danes With and Without Cervical Spondylomyelopathy. *Journal of Veterinary Internal Medicine*, v. 28, n. 6, p. 1799-1804, nov.-dez. 2014.

ASNIS, S. E.; ERNBERG, J. J.; BOSTROM, M. P.; WRIGHT, T. M.; HARRINGTON, R. M.; TENCER, A.; PETERSON, M. Cancellous bone screw thread design and holding power. *Journal of Orthopaedic Trauma*, v. 10, n. 7, p. 462-469, 1996.

BAILEY, R. W. Observations of cervical intervertebral disc lesions in fractures and dislocations. *J. Bone Joint Surg. Am.*, v. 45, p. 461, abr. 1963.

BARBER, J. W.; BODEN, S. D.; GANEY, T.; HUTTON, W. C. Biomechanical study of lumbar pedicle screws: does convergence affect axial pullout strength? *J. Spinal Disord.*, v. 11, n. 3, p. 215-220, jun. 1998.

BARBIER, L.; VANDER SLOTEN, J.; KRZESINSKI, G. et al. Finite elements analysis of non-axial versus 26 axial loading of oral implants in the mandible of the dog. *J. Oral Rehabil.*, v. 25, n. 11, p. 847-858, nov. 1998.

BARBOR, R. Spinal traction. *Lancet*, v. 263, p. 437-439, fev. 1954.

BARTOLOMEI, J. C.; THEODORE, N.; SONNTAG, V. K. Adjacent level degeneration after anterior cervical fusion: a clinical review. *Neurosurgery Clinics of North America*, v. 16, n. 4, p. 575-587, out. 2005.

BAYLEY, J. C.; YOO, J. U.; KRUGER, D. M. et al. The role of distraction in improving the space available for the cord in cervical spondylosis. *Spine (Phila. Pa. 1976)*, v. 20, n. 7, p. 771-775, abr. 1995.

BECKER, S.; CHAVANNE, A.; SPITALER, R.; KROPIK, K.; AIGNER, N.; OGON, M.; REDL, H. Assessment of different screw augmentation techniques and screw designs in osteoporotic spines. *European Spine Journal*, v. 17, n. 11, p. 1462-1469, nov. 2008.

BENTO, D. A.; DALLACOSTA, D.; CUNHA, G. M. Análise computacional do comportamento mecânico de sistemas de fixação da coluna vertebral através de parafusos pediculares. In: CONGRESSO LATINO AMERICANO DE ÓRGÃOS ARTIFICIAIS E BIOMATERIAIS, 2012, Natal. *Anais eletrônicos...* Natal, 2012. Disponível em: <www.metallum.com.br/7colaob/resumos/trabalhos_completos/02-013.doc>. Acesso em: 24 dez. 2016.

BENZEL, E. C. Ventral Subaxial Spine Constructs. In: _____. *Biomechanics of spine stabilization*. 3th ed. New York: Thieme, 2015. 568 p.

_____. *Ventral subaxial spine constructs in biomechanics of spine stabilization*. New York: Thieme, 2001. p. 239-253.

BERGMAN, R. L.; LEVINE, J. M.; COATES, J. R.; BAHR, A.; HETTLICH, B. F.; KERWIN, S. C. Cervical spinal locking plate in combination with cortical ring allograft for a one level fusion in dogs with cervical spondylotic myelopathy. *Veterinary Surgery*, v. 37, n. 6, p. 530-536, ago. 2008.

BIANCO, R. J.; ARNOUX, P. J.; WAGNAC, E.; MAC-THIONG, J. M.; AUBIN, C.-E. Minimizing Pedicle Screw Pullout Risks: A Detailed Biomechanical Analysis of Screw Design and Placement. *Clin. Spine Surg.*, v. 30, n. 3, p. E226-E232, abr. 2017.

BLASS, C. E.; WALDRON, D. R.; VAN EE, R. T. Cervical stabilization in three dogs using steinmann pins and methyl methacrylate. *J. Am. Anim. Hosp. Assoc.*, v. 24, p. 61-68, 1988.

BOGDUK, N. *Clinical Anatomy of the Lumbar Spine and Sacrum*. 5th. ed. Amsterdam: Elsevier, 2008.

BOLHMAN, H.; EMERY, S.; GOODFELLOW, D.; JONES, P.K. Robinson anterior cervical discectomy and arthrodesis for cervical radiculopathy. Long term follow-up of one hundred and twenty-two patients. *Journal of Bone & Joint Surgery American*, v. 75, n. 9, p. 1298-1307, set. 1993.

BOOS, N.; WEBB, J. K. Pedicle screw fixation in spinal disorders: a European view. *Eur. Spine J.*, v. 6, n. 1, p. 2-18, 1997.

BRANTLEY, A. G.; MAYFIELD, J. K.; KOENEMAN, J. B.; CLARK, K. R. The effects of pedicle screw fit. An in vitro study. *Spine (Phila. Pa. 1976)*, v. 19, n. 15, p. 1752-1758, ago. 1994b.

BRASILIANSE, L. B. C.; LAZARO, B.C.; REYES, P. M.; NEWCOMB, A. G.; TURNER, J. L.; CRANDALL, D. G.; CRAWFORD, N. R. Characteristics of immediate and fatigue strength of a dualthreaded pedicle screw in cadaveric spines. *Spine Journal*, v. 13, n. 8, p. 947-956, ago. 2013.

BREIT, S.; KUNZEL, W. Shape and orientation of articular facets of cervical vertebrae (C3-C7) in dogs denoting axial rotational ability: an osteological study. *Eur. J. Morphol.*, v. 40, n. 1, p. 43-51, fev. 2002.

BRODKE, D. S.; BACHUS, K. N.; MOHR, R. A.; NGUYEN, B. K. Segmental pedicle screw fixation or cross-links in multilevel lumbar constructs. A biomechanical analysis. *The Spine Journal*, v. 1, n. 5, p. 373-379, set.-out. 2001a.

_____; GOLLOGLY, S.; ALEXANDER MOHR, R.; NGUYEN, B. K.; DAILEY, A. T.; BACHUS, A. K. Dynamic cervical plates: biomechanical evaluation of load sharing and stiffness. *Spine (Phila. Pa. 1976)*, v. 26, n. 12, p. 1324-1329, jun. 2001b.

BRUECKER, K. A.; SEIM, H. B.; BLASS, C. E. Caudal cervical spondylomyelopathy: decompression by linear traction and stabilization with Steinmann pins and polymethyl methacrylate. *Journal of the American Animal Hospital Association*, v. 25, n. 6, p. 677-683, 1989.

_____.; SEIM, H. B.; WITHROW, S. J. Clinical evaluation of three surgical methods for treatment of caudal cervical spondylomyelopathy of dogs. *Veterinary Surgery*, v. 18, n. 3, p. 197-203, maio-jun.1989.

BUDSBERG, S. C. Implant failure. In: JOHNSON, A. L.; HOULTON J. E. F.; VANNINI, R. (Eds.). *AO principles of fracture management in the dog and cat*. Davos, Suíça/Stuttgart, Alemanha: AO Publishing/Thieme, 2005. p. 425-426.

BURBIDGE, H. M. Caudal cervical malformation in the Doberman pinscher. 135p. 1999. Tese (PhD) – Nova Zelândia: Massey University, 1999. p. 121-135.

_____.; PFEIFFER, D. U.; BLAIR, H. T. Canine wobblers syndrome: a study of the Doberman pinscher in New Zealand. *New Zealand Veterinary Journal*, v. 42, n. 6, p. 221-228, dez. 1994.

_____.; PFEIFFER, D. U.; GUILFORD, W. G. Presence of cervical vertebral malformation in Doberman puppies and the effects of diet and growth rate. *Australian Veterinary Journal*, v. 77, n. 12, p. 814-818, dez. 1999.

BUSSCHER, I.; VAN DER VEEN, A. J.; VAN DIEËN, J. H.; KINGMA, I.; VERKERKE, G. J.; VELDHUIZEN, A. G. In vitro biomechanical characteristics of the spine. A comparison between human and porcine spinal segments. *Spine (Phila. Pa. 1976)*, v. 35, p. E35-E42, jan. 2010.

CAMPELLO, T. N.; SILVA, I. N. L.; SIMÕES, M. S. Prótese para substituição total de disco intervertebral: desenvolvimento de modelo computacional e análise por elementos finitos. *Coluna*, v. 8, p. 38-42, 2009.

CANN, C. E.; GENANT, H. K. Precise measurement of vertebral mineral content using computed tomography. *J. Comput. Assist. Tomogr.*, v. 4, n. 4, p.493-500, ago. 1980.

CARL, A. L.; TROMANHAUSER, S. G.; ROGER, D. J. Pedicle crew instrumentation for thoracolumbar burst fractures and fracture-dislocations. *Spine (Phila. Pa. 1976)*, v. 17, n. 8 (suppl.), p. 317S-324S, ago. 1992.

CARMOUCHE, J. J.; MOLINARI, R. W.; GERLINGER, T.; DEVINE, J.; PATIENCE, T. Effects of pilot hole preparation technique on pedicle screw fixation in different regions of the osteoporotic thoracic and lumbar spine. *J. Neurosurg. Spine*, v. 3, n. 5, p. 364-370, nov. 2005.

CHAMBERS, J. N.; OLIVER, J. E.; BJORLING, D. E. Update on ventral decompression for caudal cervical disk herniation in Doberman Pinschers. *Journal of the American Animal Hospital Association*, v. 22, n. 6, p. 775-778, 1986.

CHAO, C. K.; HSU, C. C.; WANG, J. L.; LIN, J. Increasing Bending Strength and Pullout Strength in Conical Pedicle Screws: Biomechanical Tests and Finite Element Analyses. *Journal of Spinal Disorders & Techniques*, v. 21, n. 2, p. 130-138, abr. 2008.

CHAPMAN, J. R.; HARRINGTON, R. M.; LEE, K. M.; ANDERSON, P. A.; TENCER, A. F.; KOWALSKI, D. Factors affecting the pullout strength of cancellous bone screws. *Journal of Biomechanical Engineering*, v. 118, n. 3, p. 391-398, ago. 1996.

CHEN C. S.; CHEN W. J.; CHENG C. K.; JAO S. H.; CHUEH S. C.; WANG C. C. Failure analysis of broken screws on spinal instrumentation. *Medical Engineering & Physics*, v. 27, n. 6, p. 487-496, jul. 2005.

CHEN L. H.; TAI C. L.; LEE D. M.; LAI P. L.; LEE Y. C.; NIU C. C.; CHEN W. J. Pullout strength of pedicle screws with cement augmentation in severe osteoporosis: a comparative study between cannulated screws with cement injection and solid screws with cement pre-filling. *BMC Musculoskeletal Disorders*, v. 12, p. 33, fev. 2011.

CHEN P. Q.; LIN S. J.; WU S. S.; SO H. Mechanical performance of the new posterior spinal implant: effect of materials, connecting plate, and pedicle screw design. *Spine (Phila. Pa. 1976)*, v. 28, n. 9, p. 881-866, maio 2003.

