Original Article

High-speed dental drill may be an acceptable instrument performing canine laminectomy

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Abstract

Laminectomy is usually used in spinal cord dysfunction like intervertebral disc herniation. High-speed pneumatic surgical drill is the most common surgical instrument for canine laminectomy operation. However, since the finical problem, the professional instrument has a low installation rate in animal hospitals in developing country. In this study, we hypothesized that dental drill may replace pneumatic surgical drills in dorsal laminectomy and hemilaminectomy, observed if dorsal laminectomy and hemilaminectomy can been successfully operated by dental drill, and compared the canine dorsal laminectomy and hemilaminectomy. Operations were performed in L2-L3 of lumbar vertebra among 12 Chinese rural dogs (6 for dorsal laminectomy and 6 for hemilaminectomy) under experimental condition. After surgeries, close monitoring was carried out within 10 days. The results shown that both dorsal laminectomy and hemilaminectomy were well done and all dogs were well recovered by dental drill. There was no significant difference in the intraoperative and postoperative data between dorsal laminectomy and hemilaminectomy all the time statistically, while the dogs with hemilaminectomy seems to recover better than dorsal laminectomy. Therefore, dental drill may be utilized both in the dorsal laminectomy and hemilaminectomy in emergency without suitable professional surgical instruments.

Keywords: High-speed dental drill, dorsal laminectomy, hemilaminectomy, canine

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Introduction

Laminectomy provides access to spinal canal, which is often used for intravertebral tumor removal, posterior intervertebral disc removal, decompression after spinal cord injury, spinal stenosis, spondylolisthesis, and intraspinal exploration(Ghogawala, Z., Dziura, J., Butler, W. E., Dai, F., Terrin, N., Magge, S. N., Coumans, J.-V. C., Harrington, J. F., Amin-Hanjani, S., and Schwartz, J. S., 2016: Katz, J. N., Lipson, S. J., Larson, M., McInnes, J., Fossel, A., and Liang, M., 1991: Komotar, R. J., Mocco, J., and Kaiser, M. G., 2006: Postacchini, F., Cinotti, G., Perugia, D., and Gumina, S., 1993). In dogs, intervertebral disc herniation (IVDH) is considered the most common reason of spinal cord dysfunction(Huska, J. L., Gaitero, L., Brisson, B. A., Nykamp, S., Thomason, J., and Sears, W. C., 2014: Langerhuus, L. and Miles, J., 2017). Due to the physiological structure of dog, IVDH mostly occurs in the thoracolumbar region from T10 to L4(Aikawa, T., Fujita, H., Kanazono, S., Shibata, M., and Yoshigae, Y., 2012: Boursier, J. F., Fournet, A., Bassanino, J., Manassero, M., Bedu, A. S., and Leperlier, D., 2018: Downes, C. J., Gemmill, T. J., Gibbons, S. E., and McKee, W. M., 2009: Hady, L. L. and Schwarz, P. D., 2015). Dorsal laminectomy and hemilaminectomy are the methods that decompress the spinal cord and provide an access to removing compresses(Potanas, C. P., Grange, A., and Casale, S. A., 2012: Taylor-Brown, F. E., Cardy, T. J., Liebel, F. X., Garosi, L., Kenny, P. J., Volk, H. A., and De Decker, S., 2015). Previous studies illustrated that canine neurological status of hemilaminectomy is better after surgery than that of dorsal laminectomy(McKee, W. M., 1992: Muir, P., Johnson, K. A., Manley, P. A., and Dueland, R. T., 1995). Dorsal laminectomy can cause spinal instability during the resection of the spine and bony ligament structure, resulting in high postoperative recurrence rate, more complications, long hospital stay, and long recovery time(Taylor-Brown, F. E., Cardy, T. J., Liebel, F. X., Garosi, L., Kenny, P. J., Volk, H. A., and De Decker, S., 2015), while hemilaminectomy does not damage the mechanical properties and structure of the spine(Muir, P., Johnson, K. A., Manley, P. A., and Dueland, R. T., 1995).

