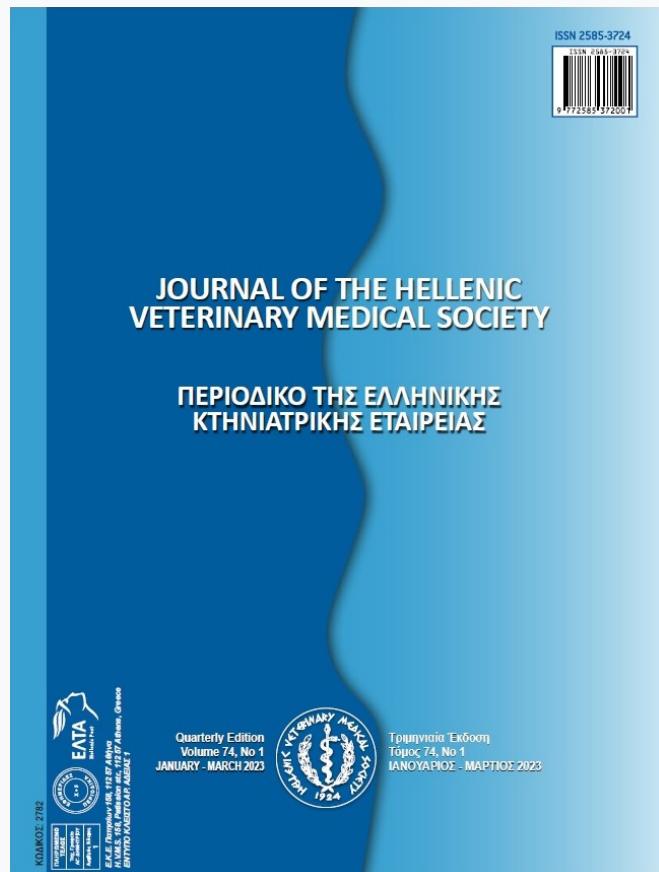


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Canine pododermatitis: A retrospective study of 300 cases

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ABSTRACT: The medical records of 300 dogs with pododermatitis were reviewed and the possible associations between signalment, history, clinical and laboratory findings, as well as various primary and secondary causative factors were investigated. The age of the dogs ranged from 3 months to 15 years. Most dogs were mongrels, West Highland white terriers (WHWTs), French bulldogs, German Shepherd dogs (GSDs) and Shar-Peis. In most of the cases pododermatitis was chronic/recurrent (69%), pruritic (75%) and affected all four feet (54%). The predominantly affected site was the interdigital skin (66%). Erythema (77.7%), hypotrichosis/alopecia (57%), skin thickening (26.3%), crusts (25%) and hyperpigmentation (22%) were the most frequently encountered lesions. Among the secondary causes, bacteria (36.3%) were more commonly found than *Malassezia* spp. (14.3%). The principal primary causes were allergies (43.7%), demodicosis (10.7%), sarcoptic mange (5.7%), skin neoplasms (4.7%), leishmaniosis (4.7%) and interdigital furunculosis (3.7%). In this study, WHWT, Shar-Peis and French bulldogs were predominantly presented with allergic pododermatitis ($P=0.001$). Interdigital skin was more commonly involved in dogs with allergic dermatitis (89.3%) and demodicosis (62.5%), while metatarsal area in dogs with sarcoptic mange (100%). Crusts were commonly seen in bacterial pododermatitis ($P<0.001$), whereas greasy crusts ($P<0.001$) and lichenification ($P=0.008$) were seen in *Malassezia* pododermatitis. Finally, dogs that did not have frequent paw cleaning had the lowest rates of *Malassezia* dermatitis ($P=0.047$).