CHEN S. H.; MO LIN R.; CHEN H. H.; TSAI K. J. Biomechanical effects of polyaxial pedicle screw fixation on the lumbosacral segments with an anterior interbody cage support. *BMC Musculoskeletal Disord*, v. 8, p. 28, mar. 2007.

CHEN S. I.; LIN R. M.; CHANG C. H. Biomechanical investigation of pedicle screw-vertebrae complex: a finite element approach using bonded and contact interface conditions. *Med Eng Phys*, v. 25, n. 4, p. 275-282, maio 2003.

CHO W.; CHO S. K.; WU C. The biomechanics of pedicle screw-based instrumentation. *The Journal of Bone & Joint Surgery (Br)*, v. 92, n. 8, p. 1061-1065, ago. 2010.

CHUTKAN, N. B.; ZHOU H.; AKINS, J. P.; WENGER, K. H. Effects of facetectomy and crosslink augmentation on motion segment flexibility in posterior lumbar interbody fusion. *Spine (Phila. Pa. 1976)*, v. 33, n. 22, p. 828-835, out. 2008.

COE, J. D.; WARDEN, K. E.; HERZIG, M. A.; MCAFEE, P. C. Influence of bone mineral density on the fixation of thoracolumbar implants. A comparative study of transpedicular screws, laminar hooks, and spinous process wires. *Spine (Phila. Pa. 1976)*, v. 15, n. 9, p. 902-907, set. 1990.

COOK, S. D.; SALKELD, S. L.; STANLEY, T.; FACIANE, A.; MILLER, S. D. Biomechanical study of pedicle screw fixation in severely osteoporotic bone. *The Spine Journal*, v. 4, n. 4, p. 402-408, jul.-ago. 2004.

CORLAZZOLI, D. Bicortical implant insertion in caudal cervical spondylomyelopathy: a computed tomography simulation in affected Doberman Pinschers. *Veterinary Surgery*, v. 37, n. 2, p. 178-185, fev. 2008.

DA COSTA, R. C. Cervical spondylomyelopathy (wobbler syndrome) in dogs. *Veterinary Clinics of North America. Small Animal Practice*, v. 40, n. 5, p. 881-913, set. 2010.

_____. Pathogenesis of cervical spondylomyelopathy: lessons from recent years. In: 2007 ACVIM FORUM, 2007, Seattle. *ACVIM Proceedings*, Lakewood, 2007. p. 318-320.

_____; ARMSTRONG, J.; RUSSELL, D. Is apoptosis present in the spinal cord of dogs with cervical spondylomyelopathy? 2013 ACVIM FORUM, 2013, Seattle. *ACVIM Proceedings*, Seattle, 2013.

_____; JOHNSON, J. A. Intervertebral and intravertebral ratios in Doberman pinscher dogs with cervical spondylomyelopathy. *Veterinary Radiology & Ultrasound*, v. 53, n. 5, p. 518-523, set. 2012.

_____; PARENT, J. M.; PARTLOW, G.; DOBSON, H.; HOLMBERG, D. L.; LAMARRE, J. Morphologic and morphometric magnetic resonance imaging features of Doberman pinscher dogs with and without clinical signs of cervical spondylomyelopathy. *American Journal of Veterinary Research*, v. 67, n. 9, p. 1601-1612, set. 2006.

_____; STERN, J. A.; MARTIN-VAQUERO, P.; HEINTEL, A.; MEUR, K. Inheritance of cervical spondylomyelopathy in Doberman Pinscher Dogs. *Journal of Veterinary Internal Medicine*, v. 27, p. 680, 2013.

DAFTARI, T. K.; HORTON, W. C.; HUTTON, W. C. Correlations between screw hold preparation, torque of insertion, and pullout strength for spinal screws. *J. Spinal Disord.*, v. 7, n. 2, p. 139-145, abr. 1994.

DAI L. Disc degeneration and cervical instability. Correlation of magnetic resonance imaging with radiography. *Spine (Phila. Pa. 1976)*, v. 23, n. 16, p. 1734-1738, ago. 1998.

DANIELSKI, A.; VANHAESEBROUCK, A.; YEADON, R. Ventral stabilization and facetectomy in a Great Dane with Wobbler syndrome due to cervical spinal canal stenosis. *Veterinary and Comparative Orthopaedics and Traumatology*, v. 25, n. 4, p. 337-341, 2012.

DAVNE, S. H.; MYERS, D. L. Complications of lumbar spinal fusion with transpedicular instrumentation. *Spine (Phila. Pa. 1976)*, v. 17, p. S184-S189, jun. 1992.

DE DECKER, S.; BHATT, S.; GIELEN, I.; VAN HAM, L. Diagnosis, treatment and prognosis of disc associated Wobbler syndrome in dogs. *Vlaams Diergeneeskundig Tijdschrift*, v. 78, p. 139-146, 2008.

_____; CAEMAERT, J.; TSHAMALA, M.C.; GIELEN, I.M.; VAN BREE, H.J.; BOSMANS, T.; WEGGE, B.; VAN HAM, L. M. Surgical treatment of disk-associated Wobbler syndrome by a distractable vertebral titanium cage in seven dogs. *Veterinary Surgery*, v. 40, n. 5, p. 544-554, jul. 2011.

DE RISIO, L.; MUNANA, K.; MURRAY, M.; OLBY, N.; SHARP, N. J.; CUDDON, P. Dorsal laminectomy for caudal cervical spondylomyelopathy: postoperative recovery and long-term follow-up in 20 dogs. *Veterinary Surgery*, v. 31, n. 5, p. 418-427, set.-out. 2002.

DEFINO, H. L. A. et al. Mechanical Performance of Cylindrical and Dual-Core Pedicle Screws After Repeated Insertion. *Spine (Phila. Pa. 1976)*, v. 37, n. 14, p. 1187-1191, jun. 2012.

_____; ROSA, R. C.; SILVA, P. et al. The effect of repetitive pilot-hole use on the insertion torque and pullout strength of vertebral system screws. *Spine (Phila. Pa.)*, v. 34, n. 9, p. 871-876, abr. 2009.

DELIGIANNI, D.; KOROVISSIS, P.; BAIKOUSIS, A. et al. Factor analysis of the effectiveness of transfixation and rod characteristics on the TSRH screw-rod instrumentation. *J. Spinal Disord.*, v. 13, n. 1, p. 50-57, fev. 2000.

DENNY, H. R.; GIBBS, C.; GASKELL, C. J. Cervical spondylopathy in the dog - a review of thirty-five cases. *Journal of Small Animal Practice*, v. 18, n. 2, p. 117-132, fev. 1977.

DIAMANTE, G. A. C. *Avaliação ex vivo do conceito dos três compartimentos em fraturas toracolumbares em cães*. 2016. 72 fls. Dissertação (Mestrado em Ciência Animal) - Universidade Estadual de Londrina, Londrina, 2016.

DIANGELO, D. J.; FOLEY, K. T.; VOSSEL, K. A. et al. Anterior cervical plating reverses load transfer through multilevel strut grafts. *Spine (Phila. Pa. 1976)*, v. 25, n. 7, p. 783-795, abr. 2000.

_____; ROBERTSON, J.; METCALF, N.; MCVAY, B. J.; DAVIS, R. C. Biomechanical testing of an artificial cervical joint and an anterior cervical plate. *Journal of Spinal Disorders & Techniques*, v. 16, n. 4, p. 314-323, ago. 2003.

DICK, J. C.; ZDEBLICK, T. A.; BARTEL, B. D.; KUNZ, D. N. Mechanical evaluation of cross-link designs in rigid pedicle screw systems. *Spine (Phila. Pa.)*, v. 22, n. 4, p. 370, fev. 1997.

DICKMAN, C. A.; FESSLER, R. G.; MACMILLAN, M.; HAID, R. W. Transpedicular screw-rod fixation of the lumbar spine: operative technique and outcome in 104 cases. *Journal of Neurosurgery*, v. 77, n. 6, p. 860-870, dez. 1992.

DIXON, B.; TOMLINSON, J. L.; KRAUS, K. H. Modified distraction-stabilization techniques using an interbody polymethyl methacrylate plug in dogs with caudal cervical spondylomyelopathy. *Journal of the American Veterinary Medical Association*, v. 208, n. 1, p. 61-68, jan. 1996.

DOHT, S.; MEFFERT, R. H.; RASCHKE, M. J.; BLUNK, T.; OCHMAN, S. Biomechanical analysis of the efficacy of locking plates during cyclic loading in metacarpal fractures. *Sci World J*, p. 1-5, mar. 2014.

ECK, J. C.; HUMPHREYS, S. C.; LIM T. H.; JEONG, S. T.; KIM, J. G.; HODGES, S. D.; AN H. S. Biomechanical study on the effect of cervical spine fusion on adjacent-level intradiscal pressure and segmental motion. *Spine (Phila. Pa.)*, v. 27, n. 22, p. 2431-2134, nov. 2002.

EGOL, K. A.; KUBIAK, E. N.; FULKERSON, E.; KUMMER, F. J.; KOVAL, K. J. Biomechanics of locked plates and screws. *J. Orthop. Trauma*, v. 18, n. 8, p. 488-493, nov. 2004.

ELLISON, G. W.; SEIM, H. B.; CLEMMONS, R. M. Distracted cervical spinal fusion for management of caudal cervical spondylomyelopathy in large-breed dogs. *Journal of the American Veterinary Medical Association*, v. 193, n. 4, p. 447-453, ago. 1988.

ERB, K.; PFEIL, I. Treatment of 65 dogs with a wobbler syndrome by distraction and fusion with TTA cages from KYON. In: 16th ESVOT CONGRESS, 12-16 set., Bologna (Itália).

ERKAN, S.; HSU, B.; WU, C. et al. Alignment of pedicle screws with pilot holes: can tapping improve screw trajectory in thoracic spines?. *Eur. Spine J.*, v. 19, n. 1 p. 71-77, jan. 2010.

_____; WU, C.; MEHBOD, A. A.; CHO, W.; TRANSFELDT, E. E. Biomechanical comparison of transpedicular versus extrapedicular vertebroplasty using polymethylmethacrylate. *J. Spinal Disord. Tech.*, v. 23, n. 3, p. 180-185, maio 2010.

ESSES, S. I.; SACHS, B. L.; DREYZIN, V. Complications associated with the technique of pedicle screw fixation. A selected survey of ABS members. *Spine (Phila. Pa. 1976)*, v. 18, n. 15, p. 2231-2238, nov. 1993.

FARRELL, M.; FITZPATRICK, N. Lumbosacral Disc Disease: Is Vertebral Stabilization Indicated? In: FINGEROTH, J. M.; THOMAS, W. B. *Advances in Intervertebral Disc Disease in Dogs and Cats*. 1st. ed. Hoboken: Wiley Blackwell, 2015. p. 237-250.

