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Retrospective Evaluation of Canine and Feline Maxillomandibular Trauma Cases; Comparison of Lunar Cycle and Seasonality with Non-maxillomandibular Traumatic Injuries (2003-2012)

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Summary

Objectives—To determine relationships between seasonality and lunar cycle and the frequency of maxillomandibular (MM) and non-maxillomandibular (non-MM) injury in canine and feline trauma patients.

Methods—A medical records database was searched to identify all MM trauma patients (67) and a random sample of non-MM trauma patients (129) according to search criteria. Season of injury, moon phase and moon luminosity were calculated for the date of injury.

Results—MM injury occurred predominately in the spring and decreased through winter while non-MM injury occurred more frequently in the summer and fall. The difference in the frequency of MM and non-MM injuries during different seasons was not significant ($p=0.071$). When comparing injuries occurring in the quarters following the full moon and leading up to the full moon, a difference ($p=0.007$) was noted with an increased percentage of moon was illuminated at the time injuries occurred following a full moon as compared to leading up to the full moon.

Clinical Significance—These results may guide clinicians to closely evaluate trauma patients that are presented on emergency during a particular season or lunar phase. Based on the season at the time of injury, close evaluation for MM versus non-MM trauma may be appropriate.

Keywords

maxillomandibular; trauma; fracture; lunar cycle; seasonality; injury

Introduction

Traumatic injuries that affect the mandible or maxilla (maxillomandibular(MM)) result from multiple causes in domestic dogs and cats (1-4). The MM region includes the incisive, palatine, zygomatic, frontal, nasal and maxillary bones. It also includes the zygomatic bone and zygomatic processes of the temporal bones as well as maxilla and the mandible. Influences beyond our control may contribute to the occurrence of these traumatic events. Speculation exists that the lunar cycle may influence the incidence of human traumatic injuries inflicted by animals (5) and human behaviour (6). Particular lunar phases may result in an increase in humans inflicting or sustaining trauma (5, 6). Studies evaluating the association between lunar cycle, human behaviour and emergency room admissions have shown various results. In humans, panic attacks, anxiety disorders, suicidal thoughts (7), bite injuries from either similar or different species (8), and the number of motor vehicle accidents (9) have been shown to have a positive correlation with the days leading up to, and including a full moon (7-10). Other studies did not find any correlation between lunar phases and frequency of traumatic events in humans (6, 11). The association between lunar cycle and frequency of trauma associated with dogs and cats has been investigated in previous studies (11, 12). One of these studies failed to demonstrate the existence of a positive correlation between the full moon and dog bites requiring medical attention (11). However, authors of another study suggested that an increased number of veterinary emergency room visits occur on days when the moon has increased luminosity (12). The association of MM trauma and non-MM trauma in correlation with the lunar cycle was investigated in the current study.

To understand if different lunar phases may be correlated with animal behaviour resulting in traumatic injury, lunar phases must be described. The lunar cycle is calculated as a synodic month (13). A synodic month is defined as the average length of time for the Moon to revolve around the Earth while both bodies are orbiting the Sun. The lunar phase is defined as the amount of the moon illuminated and is dependent on the relationship of the Moon with the Earth as well as the relative position of the Moon to the Sun. The average duration of a complete progression of the lunar phase is 29 days, 12 hours, 44 minutes, and 3 seconds (13).

During the lunar cycle, the Moon progresses through the following lunar phases: New Moon, Waxing Crescent, First Quarter, Waxing Gibbous, Full Moon, Waning Gibbous, Last Quarter (3rd Quarter), and Waning Crescent (Figure 1). The New Moon is described as the phase where the Moon is aligned between the Sun and the Earth resulting in the Moon appearing less illuminated and diminished in luminescence (dark). The Full Moon is

observed when the Sun, Earth and Moon are in alignment; however the Earth is between the Moon and Sun resulting in full illumination of Moon. First Quarter and Last Quarter (3rd Quarter) Moons are commonly called half-Moons. This occurs when the Moon is positioned between the Sun and the Earth at 90°, and half the Moon is illuminated. Furthermore, the shape of illumination is described as more illuminated (gibbous), or less illuminated (crescent). If the illumination is increasing towards a full Moon it is considered waxing, if it is decreasing away from a full Moon, it is waning in illumination.

Seasonality has also been proposed to influence animal and human behaviour resulting in increased frequency of traumatic injuries (5). A seasonal variation in wrist and forearm fractures in children has been reported, with an increased incidence in the spring and summer months (14). Alonso reported a statistically significant increase in the number of motor vehicle accidents occurring in the summer months (9). Previous reports have also demonstrated motor vehicle accidents as a common cause of maxillomandibular fractures in dogs (3, 15, 16); however, a seasonal relationship to these injuries has not been evaluated. The influence of seasonality may impact MM trauma and non-MM trauma differently. An association between seasonality and type of traumatic injury in animals has not previously been reported.