Keywords: pododermatitis, dog

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INTRODUCTION

Canine pododermatitis is a common clinical condition in clinical practice that can be frustrating to diagnose and treat, especially if it has become a chronic problem (Breathnach et al., 2008; Moriello, 2008; Broek and Horvath-Ungerboeck, 2011; Bajwa, 2016). Pododermatitis is a clinical presentation of multifactorial etiology, and not an etiological diagnosis. A wide variety of cutaneous and systemic diseases can affect canine feet including atopic dermatitis, autoimmune skin diseases, demodicosis, trauma, neoplasia and interdigital furunculosis (Breathnach et al., 2008; Broek and Horvath-Ungerboeck, 2011; Duclos, 2013; Bajwa, 2016). Additionally, secondary infections, that frequently complicate pododermatitis, may increase the severity of clinical signs, extend chronicity of the skin disease and complicate management protocol (Moriello, 2008; Nuttall 2019a). Thus, due to the numerous causes of pododermatitis in the dog, a detailed history, a thorough clinical and dermatological examination and many diagnostic tests or procedures may be indicated to narrow down the list of possible differential diagnoses. Furthermore, an effective therapeutical approach is more likely when etiological diagnosis is determined. Prognosis is usually good to guarded depending on the identification and correction or even possible elimination of primary and secondary causes.

There are several review articles, many case reports and prospective studies on the medical and/or surgical therapy of canine pododermatitis. However, according to the authors knowledge, only two retrospective studies have been published (Chhabra et al., 2020; Yevtushenko et al., 2021) that included only 99 and 16 cases, respectively, plus one large scale retrospective study on digital neoplasms (Grassinger et al., 2021). Therefore, the purpose of this retrospective study was to analyze a large number of dogs with pododermatitis and to investigate the possible associations between signalment, history, clinical and laboratory findings, with the primary and secondary causes.

MATERIALS AND METHODS

Study population and data retrieval

The complete medical records of 300 dogs, presented to the Companion Animal Clinic (School of Veterinary Medicine, Faculty of Health Sciences, AUTH, Greece) between 2009-2013 and diagnosed with pododermatitis were reviewed. All dogs that presented skin lesions on toes, interdigital skin, nail

beds, paws, metacarpal and metatarsal areas were considered, irrespective if pododermatitis was the main complaint or was found during dermatological examination.

Apart from signalment (breed, age, sex) of the dogs, the historical data including living conditions (indoors, outdoors or mixed) and vaccinations were collected and recorded. Clinical description (skin lesions and anatomical sites involved) and the results of diagnostic tests were also recorded. Other data that were retrieved, whenever they were reported in the medical records, included the presence of pruritus, pain and/or lameness, feet cleaning habits and previous therapy. Additionally, since the chronicity of pododermatitis cases was important information, duration of clinical signs was collected and recorded.

Diagnostic tests performed in the study population

A complete general physical and a thorough dermatological examination was done in every case. Skin scrapings and trichograms were performed in all cases. Cytological examination was done in most of the cases (295/300; 98.3%) to determine the presence of bacteria, *Malassezia* spp, inflammatory cells, acantholytic cells or to identify neoplastic cells. When there was a suspicion of dermatophytosis Wood's lamp examination and DTM culture were performed (8/300; 2.7%). After the exclusion of other pruritic diseases, in cases that showed compatible history and clinical symptoms of allergic dermatitis an elimination diet was recommended. A 6-8 week duration elimination diet with novel protein or hydrolyzed food was completed in 34 dogs and further diagnosis of adverse food reactions and environmental atopic dermatitis was made. When there was evidence of a systemic underlying disease other laboratory tests and specific examinations (complete blood and serum biochemistry examinations, urinalysis, hormonal testing, diagnostic imaging) were performed to exclude possible diagnoses or to confirm the final one. Skin biopsy and histopathological examination was helpful in cases where tumours, immune-mediated and metabolic diseases were suspected. In cases where leishmaniosis was suspected, diagnosis was confirmed by direct observation of the parasite in aspiration smears taken from lymph nodes or bone marrow, or/and the detection of antileishmanial antibodies using quantitative serological techniques.

Statistical Analysis

Statistical analysis was used to investigate a) pos-

sible association between the breed, the feet cleaning and the type of skin lesions with the presence of bacteria or *Malassezia* dermatitis b) possible association between the breeds or the age of the dogs with the primary causes of pododermatitis. The association between nominal variables was tested using the chi-square test. In order to assess the relationship between breed and primary cause, Correspondence Analysis (CA) methodology was utilized. Initially, chi-square test was used to examine the association between the two nominal variables and then, CA and more precisely, the scatter plot derived from CA, was analyzed to explore the structure and the relationship between the categories of the two variables. Distribution of variables was checked using the Kolmogorov-Smirnov (K-S) test. Since age did not follow a normal distribution it was logarithmically transformed, and Kruskal-Wallis and Mann-Whitney analyses were used to compare this variable between groups. For all the comparisons differences were considered significant if P was <0.05.