FERGUSON, S. J.; STEFFEN, T. Biomechanics of spinal stabilization. In: AEBI, M.; ARLET, V.; WEBB, J. K. (Eds.). *AO spine manual, principles and techniques*, v. 1. New York: Thieme, 2007. p. 53-68.

FITCH, R. B.; KERWIN, S. C.; HOSGOOD, G. Caudal cervical intervertebral disk disease in the small dog: role of distraction and stabilization in ventral slot decompression. *J. Am. Anim. Hosp. Assoc.*, v. 36, n. 1, p. 68-74, jan.-fev. 2000.

FITZPATRICK, N. Lumbosacral distraction-fusion using an intervertebral spacer and screw-rod fixation system for treatment of degenerative lumbosacral stenosis. In: VOS-WVOC CONGRESS, Breckenridge, CO, 2014.

FOGEL, G. R.; REITMAN, C. A.; LIU, W.; ESSES, S. I. Physical characteristics of polyaxialheaded pedicle screws and biomechanical comparison of load with their failure. *Spine (Phila. Pa. 1976)*, v. 28, n. 1, p. 470-473, mar. 2003.

FULLER, D. A.; KIRKPATRICK, J. S.; EMERY, S. E. et al. A kinematic study of the cervical spine before and after segmental arthrodesis. *Spine (Phila. Pa. 1976)*, v. 23, n. 15, p. 1649-1656, ago. 1998.

GALANO, H.; OLBY, N. J.; SHARP, N. J.; SKEEN, T.; MUNANA, K.; EARLY, P.; SULLIVAN, S. Long-term effect of cervical fusion on neurological status and vertebral canal diameter in giant breed dogs with cervical stenotic myelopathy. *Journal of Veterinary Internal Medicine*, v. 19, n. 3, p. 419, 2005.

GAUTIER, E.; SOMMER, C. Guidelines for the clinical application of the LCP. *Injury*, v. 34 (suppl. 2), p. B63-B76, nov. 2003.

GELALIS, I. D.; PASCHOS, N. K.; PAKOS, E. E.; POLITIS, A. N.; ARNAOUTOGLU, C. M.; KARAGEORGOS, A. C.; PLOUMIS, A.; XENAKIS, T. A. Accuracy of pedicle screw placement: a systematic review of prospective in vivo

studies comparing free hand, fluoroscopy guidance and navigation techniques. *European Spine Journal*, v. 21, n. 2, p. 247-255, fev. 2012.

GEORGE, D. C.; KRAG, M. H.; JOHNSON, C. C.; VAN HAL, M. E.; HAUGH, L. D.; GROBLER, L. J. Hole preparation techniques for transpedicle screws. Effect on pull-out strength from human cadaveric vertebrae. *Spine (Phila. Pa.)*, v. 16, n. 2, p. 181-184, fev. 1991.

GLASSMAN, S. D.; DIMAR, J. R.; PUNO, R. M.; JOHNSON, J. R.; SHIELDS, C. B.; LINDEN, R. D. A prospective analysis of intraoperative electromyographic monitoring of pedicle screw placement with computed tomographic scan confirmation. *Spine (Phila. Pa.)*, v. 20, n. 12, p. 1375-1379, jun. 1995.

GOFFIN, J.; GEUSENS, E.; VANTOMME, N.; QUINTENS, E.; WAERZEGGERS, Y.; DEPREITERE, B.; VAN CALENBERGH, F.; VAN LOON, J. Long-term followup after interbody fusion of the cervical spine. *Journal of Spinal Disorders & Techniques*, v. 17, n. 2, p. 79-85, abr. 2004.

GORING, R. L.; BEALE, B. S.; FAULKNER, R. F. The inverted cone decompression technique: a surgical treatment for cervical vertebral instability "wobbler syndrome" in Doberman Pinschers. *Journal of the American Veterinary Medical Association*, v. 27, n. 4, p. 403-409, 1991.

GOSCH, H. H.; GOODING, E.; SCHNEIDER, R. C. An experimental study of cervical spine and cord injuries. *J. Trauma*, v. 12, n. 7, p. 570-575, jul. 1972.

GRAUER, J. N.; PANJABI, M. M. Biomecânica clínica relevante da coluna. In: VACCARO, A. R.; BETZ, R. R.; ZEIDMAN, S. M. *Cirurgia da coluna - princípios e prática*. Rio de Janeiro: Di Livros, 2007. p. 35-42.

GUILEE, J.; MILLER, A.; BOWEN, J.; FORLIN, E.; CARO, P. A. The natural history of Klippel-Foil syndrome: clinical, roentgenographic, and magnetic resonance imaging findings at adulthood. *Journal of Pediatric Orthopaedics*, v. 15, n. 5, p. 617-626, set.-out. 1995.

HACKENBERG, L.; LINK, T.; LILJENQVIST, U. Axial and tangential fixation strength of pedicle screws versus hooks in the thoracic spine in relation to bone mineral density. *Spine (Phila. Pa. 1976)*, v. 27, n. 9, p. 937-942, maio 2002.

HAERDI, C.; DALLA COSTA, R.; AUER, J. A.; LINKE, B.; STEINER, A. Mechanical comparison of 3 different clamp and 2 different rod types of a new veterinary internal fixation system, 4.5/5.5-mm VetFix. *Veterinary Surgery*, v. 32, n. 5, p. 431-438, set.-out. 2003.

HAKALO, J.; PEZOWICZ, C.; WRONSKI, J.; BEDZINSKI, R.; KASPROWICZ, M. Comparative biomechanical study of cervical spine stabilisation by cage alone, cage with plate, or plate-cage: a porcine model. *J. Orthop. Surg.*, v. 16, n. 1, p. 9-13, abr. 2008.

HAKATO, J.; WRONSKI, J.; CIUPIK, L. Subsidence and its effect on the anterior plate stabilization in the course of cervical spondylodesis. Part I: definition and review of the literature. *Neurologia i Neurochirurgia Polska*, v. 37, n. 4, p. 903-915, 2003.

HAKOZAKI, T.; ICHINOHE, T.; KANNO, N.; YOGO, T.; HARADA, Y.; INABA, T.; KASAI, Y.; HARA, Y. Biomechanical assessment of the effects of vertebral distraction-fusion techniques on the adjacent segment of canine cervical vertebrae. *Am. J. Vet. Res.*, v. 77, n. 11, p. 1194-1199, nov. 2016.

HALAWA, M.; LEE, A. J.; LING, R. S.; VANGALA, S. S. The shear strength of trabecular bone from the femur, and some factors affecting the shear strength of the cement-bone interface. *Archives of Orthopaedic and Traumatic Surgery*, v. 92, n. 1, p. 19-30, ago. 1978.

HEDHAMMAR, A.; WU, F. M.; KROOK, L.; SCHRYVER, H. F.; HINTZ, H. F. Overnutrition and skeletal disease. An experimental study in growing Great Dane dogs. *Cornell Vet*, v. 64, n. 2, p. 5-160, abr. 1974.

HEE, H. T.; KHAN, M. S.; GOH, J. C.; WONG, H. K. Insertion torque profile during pedicle screw insertion of the thoracic spine with and without violation of the pedicle wall: comparison between cylindrical and conical designs. *Spine (Phila. Pa. 1976)*, v. 31, n. 22, p. E840-E846, out. 2006.

HELGESON, M. D.; KANG, D. G.; LEHMAN JR., R. A. ; DMITRIEV, A. E.; LUHMANN, S. J. Tapping insertional torque allows prediction for better pedicle screw fixation and optimal screw size selection. *Spine Journal*, v. 13, n. 8, p. 957-965, ago. 2013.

HENDERSON, F. C.; GEDDES, J. F.; VACCARO, A. R.; WOODARD, E.; BERRY, K. J.; BENZEL, E. C. Stretch-associated injury in cervical spondylotic myelopathy: new concept and review. *Neurosurgery*, v. 56, n. 5, p. 1101-1113, 2005.

HETTLICH, B. F.; ALLEN, M. J.; GLUCKSMAN, G. S.; FOSGATE, G. T.; LITSKY, A. S. Effect of an intervertebral disk spacer on stiffness after monocortical screw/polymethylmet acrylatefixation in simulated and cadaveric canine cervical vertebral columns. *Veterinary Surgery*, v. 43, n. 8, p. 988-994, nov. 2014.

_____; ALLEN, M. J.; PASCETTA, D.; FOSGATE, G. T.; LITSKY, A. S. Biomechanical Comparison Between Bicortical Pin and Monocortical Screw/Polymethylmethacrylate Constructs in the Cadaveric Canine Cervical Vertebral Column. *Veterinary Surgery*, v. 42, n. 6, p. 693-700, ago. 2013.

_____; FOSGATE, G. T.; LITSKY, A. S. Biomechanical Comparison of 2 Veterinary Locking Plates to Monocortical Screw/Polymethylmethacrylate Fixation in Canine Cadaveric Cervical Vertebral Column. *Veterinary Surgery*, v. 46, n. 1, p. 95-102, jan. 2017.

HICKS, D. G.; PITTS, M. J.; BAGLEY, R. S.; VASAVADA, A.; CHEN, A. V.; WININGER, F. A.; SIMON, J. C. In vitro biomechanical evaluations of screw bar-polymethylmethacrylate and pinpolymethylmethacrylate internal fixation implants used to stabilize the vertebral motion unit of the fourth and fifth cervical vertebrae in vertebral column specimens from dogs. *Am. J. Vet. Res.*, v. 70, n. 6, p. 719-726, jun. 2009.

HILLBRAND, A. S.; CARLSON, G. D.; PALUMBO, M. A.; JONES, P. K.; BOHLMAN, H. H. Radiculopathy and myelopathy at segments adjacent to the site of a previous

anterior cervical arthrodesis. *Journal of Bone & Joint Surgery American*, v. 81, n. 4, p. 519-528, abr. 1999.

HIRANO, T.; HASEGAWA, K.; TAKAHASHI, H. E.; UCHIYAMA, S.; HARA, T.; WASHIO, T. et al. Structural characteristics of the pedicle and its role in screw stability. *Spine (Phila. Pa. 1976)*, v. 22, n. 21, p. 2504-2509, nov. 1997.

HOERLEIN, B. F. Comparative disk disease: man and dog. *Journal of the American Animal Hospital Association*, v. 15, n. 5, p. 535-545, set-out. 1979.

HOLDSWORTH, F. W. Fractures, dislocations, and fracture-dislocation of the spine. *J Bone Joint Surg Br*, v. 52, n. 8, p. 1534-1551, dez. 1970

HONGO, M.; GAY, R. E. HSU, J. Effect of multiple freeze-thaw cycles on intervertebral dynamic motion characteristics in the porcine lumbar spine. *Journal of Biomechanics*, v. 41, n. 4, p. 916-920, 2008.

