# The effect of limb amputation on standing weight distribution in the remaining three limbs in dogs

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**Keywords**

Gait analysis, amputation, musculoskeletal diseases, dog

**Summary**

Despite the fact that limb amputation is a commonly performed procedure in veterinary medicine, quantitative data regarding outcomes are lacking. The intention of this study was to evaluate the effect of limb amputation on weight distribution to the remaining three limbs at a stance in dogs. Ten dogs with a prior forelimb amputation and ten dogs with a prior hindlimb amputation; all of which had no history of orthopaedic or neural disease in the remaining three limbs were included in the study. Standing weight bearing was evaluated with a commercial stance analyzer in all dogs. Five valid trials were obtained and a mean percentage of weight bearing was calculated for each remaining limb. The dogs with a previous forelimb amputation, and also those with a previous hindlimb amputation, had the largest mean increase in weight bearing in the contralateral forelimb. In conclusion, proactive monitoring of orthopaedic disease in the contralateral forelimb may be advisable in dogs with a previous limb amputation. In addition, when determining candidacy for a limb amputation, disease of the contralateral forelimb should be thoroughly evaluated.

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**Vet Comp Orthop Traumatol 2017; 30: 59–61**
**https://doi.org/10.3415/VCOT-16-05-0075**
Received: May 18, 2016
Accepted: October 17, 2016
Epub ahead of print: December 15, 2016

Supplementary Material to this article is available online at https://doi.org/10.3415/VCOT-16-05-0075

## Introduction

Indications for limb amputation include severe trauma, ischemic necrosis, intractable musculoskeletal infection, unmanageable arthritis, paralysis, congenital deformity, or neoplasia (1). Contraindications for limb amputation include severe orthopaedic or neural disease in other limbs or extreme obesity (1). Large breeds have been historically considered poorer candidates. However, there is no evidence in the literature to suggest that smaller breeds tolerate amputation better than large breeds. To date, there are no objective data to determine the degree of lameness in other limbs that precludes amputation. The decision to not amputate is frequently based on the emotional response of the owner rather than scientific evidence, although recent evidence suggests that 86% of owners were satisfied with their decision for limb amputation for their pet (1, 2).

One consideration when making a decision about amputation is how the dog might adjust to three limbs. The adaptation to limb amputation has been studied in dogs. One study found that dogs with a forelimb amputated bear 49% of their body weight on the remaining forelimb and 53% on the hindlimbs (3). Dogs with a hindlimb amputation bear 73% of their weight on their forelimbs and 26% in the remaining hindlimb (4). This is in contrast to four-limbed control dogs which bore 60% of their weight in the forelimbs and 40% in the hindlimbs. However, there was no comparison of dogs undergoing limb amputation before and after surgery (3, 4). In addition, forelimb amputees tend to have more difficulty maintaining their balance, whereas hindlimb amputees tend to have more difficulty gaining speed (3, 4). In addition, electromyographic data suggest that dogs compensate to a three-limbed gait with a significant increase in vastus lateralis and triceps brachii activity as compared to other hindlimb and forelimb muscle groups, respectively (5). Another study of kinetics and kinematics after limb amputation revealed that there is a significant increase in weight bearing on each remaining limb, but no significant changes in range of motion of the remaining joints (6).

Objective gait analysis has been found to be superior to visual examination in the detection of lameness in dogs, and is a more objective method of evaluating limb function (7). There are advantages and disadvantages in the use of a stance analyser compared to a standard force plate. A stance analyser requires less space, is less costly and does not require as much skill for data acquisition (8). In addition, following limb amputation, patients may not be able to reliably ambulate at the required velocity or perform the number of trials while walking or trotting to obtain valid trials on a force plate, but may be able to stand long enough to collect data using a stance analyser. However, the use of the force plate has been studied more extensively and they can provide more information, such as braking and propulsion, which may be helpful in fully understand-

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ing the gait after limb amputation. One study found there was a reliable comparison between peak vertical force and vertical impulse at a trot and static weight bearing in lame dogs (9). However, there is a paucity of information which compares the two modalities. Stance analysis may be useful to determine the load applied to each limb in dogs before and after limb amputation. This knowledge may be useful to evaluate if amputation is a good treatment option for patients with disease affecting a non-amputated limb, or to screen the most load-bearing remaining limb for potential over-use injury postoperatively. Previously documented normal weight bearing in a standing position in dogs is 30% on each forelimb and 20% on each hindlimb (10). The aim of this study was to evaluate the effect of limb amputation on weight distribution to the remaining three limbs at a stance in dogs.