RESULTS

Study population

A total of 300 dogs were included in this retrospective study. The median age was 3.5 years (range: 3 months to 15 years). There were 165 males (55%; 19 neutered, 146 intact) and 135 females (45%; 35 spayed, 100 intact). There were 45 breeds represented. Most dogs with pododermatitis were mixed-bred (89/300; 29.7%), followed by WHWTs (20/300; 6.7%), French bulldogs (18/300; 6%), GSD (16/300; 5.3%), Shar-Peis (12/300; 4%), Poodles (10/300; 3.3%), Cocker spaniels (10/300; 3.3%), English bulldogs (9/300, 3%), Boxers (8/300; 2.7%), Pit bullterriers (8/300, 2.7%) and Greek hounds (8/300; 2.7%). Most of the dogs were fully vaccinated (216/300; 72%) and the remaining were partially (51/300; 17%) or unvaccinated (33/300; 11%). One hundred and fifty-three lived indoors (51%), 40% outdoors and the remaining both indoors and outdoors.

Historical data

According to history, in most of the pododermatitis cases, dogs presented lesions on skin and paws (280/300; 93.3%). Eight dogs were presented due to only claw disease (8/300; 2.7%;) and twelve dogs had both complaints (12/300; 4%;). Most of the dogs had lesions affecting all feet (162/300; 54%,). The remaining cases had one foot affected (67/300; 22.3%), both front feet (44/300; 14.7%) or both hind feet (27/300;

9%) affected. In thirty-one cases (10.3%) owners used to clean dog's feet after walk, at least twice daily, with water and shampoo (14/31; 45.2%;), wet wipes (16/31; 51.6%;) or antibacterial spray (1/31; 3.2%;). Pruritus was a common symptom noticed in two hundred and twenty-five dogs (75%), while pain was seen in only twenty-seven dogs (9%). In most of the cases (207/300; 69%) pododermatitis had a duration of more than 1 month. A total of one hundred and eighty-five dogs were second opinion cases and they had been previously treated unsuccessfully with various topical (26/185; 14.1%), systemic (112/185; 60.5%) medications (corticosteroids, antifungals, antibacterials and/or antiparasitics) or both (47/185; 25.4%).

Diagnostic examination findings

At clinical examination the most common concurrent sign was regional lymphadenomegaly (110/300; 36.7%). Lameness was a less common, seen in only fourteen (4.7%) dogs. Skin lesions were most commonly found on interdigital skin (198/300; 66%). Metatarsal and metacarpal areas were also affected in 83 (27.7%) and 70 (23.3%) dogs, respectively. Pawpads were lesional in twenty-five dogs (8.3%). Seventeen (5.7%) dogs had paronychia and nine (3%) dogs presented lesions on the digits. Erythema (233/300; 77.7%) was the most common skin lesion, followed by hypotrichosis and/or alopecia (171/300; 57%), skin thickening (79/300; 26.3%), crusts (75/300; 25%) and hyperpigmentation (66/300; 22%). Other lesions seen less commonly included serosanguineous exudate (58/300; 19.3%), purulent exudate (45/300; 15%), greasy crusts (38/300; 12.7%), lichenification (28/300; 9.3%), hair discoloration (26/300; 8.7%), papules (24/300; 8%), fistula (21/300; 7%) and skin ulcerations (19/300; 6.3%). Interdigital cysts were the least common lesions seen in 17 dogs (5.7%). Paw pad lesions were also less commonly seen. Eighteen dogs (6%) presented hyperkeratosis of paw pads and in twelve dogs (4%) paw pad ulcers were found. Onychomegaly was found in ten cases and nail bed discharge and nail bed discoloration was seen in only seven cases.