HSU C. C.; CHAO C. K.; WANG J. L.; HOU S. M.; TSAI Y. T.; LIN J. Increase of pullout strength of spinal pedicle screws with conical core: Biomechanical tests and finite element analyses. *Journal of Orthopaedic Research*, v. 23, n. 4, p. 788-794, jul. 2005.

ICHCHOU, L.; ALLALI, F.; ROSTOM, S.; BENNANI, L.; HMAMOUCI, I.; ABOURAZZAK, F. Z.; KHAZZANI, H.; EL MANSOURI, L.; ABOUQAL, R.; HAJJAJ-HASSOUNI, N. Relationship between spine osteoarthritis, bone mineral density and bone turn over markers in post menopausal women. *BMC Womens Health*, v. 25, n. 10, p. 1-10, ago. 2010.

ICHIHARA, K.; TAGUCHI, T.; SAKURAMOTO, I.; KAWANO, S.; KAWAI, S. Mechanism of the spinal cord injury and the cervical spondylotic myelopathy: new approach based on the mechanical features of the spinal cord white and gray matter. *Journal of Neurosurgery*, v. 99, suppl. 3, p. 278-285, 2003.

INCEOGLU, S.; FERRARA, L.; MCLAIN, R. F. Pedicle screw fixation strength: pullout versus insertional torque. *The Spine Journal*, v. 4, n. 5, p. 513-518, set-out. 2004.

JAGGY, A.; GAILLARD, C.; LANG, J. et al. Hereditary cervical spondylopathy (wobbler syndrome) in the Borzoi dog. *Journal of the American Veterinary Medical Association*, v. 4, p. 453-460, 1988.

JEFFERY, N. D. The 'wobbler' syndrome. In: JEFFERY, N. D. *Handbook of small animal spinal surgery*. London: Saunders; 1995. p. 169-186.

_____. Vertebral fracture and luxation in small animals. *Vet. Clin. North Am. Small Anim. Pract.*, v. 40, n. 5, p. 809-828, set. 2010.

_____; MCKEE, W. Surgery for disc associated wobbler syndrome in the dog – an examination of the controversy. *Journal of Small Animal Practice*, v. 42, n. 12, p. 574-581, dez. 2001.

JOHNSON, J. A.; DA COSTA, R. C.; ALLEN, M. J. et al. Kinematics of the cranial and caudal cervical spine in large breed dogs. *Vet. Surg.*, v. 40, n. 6, p. 720-727, ago. 2010.

JONES, B. G.; FOSGATE, G. T.; GREEN, E. M.; HABING, A. M.; HETTLICH, B. F. Resonance imaging susceptibility artifacts in the cervical vertebrae and spinal cord related to monocortical screw-polymethylmethacrylate implants in canine cadavers. *Am. J. Vet. Res.*, v. 78, n. 4, p. 458-464, abr. 2017.

KAIGLE, A. M.; WESSBERG, P.; HANSSON, T. H. Muscular and kinematic behavior of the lumbar spine during flexion-extension. *Journal of Spinal Disorders*, v. 11, n. 2, p. 163-174, abr. 1998.

KAISER, M. G.; HAID JR., R. W.; SUBACH, B. R. et al. Anterior cervical plating enhances arthrodesis after discectomy and fusion with cortical allograft. *Neurosurgery*, v. 50, n. 2, p. 229-236, fev. 2002.

KANTER, A. S.; DAILEY, A. T.; MUMMANENI, P. V. Posterior, transforaminal and anterior lumbar interbody fusion: Techniques and instrumentation. In: WINN, H. R. *Youmans Neurological Surgery*. Amsterdam: Elsevier, 2011. p. 3076-3082.

KARAMI, K. J.; BUCKENMEYER, L. E.; KIAPOUR, A. M.; KELKAR, P. S.; GOEL, V. K.; DEMETROPOULOS, C. K.; SOO, T. M. Biomechanical evaluation of the pedicle screw insertion depth effect on screw stability under cyclic loading and subsequent pullout. *Journal of Spinal Disorders & Techniques*, v. 28, n. 3, p. E133-E139, abr. 2015.

KIM, Y. Y.; CHOI, W. S.; RHYU, K. W. Assessment of pedicle screw pullout strength based on various screw designs and bone densities — an ex vivo biomechanical study. *The Spine Journal*, v. 12, n. 2, p. 164-168, fev. 2012.

KINER, D. W.; WYBO, C. D.; STERBA, W.; YENI, Y. N.; BARTOL, S. W.; VAIDYA, R. Biomechanical analysis of different techniques in revision spinal instrumentation: larger diameter screws versus cement augmentation. *Spine*, v. 33, n. 24, p. 2618-2622, nov. 2008.

KINOSHITA, H.; TAMAKI, T.; HASHIMOTO, T.; KASAGI, F. Factors influencing lumbar spine bone mineral density assessment by dual-energy X-ray absorptiometry: Comparison with lumbar spinal radiogram. *J. Orthop. Sci.*, v. 3, n. 1, p. 3-9, 1998.

KNIGHT, S. M.; RING, E. F. J.; BHALLA, A. K. Bone mineral density and osteoarthritis. *Ann. Rheum. Dis.*, v. 51, n. 9, p. 1025-1026, set. 1992.

KOCH, D. Implants: description application. In: JOHNSON, A. L.; HOULTON, J. E. F.; VANNINI, R. (Eds.). *AO principles of fracture management in the dog and cat*. Davos, Switzerland/Stuttgart, Germany: AO Publishing/Thieme, 2005. p. 27-50.

KOEHLER, C. L.; STOVER, S. M.; LECOUTEUR, R. A.; SCHULZ, K. S.; HAWKINS, D. A. Effect of a ventral slot procedure and of smooth or positive-profile threaded pins with polymethylmethacrylate fixation on intervertebral biomechanics at treated and adjacent canine cervical vertebral motion units. *Am. J. Vet. Res.*, v. 66, n. 4, p. 678-687, abr. 2005.

KOKTEKIR, E.; TOKTAS, Z. O.; SEKER, A.; AKAKIN, A.; KONYA, D.; KILIC, T. Anterior transpedicular screw fixation of cervical spine: Is it safe? Morphological feasibility, technical properties, and accuracy of manual insertion. *J. Neurosurg. Spine*, v. 22, n. 6, p. 596-604, jun. 2015.

KOLLER, H.; ACOSTA, F.; TAUBER, M.; FOX, M.; MARTIN, H.; FORSTNER, R.; AUGAT, P.; PENZKOFER, R.; PIRICH, C.; KÄSSMANN, H.; RESCH, H.; HITZL, W. Cervical anterior transpedicular screw fixation (ATPS) - Part II. Accuracy of manual insertion and pull-out strength of ATPS. *Eur. Spine J.*, v. 17, n. 4, p. 539-555, abr. 2008a.

_____; HEMPFING, A.; ACOSTA, F.; FOX, M.; SCHEITER, A.; TAUBER, M.; HOLZ, U.; RESCH, H.; HITZL, W. Cervical anterior transpedicular screw fixation. Part I: Study on morphological feasibility, indications, and technical prerequisites. *Eur. Spine J.*, v. 17, n. 4, p. 523-338, abr. 2008b.

_____; HITZL, W.; ACOSTA, F.; TAUBER, M.; ZENNER, J.; RESCH, H.; YUKAWA, Y.; MEIER, O.; SCHMIDT, R.; MAYER, M. In vitro study of accuracy of cervical pedicle screw insertion using an electronic conductivity device (ATPS part III). *Eur. Spine J.*, v. 18, n. 9, p. 1300-1313, set. 2009.

KOROVESSIS, P.; BAIKOUSIS, A.; DELIGIANNI, D. et al. Effectiveness of transfixation and length of instrumentation on titanium and stainless steel transpedicular spine implants. *J. Spinal Disord.*, v. 14, n. 2, p. 109-117, abr. 2001.

KOSTUIK, J. P.; MUNTING, E.; VALDEVIT, A. Biomechanical analysis of screw load sharing in pedicle fixation of the lumbar spine. *J. Spinal Disord.*, v. 7, n. 5, p. 394-401, out. 1994.

KRAG, M. H.; BEYNNON, B. D.; POPE, M. H.; DECOSTER, T. A. Depth of insertion of transpedicular vertebral screws into human vertebrae: effect upon screw-vertebra interface strength. *Journal of Spinal Disorders*, v. 1, n. 4, p. 287-94, 1988.

_____; BEYNNON, B. D.; POPE, M. H.; FRYMOYER, J. W.; HAUGH, L. D.; WEAVER, D. L. An internal fixator for posterior application to short segments of the thoracic, lumbar, or lumbosacral spine: design and testing. *Clin. Orthop.*, v. 203, p. 75-98, fev. 1986.

KRENN, M. H.; PIOTROWSKI, W. P.; PENZKOFER, R.; AUGAT, P. Influence of thread design on pedicle screw fixation. Laboratory investigation. *Journal of Neurosurgery. Spine*, v. 9, n. 1, p. 90-95, jul. 2008.

KUENY, R. A.; KOLB, J. P.; LEHMANN, W.; PÜSCHEL, K.; MORLOCK, M. M.; HUBER, G. Influence of the screw augmentation technique and a diameter increase on pedicle screw fixation in the osteoporotic spine: pullout versus fatigue testing. *European Spine Journal*, v. 23, n. 10, p. 2196-2202, out. 2014.

KUKLO, T. R.; DMITRIEV, A. E.; CARDOSO, M.J., et al. Biomechanical contribution of transverse connectors to segmental stability following long segment instrumentation with thoracic pedicle screws. *Spine (Phila. Pa.)*, v. 33, n. 1, p. 482-487, jul. 2008.

KUMARESAN, S.; YOGANANDAN, N.; PINTAR, F. A.; MAIMAN, D. J.; GOEL, V. K. Contribution of disc degeneration to osteophyte formation in the cervical spine: a biomechanical investigation. *Journal of Orthopaedic Research*, v. 19, n. 5, p. 977-984, set. 2001.

KWOK, A. W.; FINKELSTEIN, J. A.; WOODSIDE, T.; HEARN, T. C.; HU, R. W. Insertional torque and pull-out strengths of conical and cylindrical pedicle screws in cadaveric bone. *Spine (Phila. Pa.)*, v. 21, n. 21, p. 2429-2434, nov. 1996.

LAW, M.; TENCER, A. F.; ANDERSON, P. A. Caudo-cephalad loading of pedicle screws: mechanisms of loosening and methods of augmentation. *Spine (Phila. Pa. 1976)*, v. 18, n. 16, p. 2438-2443, dez. 1993.

LEHMAN JR., R. A.; POLLY JR., D. W.; KUKLO, T. R. et al. Straight-forward versus anatomic trajectory technique of thoracic pedicle screw fixation: a biomechanical analysis. *Spine (Phila. Pa. 1976)*, v. 28, n. 18, p. 2058-2065, set. 2003.

LEVINE, D. N. Pathogenesis of cervical spondylotic myelopathy. *Journal of Neurology, Neurosurgery, and Psychiatry*, v. 62, n. 4, p. 334-340, abr. 1997.