## Materials and methods

Patients that underwent a previous limb amputation at the University of Tennessee Veterinary Medical Center between December 2012 and June 2015 were retrospectively enrolled in the study with client consent. This study was approved by the IACUC Committee at the University of Tennessee Veterinary Medical Center. Exclusion criteria included dogs that were unable to stand on the stance analyser, dogs weighing less than 6 kg, and dogs with a history of orthopaedic or neural disease in any of the three remaining limbs, and patients in which abnormalities were found on orthopaedic and neurological examination. Ten dogs with prior forelimb amputations and ten dogs with prior hindlimb amputations were evaluated. Prior to data collection, a history was collected from the owner and orthopaedic and neurological examinations were performed by the same investigator (GC), a resident in small animal surgery supervised by a board certified Diplomate (ACVS, ACVSMR). Static weight bearing with the stance analyser[a] and body weight were recorded as previously described (8). All data were collected by the same investigator (GC). The dogs were walked onto the platform such that the three limbs were on three separate sensor pads with the limbs positioned such that the load was comfortably distributed among the three limbs. If the limbs were not appropriately distributed, the patient was walked off of the sensor pad and back on to it until the limbs were positioned appropriately. The handler was positioned directly in front of the dog to be certain that the head and neck were facing forward without turning to the side. When the patient was not moving and looking forward, a remote was used to record a trial. Five valid trials were collected. The measurements for each limb were displayed as a percentage of the total body weight. The average of the five trials (± standard deviation) was calculated.

a Companion Laser: LiteCure, LLC, Newark, DE, USA

## Results

For dogs with a previous forelimb amputation, the mean weight applied to the contralateral forelimb was 47.5% (±7.82). The mean weight applied to the contralateral hindlimb was 26.3% (± 4.28) and the mean weight applied to the ipsilateral hindlimb was 26.2% (± 5.60) (► Appendix Table 1: available online at www.vcot-online.com). When compared to historical normal values, the mean increase in weight bearing was 17.5% for the contralateral forelimb, 6.3% for the contralateral hindlimb, and 6.2% for the ipsilateral hindlimb. Therefore, the largest increase in weight bearing occurred in the contralateral forelimb according to our results.

For dogs with a previous hindlimb amputation, the mean weight applied to the contralateral hindlimb was 28% (± 4.81). The mean weight applied to the contralateral forelimb was 39.6% (± 7.18), and the mean weight applied to the ipsilateral forelimb was 32.4% (± 5.36) (► Appendix Table 1: available online at www.vcot-online.com). When compared to normal non-amputated values, the mean increase in weight bearing was 8% for the contralateral hindlimb, 9.6% for the contralateral forelimb and 2.4% for the ipsilateral forelimb. Therefore, the largest increase in weight bearing occurred in the contralateral forelimb.

## Discussion

The results of this study may aid veterinary practitioners in evaluating the limb with the largest expected increase in weight bearing following amputation for possible overuse. In addition, dogs with standing weight bearing that differs significantly from what is described should be evaluated carefully for orthopaedic or neural disease in the limb in which weight bearing is less than expected.

Limitations of this study include those associated with the use of the stance analyser. Stance analysis results may be affected by positioning of the handler, proximity of the closest wall, and other parameters (8). In addition, dogs undergoing limb amputation may have variation in the chronicity and severity of their lameness prior to limb amputation, potentially affecting results because of the time available for adaptation to a three-limbed gait. Although none of the dogs in this study had a history or any evidence of orthopaedic or neural disease in the remaining limbs on physical examination, advanced imaging was not performed. It is possible that other underlying pathology was present that could have affected our results. However, several recent studies describing kinetic changes after limb amputation have similarly used a physical examination as a screening tool for neurological and orthopaedic disease (3-6).

Future research should evaluate if there is a correlation between the results of stance analysis in patients prior to limb amputation and clinical outcome and weight bearing after amputation to establish guidelines for appropriate amputation candidates. Further work should also be performed to determine what long-term changes occur with weight bearing in dogs after amputation. Although force plate kinetics and kinematics provide more objective data regarding weight bearing in dogs, stance analysis may be a more readily available modality and easier to use with minimally ambulatory patients. In con-


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clusion, we found that both forelimb and hindlimb amputees have greater weight bearing on the contralateral forelimb as compared to previously studied quadruped control animals.