Laboratory test results

Skin scrapings were positive in thirty-two (32/300; 10.7%) dogs for *Demodex canis* and in twelve (12/300, 4%) dogs for *Sarcoptes scabiei*. Dermatophytosis was diagnosed with hair examination and DTM culture in eight dogs (2.7%). Secondary bacterial and yeast infection was investigated with cytology and was found

in 135/295 cases (45.8%). The presence of *Malassezia* yeast was revealed in 43/135 cases (31.9%) and bacteria in 109/135 cases (80.7%); both *Malassezia* spp. and bacteria were present in 17/135 (12.6%) of these dogs. Neutrophils and phagocytosed bacteria were found in 68/109 dogs (62.4%). Cytological examination revealed neoplastic cells in eight dogs (8/295; 2.7%).

Causes of pododermatitis

Allergic dermatitis was the principal primary cause of canine pododermatitis. Atopic dermatitis was diagnosed as environmental allergen-induced in 30 cases and as food-induced in only 4 cases. Etiological diagnosis of atopic dermatitis in the other dogs remain unknown due to owner's non-compliance. Parasites (*Demodex* and *Sarcoptes*) were the second most common cause of canine pododermatitis. Skin neoplasms were the cause in fourteen cases (4.7%) and they included mast cell tumour(3/14), basal cell carcinoma (2/14), sebaceous epithelioma (2/14) and histiocytoma(1/14). Epithelial tumours and vascular neoplasms were suspected in two and one case, respectively, but were not confirmed by histopathology. In the remaining three cases the causative neoplasms remain unknown. In twenty two of the 300 dogs a fi-

nal etiological diagnosis was not achieved. Primary causes of the 278 dogs are presented on Table 1.

Statistical analysis showed no association between breed and bacterial infection ($P=0.115$), a decreased prevalence of *Malassezia* dermatitis in mixed breed dogs ($P=0.012$), an increased prevalence of pododermatitis due to allergy in WHWTs, French bulldogs and Shar-Peis ($P=0.001$) and an increased age of dogs with pododermatitis due to neoplasia compared those with allergic pododermatitis, demodicosis, sarcoptic mange and leishmaniosis ($P<0.039$). Also dogs that did not have frequent paw cleaning had the lowest rates of *Malassezia* infection ($P=0.047$) and the prevalence of *Malassezia* dermatitis was significantly higher in dogs with greasy crusts ($P<0.001$) or lichenification ($P=0.008$), whereas bacteria were more commonly present in dogs with crusts ($P<0.001$).

DISCUSSION

Pododermatitis is common in everyday clinical practice (Breathnach et al., 2008; Moriello, 2008; Broek and Horvath-Ungerboeck, 2011; Bajwa, 2016). It can be accompanied by lesions in other areas of the body or it can be the only clinical manifestation (Breathnach et al., 2008; Bajwa, 2016). A single foot

Table 1. Primary causes of canine pododermatitis in 300 dogs.

Allergies	131/300 (43.7%)
Pododemodicosis	32/300 (10.7%)
Sarcoptic mange	17/300 (5.7%)
Leishmaniosis	14/300 (4.7%)
Neoplasia	14/300 (4.7%)
Interdigital furunculosis	11/300 (3.7%)
Dermatophytosis	8/300 (2.7%)
Foreign body (grass awns)	8/300 (2.7%)
Trauma	8/300 (2.7%)
Lick acral dermatitis	5/300 (1.7%)
Pemphigus	5/300 (1.7%)
Ischemic dermatitis/vasculitis	5/300 (1.7%)
Idiopathic-familiar paw pad hyperkeratosis	3/300 (1%)
Contact irritant dermatitis	3/300 (1%)
Hyperadrenocorticism	3/300 (1%)
Decubitus ulcers	2/300 (0.7%)
Lupoid onychodystrophy	2/300 (0.7%)
Hypothyroidism	2/300 (0.7%)
Tick infestation	1/300 (0.3%)
Viral papillomatosis	1/300 (0.3%)
Superficial necrolytic dermatitis	1/300 (0.3%)
Actinic dermatitis	1/300 (0.3%)
Canine distemper	1/300 (0.3%)
Unknown	22/300 (7.3%)