LEWIS, M.; OLBY, N. J.; SHARP, N. J. H; EARLY, P. Long-Term Effect of Cervical Distraction and Stabilization on Neurological Status and Imaging Findings in Giant Breed Dogs With Cervical Stenotic Myelopathy. *Veterinary Surgery*, v. 42, n. 6, p. 701-709, ago. 2013.

LIEBENSON, C. The relationship of the sacroiliac joint, stabilization musculature, and lumbo-pelvic instability. *Journal of Bodywork and Movement Therapies*, v. 8, n. 1, p. 43-45, jan. 2004.

LILL, C. A.; SCHLEGEL, U.; WAHL, D.; SCHNEIDER, E. Comparison of the in vitro holding strengths of conical and cylindrical pedicle screws in a fully inserted setting and backed out 180 degrees. *J. Spinal Disord.*, v. 13, n. 3, p. 259-266, jun. 2000.

_____; SCHNEIDER, E.; GOLDHAHN, J.; HASLEMANN, A.; ZEIFANG, F. Mechanical performance of cylindrical and dual core pedicle screws in calf and human vertebrae. *Arch. Orthop. Trauma Surg.*, v. 126, n. 10, p. 686-694, dez. 2006.

LIM, T. H.; ECK, J. C.; AN, H. S. et al. Biomechanics of transfixation in pedicle screw instrumentation. *Spine (Phila. Pa. 1976)*, v. 21, n. 19, p. 2224-2229, out. 1996.

_____; KIM, J. G.; FUJIWARA, A. et al. Biomechanical evaluation of diagonal fixation in pedicle screw instrumentation. *Spine (Phila. Pa. 1976)*, v. 26, n. 22, p. 2498-2503, nov. 2001.

LIN, L. C.; CHEN, H. H.; SUN, S. P. A biomechanical study of the cortex-anchorage vertebral screw. *Clin. Biomech.*, v. 18, n. 8, p. S25-S32, jul. 2003

LINK, H. D.; MCAFEE, P. C.; PIMENTA, L. Choosing a cervical disc replacement. *Spine J.*, v. 4 (suppl. 6), p. 294S-302S, nov.-dez. 2004.

LIU, G.; PEACOCK, M.; EILAM, O.; DORULLA, G.; BRAUNSTEIN, E.; JOHNSTON, C. C. Effect of osteoarthritis in the lumbar spine and hip on bone mineral density and diagnosis of osteoporosis in elderly men and women. *Osteoporos. Int.*, v. 7, n. 6, p. 564-569, 1997.

LIU, Y. K.; NJUS, G. O.; BAHR, P. A.; GENG, P. Fatigue life improvement of nitrogen-ionimplanted pedicle screws. *Spine (Phila. Pa. 1976)*, v. 15, n. 4, p. 311-317, abr. 1990.

LYMAN, R. Continuous dorsal laminectomy for the treatment of caudal cervical instability and malformation. In: 1989 ACVIM FORUM, 1989, Seattle. *ACVIM Forum Proceedings*, Lakewood, 1989. p. 13-16.

MAIMAN, D. J.; KUMARESAN, S.; YOGANANDAN, N.; PINTAR, F. A. Biomechanical effect of anterior cervical spine fusion on adjacent segments. *Biomed. Mater. Engineering*, v. 9, n. 1, p. 27-28, 1999.

MARINHO, P. V. T. *Desenvolvimento de uma prótese de disco intervertebral cervical em cães*. 2015. 104 f. Dissertação (Mestrado em Ciência Animal) – Universidade Estadual de Londrina, Londrina. 2015.

_____; MACEDO, A. S.; FERRIGNO, C. R. A. F.; DAL-BÓ, I. S.; PAES, F.; BREGADIOLI, T.; SANTOS, J. F.; GALEAZZI, V. S. Uso de parafusos vertebrais para distração e estabilização espinhal em um cão com espondilomielopatia cervical disco-associada. In: XII CONGRESSO DE CIRURGIA VETERINÁRIA DO CBCAV E II CONGRESSO INTERNACIONAL DO CBCAV, Águas de Lindoia, SP, 2016.

MARTIN, R. B.; SHARKEY, N. A. Mechanical effects of postmortem changes preservation and allograft bone treatments. In: COWIN, S.C. *Bone mechanics handbook*. Boca Raton: CRC Press, 2001. p. 20.1-20.12.

MARTIN-VAQUERO, P.; DA COSTA, R. C. Body conformation in Great Danes with and without clinical signs of cervical spondylomyelopathy, *Vet. J.*, v. 203, n. 2, p. 219-222, fev. 2015.

_____; DA COSTA, R. C.; ALLEN, M. J.; MOORE, S. A.; KEIRSEY, J. K.; GREEN, K. B. Proteomic analysis of cerebrospinal fluid in canine cervical spondylomyelopathy, *Spine (Phila. Pa. 1976)*, v. 40, n. 9, p. 601-612, maio 2015.

_____; DA COSTA, R. C.; MOORE, S. A.; GROSS, A. C.; EUBANK, T. D. Cytokine concentrations in the cerebrospinal fluid of great danes with cervical spondylomyelopathy. *J. Vet. Intern. Med.*, v. 28, n. 4, p. 1268-1274, jul.-ago. 2014.

MASON, T. A. Cervical vertebral instability (Wobbler syndrome) in the Doberman. *Australian Veterinary Journal*, v. 53, n. 9, p. 440-445, set. 1977.

_____. Cervical vertebral instability (Wobbler syndrome) in the dog. *Veterinary Record*, v. 104, n. 7, p. 142-145, fev. 1979.

MATSUNAGA, S.; KABYAMA, S.; YAMAMOTO, T.; YONE, K.; SAKOU, T.; NAKANISHI, K. Strain on intervertebral discs after anterior cervical decompression and fusion. *Spine*, v. 24, n. 7, p. 670-675, abr. 1999.

MCGRORY, B.; KLASSEN, R. Arthrodesis of the cervical spine for fractures and dislocations in children and adolescents. A long term follow up study, *Journal of Bone & Joint Surgery American*, v. 76, n. 11, p. 1606-1614, nov. 1994.

MCKEE, W. M.; BUTTERWORTH, J.; SCOTT, H. W. Management of cervical spondylomyelopathy associated intervertebral disc protrusions using metal washers in 78 dogs. *Journal of Small Animal Practice*, v. 40, p. 465-472, out. 1999.

_____; LAVELLE, R. B.; RICHARDSON, J. L.; MASON, T. A. Vertebral distraction-fusion for cervical spondylopathy using a screw and double washer technique. *Journal of Small Animal Practice*, v. 31, n. 1, p. 21-26, jan. 1990.

_____; PINK, J. J.; GEMMILL, T. J. Cement plug technique for the management of disc associated cervical spondylopathy in 52 Doberman Pinscher dogs, *Vet. Comp. Orthop. Traumatol.*, v. 29, n. 3, p. 195-201, maio 2016.

_____; SHARP, N. J. Cervical spondylopathy. In: SLATTER, D. H. *Textbook of small animal surgery*. 3rd. ed. Philadelphia: Saunders; 2003. p. 1180-1193.

MCLAIN, R. F.; MCKINLEY, T. O.; YERBY, S. A.; SMITH, T. S.; SARIGUL-KLIJN, N. The effect of bone quality on pedicle screw loading in axial instability. A synthetic model, *Spine*, v. 22, n. 13, p. 1454-1460, jul. 1997.

MEHREN, C.; MAYER, H. M. Artificial cervical disc replacement - An update. *Neurology India*, v. 53, n. 4, p. 440-444, dez. 2005.

MEHTA, H.; SANTOS, E.; LEDONIO, C.; SEMBRANO, J.; ELLINGSON, A.; PARE, P.; MURRELL, B.; NUCKLEY, D. J. Clinical Biomechanics Biomechanical analysis of pedicle screw thread differential design in an osteoporotic cadaver model. *Clinical Biomechanics*, v. 27, n. 3, p. 234-240, mar. 2012.

MEIJ, B. P.; SUWANKONG, N.; VAN DER VEEN, A. J.; HAZEWINDEL, H. A. Biomechanical flexion-extension forces in normal canine lumbosacral cadaver specimens before and after dorsal laminectomy-discectomy and pedicle screw-rod fixation. *Vet. Surg.*, v. 36, n. 8, p. 742-751, 2007.

MEYER JR., P. R.; LAUTENSCHLAGER, E.P.; MOORE, B. K. On the setting properties of acrylic bone cement. *J. Bone Joint. Surg. Am.*, v. 55, n. 1, p.149-156, jan. 1973.

MIELE, V. J.; BHALLA, T.; JONES, G. A.; BENZEL, E. C. Concepts and mechanisms of spinal biomechanics. In: _____. *Youmans neurological surgery*. 6. ed. Philadelphia: Elsevier/Saunders, 2011. p. 2700-2710.

MILLER, D. L.; GOSWAMI, T. A review of locking compression plate biomechanics and their advantages as internal fixators in fracture healing. *Clin. Biomech.*, v. 22, n. 10, p. 1049-1062, dez. 2007.

MISENHIMER, G. R.; PEEK, R. D.; WILTSE, L. L.; ROTHMAN, S. L.; WIDELL JR., E. H. Anatomic analysis of pedicle cortical and cancellous diameter as related to screw size. *Spine*, v. 14, n. 4, p. 367-372, abr. 1989.

MIYAKOSHI, N.; ITOI, E.; MURAI, H.; WAKABAYASHI, I.; ITO, H.; MINATO, T. Inverse relation between osteoporosis and spondylosis in postmenopausal women as evaluated by bone mineral density and semiquantitative scoring of spinal degeneration. *Spine*, v. 28, n. 5, p. 492-495, mar. 2003.

MJOBERG, B.; PETTERSSON, H.; ROSENQVIST, R. et al: Bone cement, thermal injury and the radiolucent zone. *Acta Orthop. Scand.*, v. 55, n. 6, p. 597-600, dez. 1984.

MOHAMAD, F.; OKA, R.; MAHAR, A.; WEDEMEYER, M.; NEWTON, P. Biomechanical comparison of the screw-bone interface: optimization of 1 and 2 screw constructs by varying screw diameter. *Spine*, v. 31, n. 16, p. E535-E539, jul. 2006.

MOORE, D. C.; MAITRA, R. S.; FARJO, L. A.; GRAZIANO, G. P.; GOLDSTEIN, S. A. Restoration of pedicle screw fixation with an in situ setting calcium phosphate cement. *Spine (Phila. Pa. 1976)*, v. 22, n. 15, p. 1696-1705, ago. 1997.

MORGENSTERN, W.; FERGUSON, S. J.; BEREY, S.; ORR, T. E.; NOLTE, L. Posterior Thoracic Extrapedicular Fixation: A Biomechanical Study. *Spine*, v. 28, n. 16, p. 1829-1835, ago. 2003.