### Acknowledgements

The authors would like to thank Mrs. Erin Wood, LVMT, CCRP and Mrs. Danielle Browning, LVMT, VTS-Surgery for technical assistance.

### Conflict of interest

Dr. Millis was a member of the patent team that developed the stance analyser when it was owned by Petsafe. He did not receive any financial compensation nor will he in the future.

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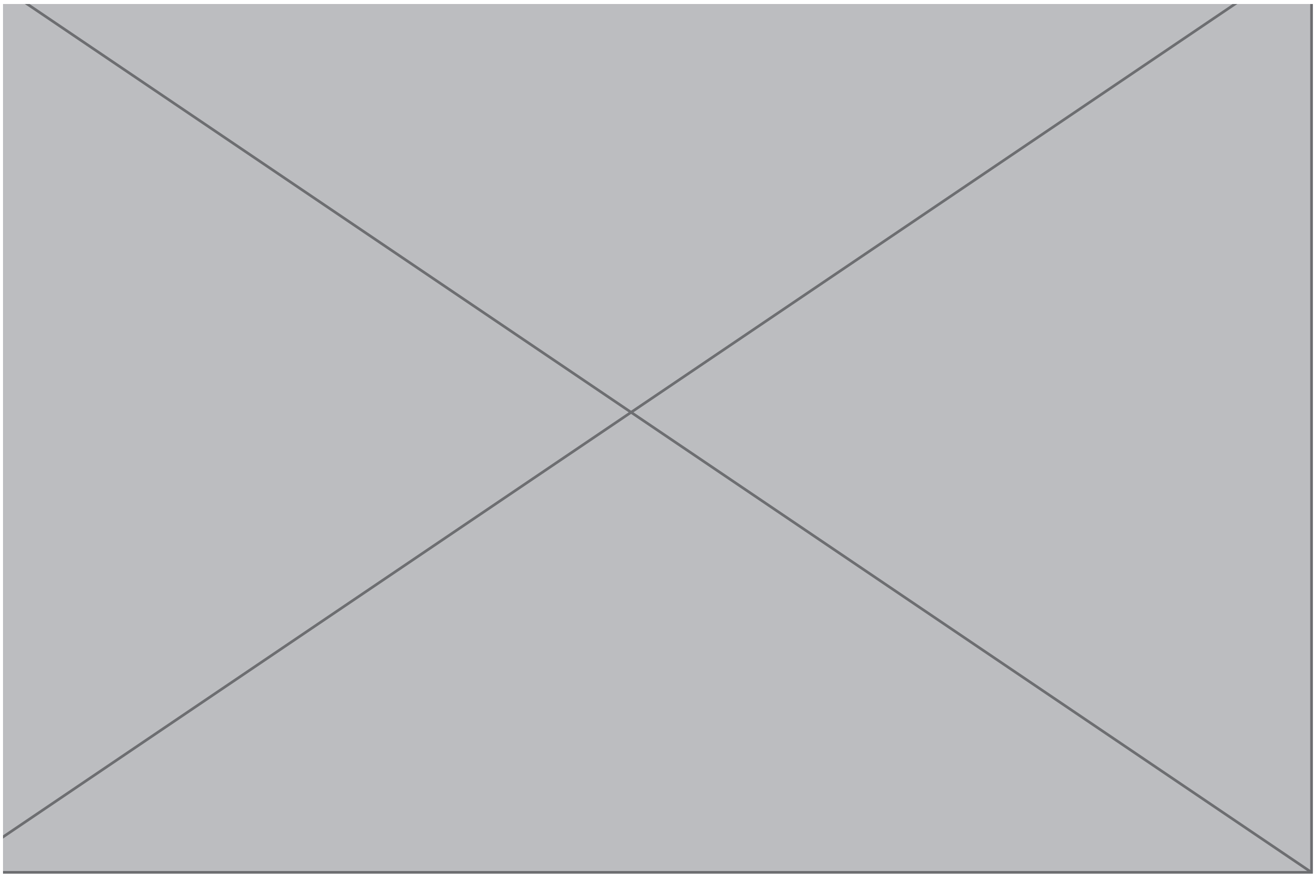

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