Identification of *Chlamydophila psittaci* of the temporomandibular joint with internal derangement

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ABSTRACT

Objective. *Reactive arthritis (ReA) has been extensively investigated as a consequence of triggering Chlamydophila (formerly Chlamydia) trachomatis infection. This study was undertaken to determine whether C. psittaci can be identified in subjects with internal derangement (ID) of the temporomandibular joint (TMJ) that have been exposed to household birds or domesticated fowl.*

Methods. *Posterior bilaminar tissue removed during TMJ surgery was evaluated by polymerase chain reaction (PCR) assays targeting 16s rRNA and ompA gene of C. psittaci. Thirty-four of 55 (62%) TMJ samples from subjects (52 F, 3 M) exposed to birds were positive for C. psittaci.*

Results. *The percentage of C. psittaci infected samples was significantly greater in the bird-exposed group than in the nonbird-exposed group (62% vs. 0%, p<0.001). The observed proportion of C. psittaci positive subjects n=34 (62%) to bird exposed but testing negative n=21 (38%) was significant p- 0.0398. Patients in households with exposure to birds are therefore more likely than chance to have transmission of C. psittaci.*

Conclusion. *Patients living in households with exposure to birds are at risk to have the zoonotic transmission of C. psittaci. Clinicians faced with patients having TMJ symptoms should explore a more thorough medical history including possible exposure to birds.*

Introduction

A previous study of patients with internal derangement of the temporomandibular joint (TMJ) was undertaken to investigate why a group of patients had continuing TMJ dysfunction and pain that interfered with their normal activities that persisted after extensive nonsurgical and surgical interventions. Analysis of human leukocyte antigens (HLA) typing was performed to determine if any underlying commonality was present between patients. The study showed an increased frequency of several alleles that have been previously associated with arthropathy, and of the B7 CREG (1). All patients that were evaluated had internal derangement (ID) of the TMJ with the non-reducing discs diagnosed with magnetic resonance imaging (MRI) with various degrees of bony changes of the mandibular condyle. These patients had intra-articular pain, difficulty opening, and pain with chewing. Patients with myofascial pain dysfunction (MPD) secondary to bruxism, clenching, but without TMJ internal derangement were not included in that study.

The group of diseases with the closest association with specific HLA alleles are the spondyloarthropathies. The spondyloarthropathies encompass a group of related rheumatic arthropathies, characterised by arthritis, enthesitis, and dactylitis with variable degrees of peripheral and axial involvements which are negative for the presence of rheumatoid factor (2, 3). These spondyloarthropathies include radiographic and non-radiographic axial spondyloarthritis, psoriatic arthritis, undifferentiated peripheral spondyloarthritis, inflammatory bowel disease-associated arthritis, and reactive arthritis (3).

It was the hypothesised that if the degenerative TMJ disease as seen in our patients was a consequence of reactive arthritis, the bacteria associated

with reactive arthritis (ReA) should be present in the TMJ. The association of *Chlamydophila* (formerly *Chlamydia*) *trachomatis* with reactive arthritis is well established (4). Identification of the presence of *C. trachomatis* within the posterior bilaminar tissue of the TMJ in subjects with internal derangement of the TMJ was detected (5, 6). The study showed by monoclonal immunostaining and polymerase chain reaction (PCR) assays that approximately 40% of TMJ samples were positive for the presence of *C. trachomatis*.

Other common precipitating organisms of reactive arthritis include gut bacteria such as *Yersinia, Salmonella, Shigella*, and *Campylobacter*, and the urogenital tract organisms *Chlamydia, Ureaplasma,* and *Mycoplasma*. In a second larger group of subjects with ID of the TMJ the presence of *Mycoplasma genitalium* and other *Mycoplasma sp*. were identified in addition to the presence of *C. trachomatis* in the posterior bilaminar tissue of the TMJ (6). *Campylobacter jejuni, Yersinia enterocolitica, Salmonella spp,* and *Shigella spp* were not identified in any TMJ samples. In approximately 66% of the TMJ samples as detected by PCR, the presence of bacteria either singly or concurrently within posterior bilaminar tissue of the TMJ was found to occur. The detection of two bacterial species in the TMJ associated with urogenital tract infections indicates that internal derangement of the TMJ may occur for some patients as an inflammatory consequence of a sexually acquired infection.