In the canine dorsal laminectomy and hemilaminectomy, high-speed pneumatic surgical drill was used as one of the specific tools to remove lamina(Barker, W. H., Witte, T. H., Driver, C. J., Jull, P., Whitehead, C. E., and Volk, H. A., 2015: Danielski, A., Bertran, J., and Fitzpatrick, N., 2013: Golini, L., Kircher, P. R., Lewis, F. I., and Steffen, F., 2014: Huska, J. L., Gaitero, L., Brisson, B. A., Nykamp, S., Thomason, J., and Sears, W. C., 2014: Potanas, C. P., Grange, A., and Casale, S. A., 2012). However, the cost of installing a high-speed pneumatic surgical drill is relatively high, and its installation rate is low in Chinese animal hospitals. Fortunately, the high-speed turbo dental drill has a similar function to the high-speed pneumatic surgical drill, which is possible to replace special high-speed pneumatic surgical drills. The two devices can be substituted for each other in some aspects, as both of them can polish hard bone and with similar rotational speed. Consequently, we hypothesized that dental drill may replace pneumatic surgical drills as one of the tools to remove lamina for dorsal laminectomy and hemilaminectomy. Under this hypothesis, we explored that whether the laminectomy operation can be performed successfully with dental drill. Based on dental drill, we compared the canine dorsal laminectomy and hemilaminectomy surgical methods according to the surgical process and postoperative nerve recovery.

Materials and Methods

Animal and anesthesia: The study was approved by the Animal Welfare Ethics Committee of Sichuan Agricultural University (Approval No. 20220219). 12 healthy Chinese rural dogs with small to middle body size were randomly divided into two groups for different laminectomies. Among them, 6 dogs were performed dorsal laminectomy, and the rest 6 dogs were performed hemilaminectomy. All the dogs were under respiratory anesthesia with isoflurane from the same manufacturer during the operation. Besides, all dogs accepted intramuscular injection (IM) of 3mg/kg Zoletil 50 (consist of 125 mg Titetamme and 125 mg Zolazepam, from Virbac) and 3mg/kg dexmedetomidine (from zoetis) as pre-anesthesia dose; intravenous injection (IV) of 2 mg/kg propofol (from Merck) as induction; continuous rate of infusion (CRI) with 50 μg/kg/min lidocaine (from Jilin Huamu Animal Health Products) under the operation and one hour after the operation; IM of 0.2 mg/kg butorphanol (from TEVA) after the operation.

Surgery operation: L2-L3, the most common IVDH pathogenic site for dog, were chosen as the operation position. Hemilaminectomy was performed through a dorsolateral approach to the spine(Huska, J. L., Gaitero, L., Brisson, B. A., Nykamp, S., Thomason, J., and Sears, W. C., 2014: Muir, P., Johnson, K. A., Manley, P. A., and Dueland, R. T., 1995). The skin incision was located 1 cm beside dorsal midline extended from the front edge of L2 to the last edge of L3. Blunt dissection were used to separate the epaxial musculature (including multifidus and longissimus) from its insertion (one side of spinous processes, articular processes, mamillary processes and accessory)(Huska, J. L., Gaitero, L., Brisson, B. A., Nykamp, S., Thomason, J., and Sears, W. C., 2014). The caudal articular processes of L2 and the cranial articular process of L3 were removed with rongeurs(Scott, H., 1997). A high-speed dental drill (SKU: VetPro 1000, from Midmark) was used to remove lamina, thus a bone window was formed. The length of the bone window covered half-L2 and half-L3. The width of the bone window was from the base of spinous process to the ventral aspect of intervertebral foramen. In order to maintain sterility, when removing lamina, sterile saline was artificially continuous spraying instead of the irrigation water from the high-speed dental drill.

Dorsal laminectomy was performed through a dorsal approach to the spine(Muir, P., Johnson, K. A., Manley, P. A., and Dueland, R. T., 1995). The dorsal midline incision was extended from the front edge of L2 to the last edge of L3(GAMBARDELLA, P. C., 1980).