MOSKOVICH, R. Biomecânica da coluna cervical. In: NORDIN, M.; FRANKEL, V. H. *Biomecânica básica do Sistema musculoesquelético*. 4 ed. Rio de Janeiro: Guanabara Koogan, 2016.

MUHLE, C.; RESNICK, D.; AHN, J. M.; SÜDMEYER, M.; HELLER, M. In vivo changes in the neuroforaminal size at flexion extension and axial rotation of the cervical spine in healthy persons examined using kinematic magnetic resonance imaging. *Spine*, v. 26, n. 13, p. E287-E293, jul. 2001.

NAGEL, D. A.; KRAMERS, P. C.; RAHN, B. A.; CORDEY, J.; PERREN, S. M. A paradigm of delayed union and non union in the lumbosacral joint. A study of motion and bone grafting of the lumbosacral spine in sheep. *Spine (Phila. Pa. 1976)*, v. 16, n. 5, p. 553-559, maio 1991.

NASH JR., C. L.; LORIG, R. A.; SCHATZINGER, L. A.; BROWN, R. H. Spinal cord monitoring during operative treatment of the spine. *Clin. Orthop. Relat. Res.*, n. 126, p. 100-105, jul.-ago. 1977.

NIU C. C.; LIAO J. C.; CHEN W. J. et al. Outcomes of interbody fusion cages used in 1 2 levels anterior cervical discectomy fusion titanium cages versus polyetheretherketone (PEEK) cages. *J. Spinal Disord. Tech.*, v. 23, n. 5, p. 310-316, jul. 2010.

OKTENÖĞLU, B. T.; FERRARA, L. A.; ANDALKAR, N.; OZER, A. F.; SARIOĞLU, A. C.; BENZEL, E. C. Effects of hole preparation on screw pullout resistance and insertional torque: a biomechanical study. *J. Neurosurg.*, v. 94 (1 Suppl.), p. 91-96, jan. 2001.

OLERUD, S.; KARLSTROM, G.; SJOSTROM, L. Transpedicular fixation of thoracolumbar vertebral fractures. *Clin. Orthop.*, v. 227, p. 44-51, fev. 1988.

OLSSON, T. H.; SELVIK, G.; WILLNER, S. Mobility in the lumbosacral spine after fusion studied with the aid of roentgen stereophotogrammetry. *Clin. Orthop. Relat. Res.*, v. 129, p. 181-190, nov.-dez. 1977.

OPPERMANN, M. Estudo com elementos finitos em vértebras lombares após subtração pedicular. 2016. 184 f. Dissertação (Mestrado em Engenharia Biomédica) – Universidade de Brasília, Brasília, 2016.

ÖZKAYA, N.; LEGER, D. Introdução à biomecânica: terminologia básica e conceitos. In: NORDIN, M.; FRANKEL, V. H. *Biomecânica básica do sistema musculoesquelético*. 3. ed. Rio de Janeiro: Guanabara Koogan, 2006. p. 1-85.

PALMER, A. C.; WALLACE, M. E. Deformation of cervical vertebrae in Basset hounds. *Veterinary Record*, v. 80, n. 14, p. 430-433, abr. 1967.

PANJABI, M. M. Biomechanical evaluation of spinal fixation devices: I. A conceptual framework. *Spine*, v.13, p. 1129-1134, Out. 1988.

_____. Clinical spinal instability and low back pain. *Journal of Electromyography and Kinesiology*, v. 13, p. 371-379, Aug. 2003.

_____. The stabilizing system of the spine. Part II. Neutral zone and instability hypothesis. *Journal of Spinal Disorders and Techniques*, v. 5 n. 4, p. 390-397, Dec. 1992.

_____; CRISTO, J. J.; VASAVADA, A.; ODA, T.; CHOLEWICKI, J.; NIBU, K.; SHIN, E. Mechanical properties of the human cervical spine as shown by three-dimensional load-displacement curves. *Spine*, v. 25, n. 24, p. 692-700, dez. 2001.

_____; YUE, J. J.; DVORAK, J. et al. Cervical spine kinematics and clinical instability. In: PANJABI, M. M.; YUE, J. J.; DVORAK, J. *The Cervical Spine Research Society*. The cervical spine. 4. ed. Philadelphia: Lippincott Williams & Wilkins; 2005. p. 55-78.

PARKER, A. J.; PARK, R. D.; CUSICK, P. K. et al. Cervical vertebral instability in the dog. *Journal of the American Veterinary Medical Association*, v. 163, n. 1, p. 71-74, jul. 1973.

PATEL, P. S. D.; SHEPHERD, D. E. T.; HUKINS, D. W. L. The effect of screw insertion angle and thread type on the pullout strength of bone screws in normal and osteoporotic cancellous bone models. *Medical Engineering and Physics*, v. 32, n. 8, p. 822-828, out. 2010.

PAUWELS, F. Biomechanics of the locomotor apparatus. Berlin: Springer Verlag, 1950. 518 p.

PEEL, N. F.; BARRINGTON, N. A.; BLUMSOHN, A. et al. Bone mineral density and bone turnover in spinal osteoarthritis. *Ann. Rheum. Dis.*, v. 54, n. 11, p.87-871, nov. 1995.

PERREN, A.; CORDEY, J. The concept of interfragmentary strain. In: UHTOFF. H. *Current Concepts of Internal Fixation of Fractures*. Berlin/New York: Springer Verlag, 1980.

PFEIFFER, F. M.; ABERNATHIE, D. L.; SMITH, D. E. A comparison of pullout strength for pedicle screws of different designs: a study using tapped and untapped pilot holes. *Spine (Phila. Pa. 1976)*, v. 31, n. 23, p. 867-870, nov. 2006.

PFEIFFER, M.; GILBERTSON, L. G.; GOEL, V. K.; GRISS, P.; KELLER, J. C.; RYKEN, T. C. et al. Effect of specimen fixation method on pullout tests of pedicle screws. *Spine (Phila. Pa. 1976)*, v. 21, n. 9, p. 1037-1044, maio 1996.

_____; HOFFMAN, H.; GOEL, V. K.; WEINSTEIN, J. N.; GRISS, P. In vitro testing of a new transpedicular stabilization technique. *European Spine Journal*, v. 6, n. 4, p. 249-255, 1997.

PHILLIPS, F. M.; GARFIN, S. R. Cervical disc replacement. *Spine (Phila. Pa., 1976)*, v. 30 (17 Suppl.), p. S27-S33, set. 2005.

PIHLAJAMAKI, H.; MYLLYNEN, P.; BOSTMAN, O. Complications of transpedicular lumbosacral fixation for non-traumatic disorders. *Br. Edit. Soc. Bone Joint Surg.* v. 79, n. 2, p. 183-189, mar. 1997.

PLATT, S. R.; DA COSTA, R. C. Cervical spine. In: TOBIAS, K. M.; JONHSTON, S. A. (Eds.). *Veterinary Surgery: small animal*. 1st. ed. Philadelphia: Elsevier, 2011. p. 410-448.

PONNUSAMY, K. E.; IYER, S.; GUPTA, G.; KHANNA, A. J. Instrumentation of the osteoporotic spine: biomechanical and clinical considerations. *The Spine Journal*, v. 11, n. 1, p. 54-63, jan. 2011.

POSPIECH, J.; STOLKE, D.; WILKE, H.; CLAES, L. E. Intradiscal pressure recording in the cervical spine. *Neurosurgery*, v. 44, n. 2, p. 379-385, fev. 1999.

PUNO, R. M.; BECHTOLD, J. E. Biomechanical analysis of transpedicular rod systems. A preliminary report. *Spine*, v. 16, n. 8, p. 973-980, ago. 1991.

PUTTLITZ, C. M.; DIANGELO, D. J. Cervical spine arthroplasty biomechanics. *Neurosurgery Clinics of North America*, v. 16, n. 4, p. 589-594, out. 2005.

RAMOS, R. M.; DA COSTA, R. C.; OLIVEIRA, A. L.; KODIGUDLA, M. K.; GOEL, V. K. Effects of flexion and extension on the diameter of the caudal cervical vertebral canal in dogs. *Veterinary Surgery*. v. 44, n. 4, p. 459-466, maio 2015a.

_____; DA COSTA, R. C.; OLIVEIRA, A. L. A.; GOEL, V.; KODIGUDLA, M. K. Morphological Changes of the Cervical Intervertebral Foramen due to Flexion-Extension and Compression-Tension Movements in the Canine Cervical Vertebral Column. *BMC Veterinary Research*, v. 184, n. 11, p. 1-8, 2015b.

RANSOM, N.; LA ROCCA, S. H.; THALGOTT, J. The case for pedicle fixation of the lumbar spine. *Spine*, v. 19, n. 23, p. 2702-2706, dez. 1994.

READ, R. A.; ROBINS, G. M.; CARLISLE, C. M. Caudal cervical spondylo-myelopathy (wobbler syndrome) in the dog - a review of thirty cases. *Journal of Small Animal Practice*, v. 24, n. 10, p. 605-621, out. 1983.

REID, J. D. Effects of flexion-extension movements of the head and spine upon the spinal cord and nerve roots. *Journal of Neurology, Neurosurgery and Psychiatry*, v. 23, p. 214-221, ago. 1960.

REIDY, D.; FINKELSTEIN, J.; NAGPURKAR, A.; MOUSAVI, P.; WHYNE, C. Cervical spine loading characteristics in a cadaveric C5 corpectomy model using a static and dynamic plate. *J. Spinal Disord. Tech.*, v. 17, n. 2, p. 117-122, abr. 2004.

RENNER, S. M.; LIM, T. H.; KIM, W. J.; KATOLIK, L.; AN, H. S.; ANDERSSON, G. B. Augmentation of pedicle screw fixation strength using an injectable calcium

phosphate cement as a function of injection timing and method. *Spine*, v. 29, n. 11, p. E212-E216, jun. 2004.

RESINA, J.; ALVES, A. F. A technique of correction and internal fixation for scoliosis. *J. Bone Joint Surg. Br.*, v. 59, n. 2, p. 159-165, maio 1977.

RESNICK, D. K.; CHOUDHRI, T. F.; DAILEY, A. T.; GROFF, M. W.; KHOO, L.; MATZ, P. G.; MUMMANENI, P.; WATTERS, W. C. 3RD.; WANG, J.; WALTERS, B. C.; HADLEY, M. N. Guidelines for the performance of fusion procedures for degenerative disease of the lumbar spine. Part 9: fusion in patients with stenosis and spondylolisthesis. *Journal of Neurosurgery. Spine*, v. 2, n. 6, p. 679-685, jun. 2005a.

RIHN, J. A.; LAWRENCE, J.; GATES, C.; HARRIS, E.; HILIBRAND, A. S. Adjacent segment disease after cervical spine fusion. *Instructional Course Lectures*, v. 58, p. 747-756, 2009.

ROBINSON, R.; WALKER, A.; FERLIC, D. The results of anterior interbody fusion of the cervical spine. *The Journal of Bone and Joint Surgery American*, v. 44, p. 1569-1587, 1962.