In a subsequent study, a significantly increased presence of tumour necrosis factor alpha (TNFα) and interleukin 6 (IL-6) within the posterior bilaminar tissue of the TMJ was associated with the presence of *C. trachomatis versus* noninfected joints (7). The identification of two proinflammatory mediators within the TMJ demonstrates an active inflammatory response does occur as a consequence of *C. trachomatis*. Reactive arthritis has been classically considered as having joints that are sterile, that bacteria cannot be readily isolated from infected joints. More contemporary studies have shown the presence of bacteria DNA, or rRNA by polymerase chain reactions (8, 9). These studies have shown the presence of bacterial DNA in both the synovial fluid and synovial tissue.

Clinical insight by our senior author while evaluating patients with ID of the TMJ that reported a history of household exposure to birds suggested that transmission of *C. psittaci* may have occurred (10). This present study expands upon the preliminary findings in which the presence of *C. psittaci* in the posterior ligament of the TMJ that was documented by PCR assay in six of seven patients (87%). We hypothesise that the presence of bacteria within the posterior bilaminar tissue of the TMJ for some patients may serve as a pathogenetic stimulus of TMJ inflammation leading to collagen degradation, internal derangement/disc displacement, and degenerative bony changes that are observed with ID of the TMJ. The purpose of this expanded study is to determine whether *C. psittaci* can be identified in a larger group of subjects with ID of the TMJ that have been exposed to household birds.

Materials and methods

A prospective unmatched, case-control study was initiated to determine whether *C. psittaci* could be identified in bird-exposed subjects with ID of the TMJ. We selected 55 subjects with household bird-exposure. The subjects for our study were from national referrals to our senior author. The exposure of the subjects to birds such as household pets, or domestic fowl, such as chickens, was the main inclusion criterion. For our control group, 10 subjects with ID of the TMJ with no prior exposure to birds were randomly selected, and TMJ samples were evaluated for the presence of *C. psittaci*. All subjects included in this study were diagnosed with articular disc dislocation (ADD) that was non-reducing, with intra-articular pain, chewing dysfunction, and varying degrees of degenerative joint disease (DJD) via MRI and tomographic radiographs. All patients had non-reducing discs with limited mouth opening, intra-articular pain, difficulty chewing. For patients with bilateral ADD, only one tissue sample was randomly selected for evaluation. Covariates such as age, Wilke's classification of TMJ disease, previous treatments, prior non-surgical treatments, and patient photographs were not collected for analysis. Other covariates such as psychosocial factors (stress, anxiety), parafunctional habits (bruxism, clenching) were not included as they are associated with myofascial pain dysfunction, and not internal derangement with disc displacement. This group of patients selected from national referrals to our senior author may not be generalised to the broader TMJ internal derangement population but does indicate greater diagnostic considerations may be needed in surgical cases with poor outcomes with persistent symptoms.

Posterior bilaminar tissue of the TMJ obtained during surgery for articular disc repositioning and posterior ligament repair was evaluated for the presence of *C. psittaci*. One surgeon obtained all surgical specimens. Surgical specimens were surgically removed in a sterile environment with no possibility of environmental contamination or incidental colonisation. Approval by the Baylor University Medical Center Institutional Review Board (Approval # 098-085) and signed patient consents were obtained for this project. The tissue samples were immediately snap-frozen in liquid nitrogen, embedded in optimal cutting temperature (OCT) medium (Sakura Finetek, Torrance CA), and stored at -70°C until processing.

Nucleic analyses

A portion of each TMJ tissue sample was used for nucleic acid preparation/PCR screening for *C. psittaci*. PCR assays for the detection of *C. psittaci* have been reported (11-14). Nucleic acids were extracted as previously described. PCR analyses were performed with 1 ug total nucleic acid from each sample in 100uL with Ampli-Taq DNA polymerase (Perkin-Elmer Cetus Inc., Foster City, CA). The PCR assay targets the *C. psittaci* 16s rRNA and omp1 gene sequences. Both are highly specific for *C. psittaci*. Positive/negative controls were included with each assay run. Each TMJ nucleic acid prepara-

tion was assayed in duplicate, and all the assays were repeated by the same investigator on a different day. Amplification products were confirmed by hybridisation, and samples were considered positive only if both PCR assays yielded unequivocal amplification products that hybridised with the appropriate probe. The first step of amplification was genus specific, and the second amplification was multiplexed and differentiated between *C. psittaci, C. pneumoniae*, and *C. trachomatis* on the basis of the molecular weight of the amplicon.

We used a two-tailed Fisher's exact test to compare the percentage of positive bird-exposed subjects to *C. psittaci* non-bird exposed control subjects. To test the proportion of bird exposed, *C. psittaci* positive subjects to bird exposed *C. psittaci* negative subjects, a one-proportion Z-test was used to compare the observed differences. We utilised R (version 4.30: R Core Team 2023) for the statistical analysis.