The epaxial musculature was separated from both side of spinous processes, caudal articular processes and accessory. The spinous processes and the caudal articular processes of L2 were removed with rongeurs. The cranial articular process of L3 was preserved(Muir, P., Johnson, K. A., Manley, P. A., and Dueland, R. T., 1995). The length of the bone window was the same with hemilaminectomy. The width of the bone window was from the upper base of one side articular process to the upper base of another side articular process. Before stitching, dog's autologous fat needed to be filled in the bone window in both dorsal laminectomy and hemilaminectomy(De Risio, L., Muñana, K., Murray, M., Olby, N., Sharp, N. J., and Cuddon, P., 2002).

Postoperative care: Close monitoring was carried out within 10 days after the surgeries including keeping warm, pain control, infusion management, antibacterial treatment, exercise restriction, etc(Crawford, A. H. and De Decker, S., 2018). Putting the dogs in an air-conditioned room or putting warm clothes in cages to keep the dogs warm. Meloxicam (0.1 mg/kg, two injections/day, from QILU ANIMAL HEALTH) was used daily after the surgeries to keep the dogs from pain until them were able to stand. Intravenous infusion of 5% glucose to the dogs according to the body fluid loss during the surgeries. The dogs were given subcutaneously antibiotics (0.1 mL/kg Synulox RTU, consist of 80% Amoxicillin and 20% Clavulanate Potassium, from zoetis) every day for one week after the surgeries. The dogs were kept in cages 1-3 weeks after the surgeries in order to strictly limit their movement(Crawford, A. H. and De Decker, S., 2018). The observations were stopped after the animals' body temperature, diet, defecation, urination, walking returned to normal.

Data recording and analysis: The dogs' weight, gender, age and nutritional status were recorded before surgery (Table.1). The duration of the surgery, the amount of blood loss, the type of surgery (dorsal laminectomy or hemilaminectomy), spinal cord and nerve root injury, and the emergency were recorded during the surgeries. In the postoperative care, medication, defecation and urination, the time to ambulation, the time to complete recovery, neurological status and complications were recorded. Videos and pictures were applied to help to record their physical conditions. The nervous system status was evaluated by a scoring system (in Table.2) modified from Aikawa *et al*.(Aikawa, T., Fujita, H., Shibata, M., and Takahashi, T., 2012) at 1, 3, 5, and 7 days after surgery. The amount of bleeding is measured using hemostatic gauze: a 4×4 cm hemostatic gauze soaked with blood contains approximately 5-10 mL of blood. When the dogs' walking postures are normal, they are regarded as completely recovered.
IBM SPSS Statistics 23 software was used for statistical analysis. Measurement data (weight, length of operation, blood loss, time to ambulation, time to complete recovery) were recorded as mean ± standard deviation (x±s)(Gargiulo, G., Girardo, M., Rava, A., Coniglio, A., Cinnella, P., Massè, A., and Fusini, F., 2019). Independent-Samples T Test was used for comparison between the two groups in measurement data(Crawford, A. H. and De Decker, S., 2018). Enumeration data (percentage of good nutrition, good prognosis and middle-aged dogs) were recorded as rate (%). X^2 test was used for comparison between groups in enumeration data. Neurological grading scores were described as median and interquartile range. The Mann-Whitney U test was used to compare the differences in neurological grading scores between the two groups after surgery(Crawford, A. H. and De Decker, S., 2018). $P < 0.05$ was considered statistically significant.

Table 1 The information of the 12 dogs

The type of surgery	Gender	Weight (kg)	Age	Nutritional status
Hemilaminectomy	Female	4.0	Middle age	Malnourished and thin
Hemilaminectomy	Female	2.9	Old age	Malnourished and thin
Hemilaminectomy	Female	8.0	Old age	Overnourished and fat
Hemilaminectomy	Female	7.2	Middle age	Overnourished and fat
Hemilaminectomy	Female	3.4	Middle age	Eutrophic and strong
Hemilaminectomy	Male	4.6	Middle age	Eutrophic and strong
Dorsal laminectomy	Male	3.0	Middle age	Malnourished and thin
Dorsal laminectomy	Female	4.5	Old age	Overnourished and fat
Dorsal laminectomy	Male	5.6	Middle age	Eutrophic and strong
Dorsal laminectomy	Female	3.0	Middle age	Eutrophic and strong
Dorsal laminectomy	Male	5.0	Middle age	Overnourished and fat
Dorsal laminectomy	Female	4.0	Middle age	Malnourished and thin