can be affected in some cases, for example due to neoplasia, trauma, foreign bodies (Broek and Horvath-Ungerboeck, 2011; Miller et al., 2013), but typically, multiple or all four feet are affected, especially if the primary cause is allergy, immune-mediated and metabolic skin diseases (Broek and Horvath-Ungerboeck, 2011; Miller et al., 2013). Also, parasitic infections (demodicosis, trombiculiasis, pelodera) are likely to involve all feet (Broek and Horvath-Ungerboeck, 2011; Miller et al., 2013). In a previous study, that included only 16 cases, two paws were mostly affected (53.3%), while all four legs were lesional in 26.7% of the dogs (Yevtushenko et al., 2021). On the contrary in our study more than half of the dogs presented skin lesions in all four feet. The same was also reported in another retrospective study (Chhabra et al., 2020). This finding seems reasonable, because in the present study more than half of the dogs were diagnosed with allergies or pododemodicosis, that are likely to involve all four feet. Concerning the distribution of lesions between front and hind feet, the former seem to be at higher risk (Duclos et al., 2008; Bajwa, 2016; Nuttall, 2019a). The results of this study support previous findings as according to history the lesions were more often seen in front feet than in hind feet. Possible explanations are the heaviest body weight load in the front feet, the increased possibility of trauma (Nuttall, 2019a) and their more frequent involvement in at least two common primary causes of pododermatitis, namely atopic dermatitis (Favrot's criteria, Favrot et al., 2010) and interdigital furunculosis (Duclos et al., 2008). Numerous underlying causes and conditions have been associated with canine pododermatitis. Allergies, orthopedic disease and conformation seem to be the most common primary causes (Nuttall, 2019b). Also in this study allergies are the principal primary cause.

Even though there are no established breed predispositions in canine pododermatitis, certain breeds of dogs are more commonly reported in some studies. These breeds include dogs with short hairs around the pads and interdigital skin, such as Bulldogs, Boxers, Bull terriers and long-coated breeds, such as GSD, Golden retrievers and Irish setters (Breathnach et al., 2008; Broek and Horvath-Ungerboeck, 2011; Nuttall, 2019a). Additionally, several breeds are reported to be at risk of certain primary causes of pododermatitis. Pododermatitis is commonly seen in atopic canine patients since paws are the most frequent affected site (Jaeger et al., 2010). Breed predilections of canine atopic dermatitis can change over geographical

regions, but Boxer, Chow-Chow, WHWT, Cocker spaniel, French bulldog, GSD, Retrievers and Poodle are typically overrepresented (Zur et al., 2002; Favrot et al., 2010; Jaeger et al., 2010; Olivry et al., 2015). Zinc responsive dermatitis is seen in sled dogs (for example Siberian husky, Alaskan malamute) and familiar foot pad hyperkeratosis can occur in Irish setter and Retrievers (Miller et al., 2013; Duclos, 2013). Also, digital neoplasia is commonly seen in large breed dogs (Schnauzers, Rotweillers, Retrievers) (Henry et al., 2005; Moriello, 2008; Belluco et al., 2013; Duclos, 2013; Grassinger et al., 2021). In other studies, an association of paw anatomy and/or heavy body weight of certain breeds with folliculitis and pedal dermatitis have been suggested. In these reports flat and "scoop-shaped", in the vertical axis, foot of breeds (Pekingese, WHWT), as well as wide-based paws with greater distance between pads (Labradors) can predispose to paw disease (Whitney, 1970; Breathnach et al., 2008; Moriello, 2008; Bajwa, 2016). Obesity and heavy body type of the dog may increase the possibility of pododermatitis and/or paw trauma. In the present study most of the dogs were Bulldogs, WHWT, GSD, Cockers (English and American cocker spaniel), Boxer and Poodle. This can be attributed to the high percentage of atopic dermatitis as a primary cause of pododermatitis in our study, since all these breeds have an atopic predisposition.

In this study dogs that did not have frequent paw cleaning, with shampoo, wet wipes and/or sprays, had the lowest rates of *Malassezia* dermatitis. Indeed moisture and disruption of the stratum corneum barrier function due to maceration may promote *Malassezia* overgrowth (Plant et al., 1992; Matousek and Campbell, 2002; Bond et al., 2020). Therefore, in dogs at high risk of pododermatitis and/or in dogs predisposed to *Malassezia* dermatitis wet cleaning of feet and paws should be avoided or at least it should be followed by careful drying.