While the incidence of MM trauma in dogs and cats has been reported in earlier studies, the objectives of this retrospective study were to identify whether seasonality and changes in the lunar cycle influence the frequency of patients that are presented with MM injuries compared to non-MM injuries.

Materials and Methods

MM Trauma Patients

Patients were identified from the clinical case logs of Dentistry and Oral Surgery residents and from medical records and referral medical record information of canine and feline patients that were presented to the University of Wisconsin-Madison, School of Veterinary Medicine's Veterinary Medical Teaching Hospital from December 2003-September 2012. Lunar phase and calendar season were calculated for the date when trauma occurred. MM injuries were defined as trauma resulting in injury to any of the following structures: the mandible, maxilla, incisive, frontal, nasal, zygomatic, and palatine bones and zygomatic processes of the temporal bones. Patients that were presented with exclusively traumatic dentoalveolar injuries were not included within the study populations due to the proposed under diagnosis of the condition (16, 17), and the inability to ascertain whether these injuries had occurred at the time of the presenting trauma or were pre-existing within the oral cavity. Soft tissue injuries limited to the head and facial regions would have been included within the MM trauma population.

Non-MM Trauma Patients

The medical record database of cases that were presented to the School of Veterinary Medicine Veterinary Medical Teaching Hospital's Orthopaedic and Emergency Services was searched to identify canine and feline patients diagnosed with non-MM traumatic injury

from December 2003-September 2012. A “traumatic injury” was defined as any patient being presented with an acute physical injury resulting from an external source or physical interaction. Specific key words were selected to identify animals sustaining traumatic injuries (Table 1) (2). Patients that were presented for MM trauma were excluded from the non-MM trauma population. Of the non-MM trauma population, a random sample population of 129 patients was selected using statistical software^a. The lunar phase and calendar season were calculated from the date of injury.

All Patients

Seasonality for the injury date in the northern hemisphere was determined by dates designated by the United States Naval Observatory and confirmed with the National Aeronautics and Space Administration (NASA) websites (13). Seasonality was defined as Spring beginning March 21, Summer beginning June 21, Fall beginning September 22 and Winter beginning December 21 (13).

The lunar phase was determined by the Old Farmer's Almanac (18) record of moon phases in Wisconsin, USA specifically on the date of the injury and confirmed with the National Oceanic and Atmospheric Administration from the United States Department of Commerce (19). By cross referencing the trauma date with the online database, the moon phase and percent illumination were recorded. If details of the injury did not include a specific date, and a range of possible dates were given, the earliest date within the range was used to calculate the lunar phase.

Data Analysis—Statistical tests were applied to evaluate for significant differences between the MM and non-MM populations regarding seasonality, lunar phase and percent moon illumination. A Chi-Square test was performed to compare the statistical significance between MM and Non-MM patients presenting for injury and the moon phase at the time of injury. A Chi-Square test was applied to evaluate for differences between groups for seasonality at the time of injury. As a cursory evaluation, all 6 pairwise seasonal tests were compared with Bonferroni correction. A Wilcoxon Rank Sum test was performed to evaluate for statistical significance of the percentage of moon luminosity present at the time of injury. A p-value of < 0.05 was considered statistically significant.

Results

Sixty-seven complete medical records of patients with MM injuries were identified. Fifty-four canine patients and 13 feline patients were evaluated. Nine hundred and seven non-MM patients were identified from the initial query of search terms in the medical records database; eleven of these patients were identified as having suffered two separate and unrelated traumatic injuries. The computerized random sample population of non-MM patients generated a list of 150 patients. After eliminating incomplete medical records or records of patients without a documented traumatic injury, the random sample included 115 dogs and 14 cats.

^aR Core Team (2012). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL <http://www.R-project.org/>

No significant difference was found between moon phases at the time of presentation for both trauma groups ($p=0.52$) (Figure 2). For correlations between moon illumination and moon phase, there must be consideration for cyclic nature of increasing illumination from 0% (New Moon) to 100% (Full Moon) and decreasing illumination 100% (Full Moon) to 0% (New Moon). The occurrence of traumatic injury (combining the MM and non-MM groups) and the percentage of moon illumination (0-50%) on the dates of injury in the New Moon to First Quarter and Third Quarter to New Moon patients revealed no difference between groups ($p=0.073$). The percentage of moon illumination (50-100%) present on the date of injury was different for the First Quarter to Full Moon and the Full Moon to Third Quarter groups ($p=0.007$).