Table 2 The standard of neurologic grading

Grade	Symptoms
0	No neurological symptoms
1	Thoracolumbar paraspinal pain without neurologic deficit
2	Ambulatory paraparesis with ataxia (can still walk)
3	Nonambulatory paraparesis (can't walk)
4	Paraplegia with positive deep nociception in either pelvic limbs or tail (can't move voluntarily)
5	Paraplegia with complete loss of deep nociception in both pelvic limbs and tail (can't move voluntarily)

Results

Animal and surgery: The data of animals and surgery are shown in Table.3. The weight of the 12 dogs was 4.6±1.6 kg (range 2.9-8.0 kg), among them dorsal laminectomy group was 4.2±1.1kg and hemilaminectomy group was 5.0±2.1 kg, respectively. In all 12 dogs, the lamina was successfully removed to expose spinal cord (Fig.1). The average surgical duration of all dogs was 123.8±45.5 min, dorsal laminectomy group was 144.2±54.6 min and hemilaminectomy group was 103.3±24.0 min, respectively. It is worth explaining that in hemilaminectomy group, 3 cases had severe pain and prolonged bleeding during the operation, which made the surgical duration be extended. The bleeding volume of dorsal laminectomy group and hemilaminectomy group were 3.5±2.2 mL and 5.0±1.8 mL respectively. No significant difference was observed between the two groups in bleeding volume (p=0.08) and the surgical duration time (p=0.14).

Postoperative care and neurologic grading: The data of postoperative care are shown in Table.4. In all dogs, the time to ambulation was 2.2±2.5 days and the time to complete recovery was 3.0±3.0 days. The time to complete recovery in dorsal laminectomy group and hemilaminectomy group were 3±3.5 days and 1.3±0.5 days, respectively. Among the 12 dogs, all of them had good surgical results and well recovered, although one dog had reoperation.

Table 3 Data of animals and operation

	Weight (kg)	Duration of operation (min)	Amount of blood loss(mL)
Dorsal laminectomy group	4.2±1.1	144.2±54.6	3.5±2.2
Hemilaminectomy group	5.0±2.1	103.3±24.0	5.0±1.8
P value	0.41	0.14	0.08

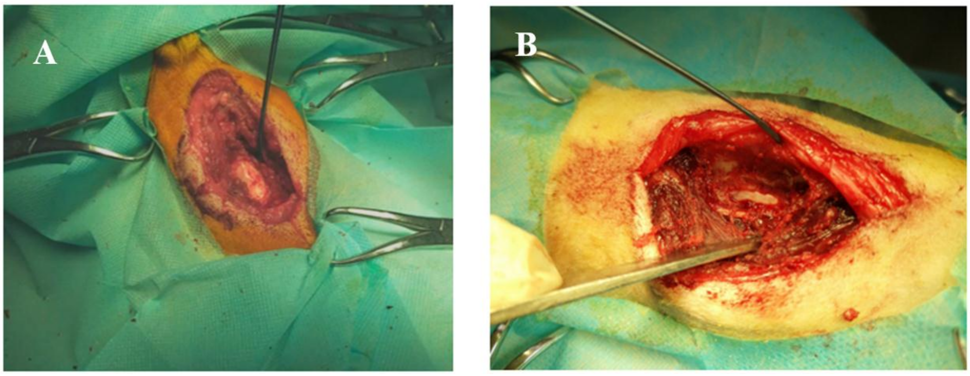

Figure 1 The expose of spinal cord. A is dorsal laminectomy and B is hemilaminectomy.