Some of the more common lesions associated with pododermatitis are erythema, alopecia, skin thickening, hyperpigmentation, salivary staining, nodules, hemorrhagic bullae, draining seropurulent or serosanguineous exudate and ulcers (Breathnach et al., 2008; Moriello, 2008; Broek and Horvath-Ungerboeck, 2011; Bajwa, 2016). In the present study, erythema was the more common skin lesion seen, as it occurs with any skin trauma, infection, or inflammation. Erythema was also the most common clinical lesion in a previous study (Chhabra et al., 2020). Hypotricho-

sis and/or alopecia was the second commonest skin lesion and can be attributed mainly to pruritus, that was reported in most of the dogs of this study. Other common lesions found were skin thickening, lichenification and hyperpigmentation that are typically seen in chronic inflammation, such as in chronic atopic dermatitis (Broek and Horvath-Ungerboeck, 2011). Thus, diagnosis of atopic dermatitis can explain the above findings since most of the dogs of the present study had atopic dermatitis that was reported to be chronic and/or recurrent.

Apart from pruritus, other clinical signs such as pain, lameness, and lymphadenomegaly are associated with canine pododermatitis. Pruritus is considered the most common clinical sign and pain the less common one (Broek and Horvath-Ungerboeck, 2011), as witnessed in ours and in a previous retrospective study (Chhabra et al., 2020). Its presence can be easily explained from the high prevalence of allergies and secondary bacterial and yeast infections in this dog population. Regional lymphadenomegaly is common in cases of severe pododermatitis due to inflammation and/or secondary infection (Moriello, 2008; Nuttall, 2019b). Additionally, generalized lymphadenomegaly may occur due to some primary causes of pododermatitis such as leishmaniosis, demodicosis and sarcoptic mange (Broek and Horvath-Ungerboeck, 2011). In severe cases, with chronic lesions, pain and occasionally lameness may appear. However, in this study pain was only seen in few dogs and lameness in fewer. In general, lameness is more often associated with pads fissuring, digital swelling and nail disease (Duclos, 2013), that were absent in most of our dogs.

In canine pododermatitis the interdigital skin is most often affected (Broek and Horvath-Ungerboeck, 2011), as seen in the present and in a previous study (Yevtushenko et al. 2021).

Cytology is a useful tool to detect microorganisms that can cause secondary infection. Bacteria and *Malassezia* infections have been reported to be common in canine pododermatitis and they occur due to the inflammation, skin barrier disruption and self-trauma (Breathnach et al., 2008; Nuttall, 2019b).

In this study almost half of the dogs had secondary infections. Bacterial organisms were found more commonly than *Malassezia*, as it was also found the cases in a previous study (Yevtushenko et al. 2021). Even though there are no data on their prevalence in canine pododermatitis, bacterial infection has been reported to be a significant component of interdigital furunculosis, pododemodicosis, leishmaniosis, skin neoplasia, trauma and foreign body-induced pododermatitis, which were some of the common primary causes in this study. Many breeds appear to be predisposed to *Malassezia* dermatitis (Bond et al., 2020) including WHWT, English setter, Shih Tzu, Basset hounds, American Cocker spaniel, Boxer, Dachshunds and Poodles (Bond et al., 2020). In the present study the prevalence of *Malassezia* dermatitis was lower in mixed breed dogs and higher in lesions with greasy crusts and lichenification. Indeed, these lesions along with erythema, scales hyperpigmentation and malodour are main clinical lesions of *Malassezia* dermatitis (Broek and Horvath-Ungerboeck, 2011; Bond et al., 2020). In general, crusts, erosions and ulcerations are often associated with pyoderma (Broek and Horvath-Ungerboeck, 2011) and, as expected, bacteria were more evident in cytological examination from crusty lesions.

CONCLUSIONS

In conclusion, this retrospective study documented that WHWT, Shar-Peis and French bulldogs are more likely to present allergic pododermatitis. Interdigital skin is mainly affected in pododermatitis due to allergy and demodicosis, while the metatarsal area is mainly affected in sarcoptic mange. Secondary bacterial infection seems to be more common than *Malassezia* dermatitis. Crusts are commonly seen in the former whereas the latter is associated with greasy crusts and lichenification. Finally, dogs without frequent paw cleaning had the lower prevalence of *Malassezia* dermatitis.

CONFLICT OF INTEREST

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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