ROSA, R. C.; SILVA, P.; SHIMANO, A. C.; VOLPON, J. B.; DEFINO, H. L. A.; SCHLEICHER, P.; KANDZIORA, F. Análise biomecânica de variáveis relacionadas à resistência ao arrancamento dos parafusos do sistema de fixação vertebral. *Rev. Bras. Ortop.*, v. 43, n. 7, p. 293-299, 2008.

ROSSMEISL JR., J. H.; LANZ, O. I.; INZANA, K. D.; BERGMAN, R. L. A modified lateral approach to the canine cervical spine: procedural description and clinical application in 16 dogs with lateralized compressive myelopathy or radiculopathy. *Veterinary Surgery*, v. 34, n. 5, p. 436-444, set.-out. 2005.

ROY-CAMILLE, R.; ROY-CAMILLE, M.; DEMEULENAERE, C. Osteosynthesis of dorsal, lumbar, and lumbosacral spine with metallic plates screwed into vertebral pedicles and articular apophyses. *La Presse Médicale*, v. 78, n. 32, p. 1447-1448, jun. 1970.

_____; SAILLANT, G.; MAZEL, C. Internal fixation of the lumbar spine with pedicle screw plating. *Clinical Orthopaedics and Related Research*, v. 203, p. 7-17, fev. 1986.

RUSBRIDGE, C.; WHEELER, S.; TORRINGTON, A. M. et al. Comparison of two surgical techniques for the management of cervical spondylomyelopathy in Dobermans. *J. Small Anim. Pract.*, v. 39, n. 9, p. 425-431, set. 1998

SANTONI, B. G.; HYNES, R. A.; MCGILVRAY, K. C. et al. Cortical bone trajectory for lumbar pedicle screws. *Spine J*, v. 9, n. 5, p. 366-373, maio 2009.

SCHNEIDER, R. C.; CHERRY, G.; PANTEK, H. The syndrome of acute central cervical spinal cord injury with special reference to the mechanism involved in hyperextension injuries of the cervical spine. *J. Neurosurg.*, v. 11, p. 546-577, nov. 1954.

SCHOLLHORN, B.; BURKI, A.; STAHL, C.; HOWARD, J.; FORTERRE, F. Comparison of the biomechanical properties of a ventral cervical intervertebral

anchored fusion device with locking plate fixation applied to cadaveric canine cervical spines. *Veterinary Surgery*, v. 42, n. 7, p. 825-831, out. 2013.

SCHULZ, K. S.; WALDRON, D. R.; GRANT, J. W.; SHWILL, L.; SMITH, G.; SHIRES, P. K. Biomechanics of the thoracolumbar vertebral column of dogs during lateral bending. *American Journal of Veterinary Research*, v. 57, n. 8, p. 1228-1231, ago. 1996.

SCHWAB, F. J.; NAZARIAN, D. G.; MAHMUD, F.; MICHELSEN, C. B. Effects of spinal instrumentation on fusion of the lumbosacral spine. *Spine*, v. 20, n. 18, p. 2023-2028, set. 1995.

SEIM H. B.; WITHROW S. J. Pathophysiology and diagnosis of caudal cervical spondylomyelopathy with emphasis on the Doberman Pinscher. *Journal of the American Animal Hospital Association*, v. 18, p. 241-251, 1982.

_____. Cirurgia da coluna cervical. In: FOSSUM, T. W. *Cirurgia de pequenos Animais*. 3. ed. São Paulo: Elsevier Mosby, 2007. p. 1402-1459.

SEKHON, L. H.; BALL, J. R. Artificial cervical disc replacement: principles, types and techniques. *Neurol. India*, v.53, n. 4, p. 445-450, dez. 2005.

SELCER, R. R.; OLIVER JR., J. E. Cervical spondylopathy - wobbler syndrome in dogs. *Journal of the American Animal Hospital Association*, v. 11, n. 2, p. 175-179, 1975.

SERBINO JR., J. W.; ALBUQUERQUE, R. F.; PEREIRA, C. A.; DE REZENDE, M. U.; LASMAR, R. C.; HERNANDEZ, A. J. Posterolateral anatomical reconstruction restored varus but not rotational stability: A biomechanical study with cadavers. *Knee*, v. 22, n. 6, p. 499-505, dez. 2015.

SHAMIR, M. H.; CHAI, O.; LOEB, E. A method for intervertebral space distraction before stabilization combined with complete ventral slot for treatment of discassociated wobbler syndrome in dogs. *Veterinary Surgery*, v. 37, n. 2, p.186-192, fev. 2008.

SHARP, N. J. H.; WHEELER, S. J. Cervical spondylomyelopathy. In: SHARP, N. J. H.; WHEELER, S. J. *Small Animal Spinal Disorders*. Diagnosis and Surgery. 2nd ed. St Louis, EUA: Elsevier Mosby, 2005. p. 211-246.

SHEA, T. M.; LAUN, J.; GONZALEZ-BLOHM, S. A.; DOULGERIS, J. J.; LEE, W. E. III.; AGHAYEV, K.; VRIONIS, F. D. Designs and Techniques That Improve the Pullout Strength of Pedicle Screws in Osteoporotic Vertebrae: Current Status. *BioMed Research International*, v. 2014, p. 1-15, 2014.

SHEPARD, M. F.; DAVIES, M. R.; ABAYAN, A.; KABO, J. M.; WANG, J. C. Effects of polyaxial pedicle screws on lumbar construct rigidity. *J. Spinal Disord. Tech.*, v. 15, n. 3, p. 233-236, jun. 2002.

SILVA, V. C.; BARBOSA, S. V.; CAMPOS, B. P.; CAMPOS, B. P. Análise histológica do osso peiimplantar após o preparo por brocas ou compactando por expansores ósseos. *Rev Bras Implant*, v. 11, n. 42, p. 113-118, 2004.

SKINNER, R.; MAYBEE, J.; TRANSFELDT, E.; VENTER, R.; CHALMERS, W. Experimental pullout testing and comparison of variables in transpedicular screw fixation. A biomechanical study. *Spine (Phila. Pa. 1976)*, v. 15, n. 3, p. 195-201, mar. 1990.

SLIJPER, E. J. Comparative biologic-anatomical investigations on the vertebral column and spinal musculature of mammals. *Verhandelingen der Koninklijke Nederlandse Akademie van Wetenschappen, Afdeling Natuurkunde*. Tweede Sectie, v. 42, p. 1-128, 1946.

SMITH, G. K. Orthopaedic biomaterials. In: NEWTON, C. D.; NUNAMAKER, D. M. (eds.). *Textbook of small animal orthopaedics*. Philadelphia, EUA: J.B. Lippincott Co., 1985. p. 231-241.

SMOLDERS, L. A.; VOORHOUT, G.; VAN DE VEN, R.; BERGKNUT, N.; GRINWIS, G. C. M.; HAZEWINDEL, H. A. W.; MEIJ, B. P. Pedicle screw-rod fixation of the canine lumbosacral junction. *Veterinary Surgery*, v. 41, n. 6, p. 720-732, ago. 2012.

SOLANO, M.A.; FITZPATRICK, N.; BERTRAN, J. Cervical Distraction-Stabilization Using an Intervertebral Spacer Screw and String-of Pearl (SOP™) Plates in 16 Dogs With Disc-Associated Wobbler Syndrome. *Veterinary Surgery*, v. 44, n. 5, p. 627-641, jul. 2015.

STEFFEN, F.; VOSS, K.; MORGAN, J. P. Distraction- fusion for caudal cervical spondylomyelopathy using an intervertebral cage and locking plates in 14 dogs. *Veterinary Surgery*, v. 40, n. 6, p. 743-752, ago. 2011.

STERBA, W.; KIM, D. G.; FYHRIE, D. P.; YENI, Y. N.; VAIDYA, R. Biomechanical analysis of differing pedicle screw insertion angles. *Clin. Biomech.*, v. 22, n. 4, p. 385-391, maio 2007.

STURGES, B. K.; LECOUEUR, R. A. Vertebral fractures and luxations. In: SLATTER, D. (Ed.). *Textbook of small animal surgery*. 3rd ed. Philadelphia: WB Saunders Co., 2003. p. 1245-1261.

SU, B. W.; KIM, P. D.; CHA, T. D.; LEE, J.; APRIL, E. W.; WEIDENBAUM, M.; VACCARO, A. R. An anatomical study of the mid-lateral pars relative to the pedicle footprint in the lower lumbar spine. *Spine (Phila. Pa. 1976)*, v. 34, n. 13, p. 1355-1362, jun. 2009.

SUK, S. I. Pedicle screw instrumentation for adolescent idiopathic scoliosis: the insertion technique, the fusion levels and direct vertebral rotation. *Clinics in Orthopedic Surgery*, v. 3, n. 2, p. 89-100, jun. 2011.

_____; KIM, W. J. Pedicle Screw Fixation in Thoracic or Thoracolumbar Burst Fractures. In: POITOUT, D.G. (Ed.). *Biomechanics and Biomaterials in Orthopedics*. 2th. ed. London: Springer-Verlag, 2016. p. 405-428.

SWAIM, S. F. Ventral decompression of the cervical spinal cord in the dog. *Journal of the American Animal Hospital Association*, v. 164, n. 5, p. 491-495, mar. 1974.

TAN, C. E; FOK, M. W.; LUK, K. D.; CHEUNG, K. M. Insertional torque and pullout strength of pedicle screws with or without repositioning: a porcine study. *Journal of Orthopaedic Surgery*, v. 22, n. 2, p. 224-227, ago. 2014.

TECHY, F.; BENZEL, E. C. Biomechanics of the Cervical Spine. In: SHEN, F. H.; SAMARTZIS, D.; FESSLER, R. G. (Eds.). *Textbook of the cervical spine*. Missouri: Elsevier Saunders, 2015. 482 p.

TELLEGEN, A. R.; WILLEMS, N.; TRYFONIDOU, M. A.; MEIJ, B. P. Pedicle screw-rod fixation: a feasible treatment for dogs with severe degenerative lumbosacral stenosis. *BMC Vet. Res.*, v. 7, n. 11, p.299, dez. 2015

TEYFIK, D.; BASGÜL, C. *The Pullout Performance of Pedicle Screws*. 1st. ed. New York, EUA: Springer; 2015.

TOOMBS, J. P.; WATERS, D. J. Intervertebral Disc Disease. In: SLATTER, D. *Textbook of small animal surgery*. 3rd ed. New York: Saunders, 2003. p. 1193-1208.

TRAYNELIS, V. C. The Prestige cervical disc replacement. *Spine J.*, v. 4 (Suppl. 6), p. 310-314, nov.-dez. 2004.

TROTTER, E. J. Cervical spine locking plate fixation for treatment of cervical spondylotic myelopathy in large breed dogs. *Veterinary Surgery*, v. 38, n. 6, p. 705-718, ago. 2009.