Table 4 Data of postoperative care

	Time to ambulation (day)	Time to complete recovery (day)
Dorsal laminectomy group	3.0±3.5	4.0±4.0
Hemilaminectomy group	1.3±0.5	2.0±1.3
P value	0.29	0.28

According to the evaluation standard (Table.2), neurologic grades was assessed after surgeries (the reoperation dog was assessed after the second operation). Immediately after awakening from surgery, 2 dogs (33%) in laminectomy group were able to stand that were judged as grade two, 4 dogs (67%) unable to stand were judged as grade three; in hemilaminectomy group, 4 dogs (67%) were able to stand judged as grade two while 2 dogs (33%) unable to stand were as grade three. Most dogs had obvious neurological disorders on the first day after surgeries, manifested as pain, unwilling to walk, and abnormal postures. On the first day after surgery, in laminectomy group, 2 dogs (33%) were grade one and 4 dogs (67%) were grade three; in hemilaminectomy group, 3 dogs (50%) were judged as grade one, 2 dogs (33%) were grade two, while 1 dog (17%) was grade three. On the third day after surgery, in dorsal laminectomy group 4 dogs were judged as grade one, 1 dog was judged as grade two, and 1 dog was judged as grade three; in hemilaminectomy group, 2 dogs (33%) were judged as grade zero, and 4 dogs (67%) were judged as grade one. All the neurological disorders disappeared at 5 days after surgeries. There was no significant difference in the neurological grades between the two groups all the time.

Other conditions: Among all experimental dogs, two dogs developed other conditions in hemilaminectomy group. 1) One dog underwent a second operation. After the first operation (hemilaminectomy), the motor ability of the dog's hind limbs gradually decreased. Specific conditions were recorded: on the first day after surgery, the movement posture of the dog was normal; but in the following days, abnormal walking posture was appeared; until the 4th day after surgery, the hind limb on the left side (the side of lamina window) does not land on the ground. Except for abnormal movement posture, the dog was normal in other aspects (the appetite was good, the dog was willing to walk, the temperature was normal, the surgical wound did not fester). After discussion, we suspected that it might because the spinal cord was compressed by excessive filling of autologous fat in the bone window. Accordingly, a second operation was performed to remove excess fat and refill the bone window with proper autologous fat. After the second operation, the dog's walking posture gradually returned to normal. Due to this situation, the postoperative care data after the second surgery were used to analysis while the postoperative care data after the first surgery were abandoned. 2) Another dog developed swelling at the surgical site on the first day of postoperative care (Fig.2). The swelling with fluctuating sensation of touch was suspected to be hematoma, and it disappeared on the fifth day.

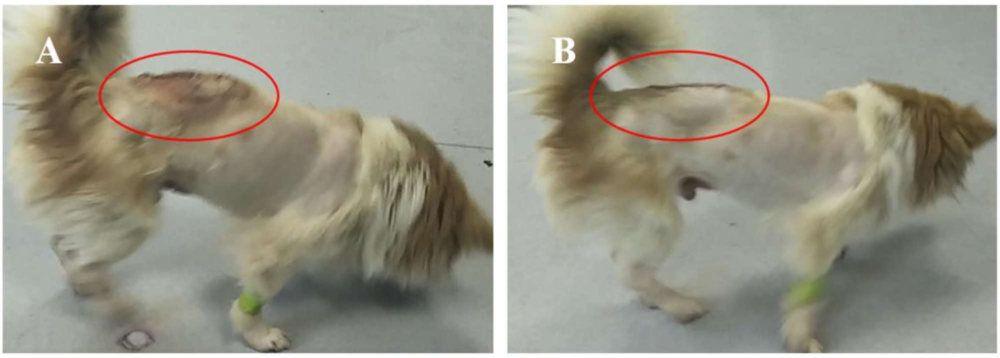

Figure 2 One dog in hemilaminectomy group developed swelling (red circle) at the surgical site. A was the first day after surgery and B was the fourth day.