A Chi-Sq test demonstrated that the differences between the season and type of trauma were not different overall between groups ($p=0.071$). The initial Chi-square test evaluated for a difference in the distribution of trauma type by season. The Chi-square test was insignificant at the 0.05 significance level that was preset for this study. Since this test was insignificant, no further exploration into two-way season differences is necessary. As a cursory check, we looked at all 6 pairwise seasonal tests and with Bonferroni correction for 6 tests all p-values were greater than 0.05.

Discussion

The Lunar Cycle

The current study demonstrated an increase in trauma in both groups on the days following the Third Quarter moon. The moon's illumination leading up to, including, and following the full moon is when the moon's illumination is greatest. With respect to animal altercations, this could elicit predator-prey behaviours. During this time in the lunar cycle, the environment is better illuminated for hunting activities, territory protection, and scavenging for food. This lunar period may lead to more traumatic injuries associated with survival behaviours and result in increased animal altercations and increased MM traumatic injury. Animal altercations have been shown to be a leading cause of MM injuries in several studies (1, 2, 4).

One animal study reported that trauma from motor vehicles was the greatest cause of non-MM injuries in dogs and cats (2). Further investigation is needed to explore whether a relationship exists between animal injuries and motor vehicle accidents and timing with the lunar cycle. If humans have an increased incidence of motor vehicle mishaps with a particular lunar phase, this may correlate with the timing of non-MM traumatic injuries sustained by animals.

Many human health care providers feel strongly that an association between the lunar cycle and animal or human behaviour exists (20). One study reported that 80% of nurses and 60% of physicians surveyed believe that a correlation exists between the lunar cycle and human behaviour (20). Wells et al. reported no significant difference between emergency room visits and the lunar cycle, although they did report an increase in emergency room visits during the days leading up to, including, and immediately following a full moon (12). The implication of the rise of traumatic injuries in association with the illumination of the moon

may help guide staff scheduling in veterinary emergency departments to be prepared for the increased caseload at times following a Full Moon and extending into the Third Quarter to New Moon phase.

An association between the full moon and animal aggression has also been suggested. Speculation exists that more animal-versus-animal attacks occur during certain lunar phases. A report discussing humans being bitten by animals (cats, rats, horses and dogs) and the association with a full moon found the frequency was higher in the days surrounding and including a full moon (8). This suggests that the period leading up to and including a full moon may incite animals to become more aggressive or more prone to sustain a traumatic insult. In the MM trauma population the results of this study demonstrate the fewest number of patients presented during the New Moon to First Quarter., The greatest number of patients (59) incurred traumatic injuries during the Third Quarter to New Moon phase. The tendency towards potential aggression and traumatic injuries has also been observed in wild animals. It is reported that lions in the Serengeti and Ngorongoro Crater have an increased abdominal circumference during the days following the Third Quarter moon leading up to the New Moon, suggesting those animals had eaten a meal, made a kill, or scavenged a carcass (5). Although no statistically significant association was shown with lunar phase in the current MM and non-MM trauma populations, significant differences were shown in the combined population with respect to the percentage of moon illuminated at the time of injury. Based on findings in this study, injuries during the Full Moon to Third Quarter phase occurred on dates when moon luminosity was greater than the moon luminosity present on dates when injuries occurred in the First Quarter to Full Moon phase. This demonstrates that injuries surrounding a Full Moon were more likely to occur immediately following the Full Moon rather than leading up to it. Increased visibility provided by moonlight enables some animals to hunt and explore, more effectively, therefore increasing the likelihood of engaging in "altercations". The fewest number of patients sustained traumatic injury during the New Moon and leading up to the First Quarter. The minimal moonlight available during this time may cause prey animals to be more cautious and explore less, but more susceptible to traumatic injuries. The effect of diurnal and nocturnal activities of dogs and cats should be considered. A study evaluating nocturnal effects and lunar phase on Africa's large carnivores, such as lions, stated that these species' nocturnal activities are not affected by the phase of moon (21). Their activity remained constant regardless of moon's luminosity (21). Alternatively, a study by Packer et al., found that lions have higher food intake on nights when the moon is decreased in luminosity (closest to the new moon), therefore suggesting increased activity for hunting during the night (5). In the current study, more traumatic injuries occurred during the Third Quarter phase. If cats are more active during the nights of the Third Quarter moon, they are at an increased risk of incurring traumatic injuries. African wild dogs had increased activity associated with moonlight availability which fluctuated with the lunar cycle (21). With domesticated canines and felines, the need for hunting is not essential for life, as their food is provided for them. Increased night-time light may influence the amount of night-time sleep an animal receives and subsequently make them more tired (22) during the day. Nocturnal activity has been shown to decrease diurnal activity (21). Quality of sleep has been shown to be able to influence the daytime behavioural actions of animals and may increase the incidence of traumatic injury as has been shown in humans

(23, 24). If increased nocturnal activities of pet owners affect the activities of canines and felines who are normally at rest during the evening, traumatic injuries may occur in animals during the daytime due to exhaustion and careless behaviour.