_____; DE LAHUNTA, A.; GEARY, J. C.; BRASMER, T. H. Caudal cervical vertebral malformation malarticulation in Great Danes and Doberman Pinschers. *Journal of the American Veterinary Medical Association*, v. 168, n. 10, p. 917-930, maio 1976.

TURNER, C. H.; BURR, D. B. Experimental technique for bone mechanics. In: COWIN, S. C. *Bone mechanics handbook*. Boca Ration: CRC Press, 2001. p. 7.1-7.35.

VACCARO, A. R.; GARFIN, S. R. Internal fixation (pedicle screw fixation) for fusions of the lumbar spine. *Spine (Phila. Pa.)*, v. 20, n. 24 Suppl, p. 157S-165S, dez. 1995.

VALENTE DE FIGUEIREDO, A. *Estudo biomecânico ex vivo em coluna tóraco-lombar de cães com técnicas de estabilização utilizando Placa Bloqueada, Clamp Rod Internal Fixation, Pino com Cimento Ósseo e Técnica Segmentar Modificada*. 2013. 119 f. Dissertação (Mestrado em Ciências) – Faculdade de Medicina Veterinária e Zootecnia, Universidade de São Paulo, São Paulo, 2013

VANGUNDY, T. Canine Wobbler syndrome, part 1. Pathophysiology and diagnosis. *Compendium on Continuing Education for the Practising Veterinarian*, v. 11, p. 144-157, 1989.

VILLAVICENCIO, A. T.; SERXNER, B. J.; MASON, A.; NELSON, E. L.; RAJPAL, S.; FAES, N.; BURNEIKIENE, S. Unilateral and Bilateral Pedicle Screw Fixation in Transforaminal Lumbar Interbody Fusion: Radiographic and Clinical Analysis. *World Neurosurgery*, v. 83, n. 4, p. 553-559, abr. 2015.

VISHNUBHOTLA, S.; MCGARRY, W. B.; MAHAR, A. T.; GELB, D. E. A titanium expandable pedicle screw improves initial pullout strength as compared with standard pedicle screws. *The Spine Journal*, v. 11, n. 8, p. 777-781, ago. 2011.

VOSS, K.; STEFFEN, F.; MONTAVON, P. M. Use of the ComPact UniLock System for ventral stabilization procedures of the cervical spine: a retrospective study.

Veterinary and Comparative Orthopaedics and Traumatology, v. 19, n. 1, p. 21-28, 2006.

WALTZ, T. A. Physical factors in the production of the myelopathy of cervical spondylosis. *Brain*, v. 90, n. 2, p. 395-404, jun. 1967.

WANG, H.; WANG, H.; SRIBASTAV, S. S.; YE, F.; LIANG, C.; LI, Z.; WANG, J.; LIU, H.; WANG, X.; ZHENG, Z. Comparison of pullout strength of the thoracic pedicle screw between intrapedicular and extrapedicular technique: a meta-analysis and literature review. *Int. J. Clin. Exp. Med.*, v. 8, n. 12, p. 22237-22245, dez. 2015.

WEBB, J. C.; SPENCER, R. F. The role of polymethylmethacrylate bone cement in modern orthopaedic surgery. *J. Bone Joint Surg. Br.*, v. 89, n. 7, p. 851-857, jul. 2007.

WEINHOFFER, S.; GUYER, R.; HERBERT, M. et al. Intradiscal pressure measurements above an instrumented fusion. A cadaveric study. *Spine (Phila. Pa.)*, v. 20, n. 5, p. 526-531, mar. 1995.

WEINSTEIN, J. N.; RYDEVIK, B. L.; RAUSCHNING, W. Anatomic and technical considerations of pedicle screw fixation. *Clinical Orthopaedics and Related Research*, v. 284, p. 34-46, nov. 1992.

_____; SPRATT, K. F.; SPENGLER, D.; BRICK, C.; REID, S. Spinal pedicle fixation: reliability and validity of roentgenogram-based assessment and surgical factors on successful screw placement. *Spine (Phila. Pa.)*, v. 13, n. 9, p. 1012-1018, set. 1988.

WESARG, S.; KIRSCHNER, M.; BECKER, M.; ERDT, M.; KAFCHITSAS, K.; KHAN, M. F. Dual-energy CT based assessment of the trabecular bone in vertebrae. *Methods Inf. Med.*, v. 51, n. 5, p. 398-405, 2012.

WHITE, A. A. III; JOHNSON, R. M.; PANJABI, M. M.; SOUTHWICK, W. O. Biomechanical analysis of clinical stability in the cervical spine. *Clin. Orthop. Relat. Res.*, v. 109, p. 85-96, 1975.

_____; PANJABI, M. M. *Clinical biomechanics of the spine*. 2nd ed. Philadelphia: J. B. Lippincott Company, 1990.

_____; PANJABI, M. M. Biomechanical considerations in the surgical management of cervical spondylotic myelopathy. *Spine (Phila. Pa.)*, v. 13, n. 7, p. 856-860, jul. 1988.

WIGFIELD, C. C.; GILL, S. S.; NELSON, R. J. et al. The new Frenchay artificial cervical joint: results from a two-year pilot study. *Spine (Phila. Pa.)*, v. 27, n. 22, p. 2446-2452, nov. 2002.

WILLETT, K.; HEARN, T. C.; CUNCINS, A. V. Biomechanical testing of a new design for Schanz pedicle screws. *Journal of Orthopaedic Trauma*, v. 7, n. 4, p. 375-380, 1993.

WRIGHT, F.; REST, J. R.; PALMER, A. C. Ataxia of the Great Dane caused by stenosis of the cervical vertebral canal: comparison with similar conditions in the Basset Hound, Doberman Pinscher, Ridgeback and the thoroughbred horse. *Veterinary Record*, v. 92, n. 1, p. 1-6, jan. 1973.

XIE, J. C.; HURLBERT, R. J. Discectomy versus discectomy with fusion versus discectomy with fusion and instrumentation: a prospective randomized study. *Neurosurgery*, v. 61, n. 1, p. 107-116, jul. 2007.

YAHIRO, M. A. Comprehensive literature review. Pedicle screw fixation devices. *Spine (Phila. Pa. 1976)*, v. 19, n. 20 (suppl.), p. 2274S-2278S, out. 1994.

YAMAGATA, M.; KITAHARA, H.; MINAMI, S.; TAKAHASHI, K.; ISOBE, K.; MORIYA, H.; TAMAKI, T. Mechanical Stability of the Pedicle Screw Fixation Systems for the Lumbar Spine. *Spine (Phila. Pa. 1976)*, v. 17, n. 3 (suppl.), p. S51-S54, mar. 1992.

YAZU, M.; KIN, A.; KOSAKA, R.; KINOSHITA, M.; ABE, M. Efficacy of novel-concept pedicle screw fixation augmented with calcium phosphate cement in the osteoporotic spine. *Journal of Orthopaedic Science*, v. 10, n. 1, p. 56-61, 2005.

YERBY, S. A.; EHTESHAMI, J. R.; MCLAIN, R. F. Loading of pedicle screws within the vertebra. *Journal of Biomechanics*, v. 30, n. 9, p. 951-954, set. 1997a.

_____. Offset laminar hooks decrease bending moments of pedicle screws during in situ contouring. *Spine (Phila. Pa. 1976)*, v. 22, n. 4, p. 376-381, fev. 1997b.

YOGANANDAN, N.; PINTAR, F. A.; STEMPER, B. D.; BAISDEN, J. L.; AKTAY, R.; SHENDER, B. S.; PASKOFF, G.; LAUD, P. Trabecular bone density of male human cervical and lumbar vertebrae. *Bone*, v. 39, n. 2, p. 336-344, ago. 2006.

YOUSSEF, J. A.; MCKINLEY, T. O.; YERBY, S. A.; MCLAIN, R. F. Characteristics of pedicle screw loading: effect of sagittal insertion angle on intrapedicular bending moments. *Spine (Phila. Pa. 1976)*, v. 24, n. 11, p. 1077-1081, jun. 1999.

YÜCESOY, Y.; KÜKSEL, K. Z.; BAEK, S.; SONNTAG, V. K.; CRAWFORD, N. R. Biomechanics of unilateral compared with bilateral lumbar pedicle screw fixation for stabilization of unilateral vertebral disease. *J. Neurosurg. Spine*, v. 8, n. 1, p. 44-51, jan. 2008.

ZAMARIOLI, A.; SIMÕES, P. A.; SHIMANO, A. C.; DEFINO, H. L. A. Torque de inserção e resistência ao arrancamento dos parafusos vertebrais com alma cilíndrica e cônica. *Rev. Bras. Ortop.*, v. 43, n. 10, p. 452-459, 2008.

ZANKEL, H. T. Photogoniometry: a new method of measurement of range of motion of joints. *Arch. Phys. Med. Rehabil.*, v. 32, n. 4, p. 227-228, abr. 1951.

ZDEBLICK, T. A.; KUNZ, D. N.; COOKE, M. E.; MCCABE, R. Pedicle screw pullout strength. Correlation with insertional torque. *Spine (Phila. Pa. 1976)*, v. 18, n. 12, p. 1673-1676, set. 1993.

ZINDL, C.; ALLEN, M. J.; FITZPATRICK, N.; DUFOUR, J. S.; LITSKY, A. S.; CRAWFORD, N. R. Motion capture analysis of the mechanical performance of a novel pedicle screw-rod fixation system for the canine lumbosacral joint. In: IV WORLD VETERINARY ORTHOPAEDIC CONGRESS & 41ST VETERINARY ORTHOPEDIC SOCIETY CONFERENCE, Breckenridge, 01-08 mar. 2014. *Abstracts...*, p. 9A, 2014.

ZINDRICK, M. R.; WILTSE, L. L.; WIDELL, E. H.; THOMAS, J. C.; HOLLAND, W. R.; FIELD, B. T.; SPENCER, C. W. A Biomechanical Study of Intrapeduncular Screw

Fixation in the Lumbosacral Spine. *Clinical Orthopaedics and Related Research*, v. 203, p. 99-112, fev. 1986.

ZOTTI, A.; GIANESELLA, M.; GASPARINETTI, N.; ZANETTI, E.; COZZI, B. A preliminary investigation of the relationship between the “moment of resistance” of the canine spine, and the frequency of traumatic vertebral lesions at different spinal levels. *Research in Veterinary Science*, v. 90, n. 2, p. 179-184, abr. 2011.

ZYND, C.; ALLEN, M. J.; FITZPATRICK, N.; DUFOUR, J. S.; LITSKY A. S.; CRAWFORD, N. R. Motion capture analysis of the mechanical performance of a novel pedicle screw-rod fixation system for the canine lumbosacral joint. In: IV WORLD VETERINARY ORTHOPAEDIC CONGRESS & 41ST VETERINARY ORTHOPEDIC SOCIETY CONFERENCE, Breckenridge, 01-08 mar. 2014. *Abstracts...*, p. 9A, 2014.