Discussion

In the study, all dogs were well recovered with no sequela, which indicated that the dental drill may be an acceptable tool to remove lamina and can make dorsal laminectomy and hemilaminectomy successfully. Crawford *et al*.(Crawford, A. H. and De Decker, S., 2018) summarized the surgical time of 53 dogs with IVD treated by hemilaminectomy with either anulectomy or partial discectomy were 238±20 min and 206±13 min, respectively. The surgical time in our study (123.8±45.5 minutes) is shorter than the clinical cases. In addition, our recovery time (2.2±2.5 days) is much shorter than the clinical median recovery time (7 days). The shorter surgical time and recover time in our study may due to the dogs in our study did not have IVD protrusion, which meant that the surgical procedure was simpler and these dogs had more recovery capability. It is undeniable that dental drill can be utilized both in the dorsal laminectomy and hemilaminectomy successfully.

However, the disadvantages of high-speed dental drill compared with pneumatic surgical drill were obviously, including sterilization of instruments, high temperature burning to spinal cord, bone debris after procedures. In this study, sterile saline was artificially continuous spraying by surgical assistant for maintaining local temperature and cleaning bone fragments, which provided additional labor costs. The sterilization of instruments may need to be additionally concerned since many dental instruments had less sterility requirements(Kayahan, E., Wu, M., Van Gerven, T., Braeken, L., Stijven, L., Politis, C., and Leblebici, M. E., 2022). Therefore, high-speed dental drill may be applied only under a limited economic condition or emergency without suitable equipment.

In general, the operation method depends on the lesion site and the specific disease. For example, lateral lamina approach is a good choice for removing the compression of lesion, while the dorsal approach is more selected for patients with type II disc herniation(Downes, C. J., Gemmill, T. J., Gibbons, S. E., and McKee, W. M., 2009: Hady, L. L. and Schwarz, P. D., 2015). Previous studies usually illustrated hemilaminectomy is the first choice for IVDH, which has a better complication and wound(Downes, C. J., Gemmill, T. J., Gibbons, S. E., and McKee, W. M., 2009: Muir, P., Johnson, K. A., Manley, P. A., and Dueland, R. T., 1995). However, with dental drill, the two methods had no significant in all the measured data statistically. This probably due to the sample size was not large enough. Even so, we found that hemilaminectomy seems to be better for postoperative recovery and dorsal laminectomy has a broader operating vision, which make the operation easy, thus reducing bleeding and operation time. However, there is no denying that broader operating vision was accompanied by larger damage, which will cause worse problem in many aspects including vertebral strength. Therefore, in clinical situation hemilaminectomy is the first choice for IVDH while dorsal laminectomy only for the specific disease(Hady, L. L. and Schwarz, P. D., 2015).

Currently, many minimally invasive methods of laminectomy have been applied in human medicine, such as discoscope and plasma ablation technologies, which may be applicable for small animal in theory(Awaya, T., Nishimura, Y., Eguchi, K., Nagashima, Y., Ando, R., Akahori, S., Yoshikawa, S., Haimoto, S., Hara, M., and Takayasu, M., 2022: Phan, K. and Mobbs, R. J., 2016: Rahman, M., Summers, L., Richter, B., Mimran, R., and Jacob, R., 2008). There are some clinical and experimental reports on the cervical and thoracolumbar regions of dogs(Boursier, J. F., Fournet, A., Bassanino, J., Manassero, M., Bedu, A. S., and Leperlier, D., 2018). The advantage of microsurgery is the opportunity for extensive bilateral decompression of the spinal canal or foramina through minor paravertebral muscle separation(Phan, K. and Mobbs, R. J., 2016). It is possible to stabilize the spine while protecting important soft tissues and bones, and simultaneously remove bilateral lesions that compress the vertebral canal or intervertebral foramen(Haddadi, K. and Ganjeh Qazvini, H. R., 2016).

In summary, our study provided that dorsal laminectomy and hemilaminectomy can be successfully done with dental drill, which may become a cheaper alternative tool for pneumatic surgical drills to remove lamina. We declare that professional equipment and methods should be used when conditions permit, especially cutting-edge methods such as minimally invasive methods. However, it is also an acceptable solution to replace professional equipment with dental drill under a limited economic condition or emergency without suitable equipment.

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