Seasonality

The majority of MM injuries were found to occur during the spring (35.8%) and summer (31.3%) months. Many MM injuries have been reported to be associated with altercations with other animals (1, 2, 4). Traumatic injuries sustained by humans have also been reported to be related to certain seasons (9, 14, 25). Spring and early summer have been shown to be the peak times for humans to sustain bite injuries from other humans (26). Summer has also been shown to be the peak time for feline aggression towards people (27). Likewise, winter months have been shown to be the period of fewest bite injuries sustained by people (26, 27). In our population, winter demonstrated the fewest MM injuries (9.0%) and non-MM injuries (17.8%). Humans and animals are expected to remain indoors during winter months, and it would be reasonable to believe that animals would be less likely to suffer traumatic injuries while indoors. For house pets, canines and felines would be expected to suffer fewer traumatic injuries resulting from altercations with unknown animals due to being mostly confined to the indoors. Different studies of oestrus and interestrus intervals in canines have shown the oestrus cycle to occur in all seasons (28) while other authors have reported increased frequency of oestrus from February to May (29). Future investigation into the relationship between trauma and sexual status with seasonality may be warranted.

Limitations

Limitations of this investigation are centred on challenges associated with retrospective study design. Cases were included only if medical records were complete. Individuals with varying levels of veterinary medical training contributed to the information in the medical record which potentially could be inaccurate. The moon phase was determined from the date of reported injury and not when the patient presented to the hospital. Patient presentation after traumatic injuries and the calculation of the lunar phase to the earliest date, if a range was given, may have yielded different results if the exact date of trauma was used. The current study evaluated percentage of moon luminosity, not moon visibility as it would be difficult to determine whether there was cloud coverage at the time of injury. Regarding the effect on traumatic injuries, the relationship between moon visibility and the impact that cloud coverage could be difficult to document. Statistical significance was also limited by the sample population. Larger populations of MM and non-MM trauma cases may have yielded statistically significant results involving the association between those particular injuries and seasonality.

Conclusion

Traumatic injuries occurring during the days of increased moon illumination following a full moon was observed in this study. The moon's luminosity may have a multifactorial association with the causes of traumatic injuries in canines and felines. A difference in the percentage of the moon's luminosity was seen demonstrating that injuries are more likely to occur when the moon is progressing to the Third Quarter, following the Full Moon. MM

injuries were shown to occur most frequently during spring and decreasing in frequency toward winter. Non-MM injuries were most prevalent during the summer and fall. Both MM and non-MM populations exhibited the fewest injuries during winter. Patients presenting with trauma during spring should be closely evaluated for MM injury and those presenting in the summer should be examined for non-MM trauma.

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Figure 1.

Eight stages of the lunar cycle. The area of the moon illuminated (portion of the moon visible) is denoted in white.

Figure 2.

Distribution of patients in the maxillomandibular (MM) and non-maxillomandibular (non-MM) groups distributed by the moon phase at the time of injury. New to 1st Q= New Moon to First Quarter Moon, 1st Q to Full= First Quarter Moon to Full Moon, Full to 3rd Q= Full Moon to Third Quarter Moon, 3rd Q to New= Third Quarter Moon to New Moon. *P*-value calculated using *Chi-square* test.

Figure 3.

Percentage of moon illumination at the time of injury for trauma groups (MM and non-MM) for each quarter of the lunar cycle. A significant difference ($p=0.007$) exists between the percentage of the moon illuminated at the time of injury for patients in the First Quarter to Full Moon and Full Moon to Third Quarter groups. A difference ($p=0.073$) exists between the groups relative to the percentage of moon illumination at the time of injury during the New Moon to First Quarter and Third Quarter to New Moon quarters of the lunar cycle. *P-values calculated using the Wilcoxon Rank Sum test.*

Figure 4.

Comparison of the distribution of maxillomandibular (MM) and non-maxillomandibular (non-MM) injuries across seasons. *P*-value calculated using *Chi-square test*. Since the *Chi-square test* was insignificant, no further exploration into two-way season differences was necessary.

Table 1
Abbreviations and Key Words Searched within the Medical Records Database

HBC (hit by car)	hit
MVA (motor vehicle accident)	injury / injured
bit(e)	motor
blow	run over
broke	struck
car	trauma (truama)
fall / fell	truck
fracture / fx	vehicle / vehicular

Abbreviations, key words and commonly misspelled words searched in the medical record database when searching for trauma patients.