Results

Posterior bilaminar tissue from 55 bird exposed subjects (52 F, 3 M) was examined for the presence of *C. psittaci* via PCR. The bird categories in the experimental group were 54% for parakeets, 33% for chickens, 18% for Cockatoos, 14% for Love birds/doves, and 10% for parrots. Six percent of patients had both parakeets and Cockatoos at home. Many subjects had more than one bird species in the household as pets, or in conjunction with chickens.

Thirty-four of 55 (62%) subjects exposed to birds were positive for the presence of *C. psittaci* of the TMJ. None (0%) of the 10 (10 F) non-bird exposed control subjects were positive for the presence of *C. psittaci* of the TMJ. The observed proportion of subjects with *C. psittaci* infection was statistically greater than the nonbird exposed control group (62% *vs.* 0%, $p<0.001$). The observed proportion of *C. psittaci* positive subjects n=34 (62%) to *C. psittaci* exposed but negative n=21 (38%) was significant with a *p*-value of 0.0398. Patients are therefore likely to have the presence of *C. psittaci* of the TMJ with exposure to house birds and domesticate fowl greater than chance.

Discussion

This study reveals the surprising zoonotic transmission of *C. psittaci* can occur in a large group of individuals exposed to household birds, either as pets or domestic fowl. The presence of *C. psittaci* is an unusual finding and not previously associated with the ID of the TMJ. The exposure to *C. psittaci* may result in the disease psittacosis. Psittacosis in humans commonly presents as an atypical pneumonia (15). Individuals involved with caged birds account for 70% of known cases (16). The disease is contracted through exposure to *C. psittaci* containing bird droppings or secretions that have dried, thus producing a bacteria-laden dust that can be inhaled (16). The incubation period averages 5-14 days although it may last up to 39 days. Patients that develop symptoms will do so within 5- 14 days of exposure. Psittacosis may present with symptoms similar to a mild community-acquired pneumonia. A sudden onset of fever, headache, dry cough may develop in young or middle-aged adults, although asymptomatic infection is possible (17). Even with treatment, psittacosis may result in complications in a variety of organ systems. These may include cardiac involvement, such as endocarditis and myocarditis (18). Pulmonary, renal, liver, haematologic diseases, as well as neurologic and cutaneous diseases can be a result of psittacosis (19). Significantly increased occurrence of dysfunction in other body systems of TMJ patients exposed to birds as compared to TMJ patients without exposure to birds has been reported (20). Compared with the non-bird group, the bird exposed group showed significantly higher frequencies of joint, urinary, ocular, sinus, respiratory, and gastrointestinal disorders. A variety of bacteria have been identified within the TMJ (6, 21, 22). The presence of *C. psittaci* has been shown to upregulate the expression of IL-6 and IL-8 via Toll-like receptor 2- and 4- mediated MAPK and NF-kB signalling pathways in human monocytes (23). The inflammatory response occurs with the temporal and sequential expression of TNF, IL-1, IL-6, and nitric oxide from activated monocytes and macrophages in response to bacterial infections (24). The production of additional inflammatory mediators such as chemokines, prostaglandins, and proteases, and activate neutrophils, B cells, and endothelial cells can be stimulated by the inflammatory cytokines (24).

Limitations of our study are that we did not record the length of exposure to birds, nor did we record the timing of bird exposure relative to the onset of TMJ symptoms. No immunohistochemistry staining was performed as our previous studies showed PCR assays had greater sensitivity in detecting the presence of *C. trachomatis*. We did not have serological data either as a confirming method of systemic infection.

Reports have shown the presence of TNF-α in the synovial fluid of the TMJ (25-29). The concentration of TNF within the synovial fluid of the TMJ was significantly greater than that within the plasma (25), indicating the local production of TNF within the TMJ. Tumour necrosis factor occurs in a greater percentage of temporomandibular joints with increasing joint disease, but not in the temporomandibular joints of patients with only masticatory muscle dysfunction (25).

The synovial fluid of TMJs with internal derangement and osteoarthritis contain higher levels of IL-1 and IL-6 than in asymptomatic controls. In these same TMJs, concentration of IL-1 and IL-6 were greater in joints with osteoarthritis than in those with internal derangement alone (30). The production of IL-1 and IL-6 by marrow cells was found to produce subchondral bone erosion via stimulation of osteoclastic activity and may account for the degenerative condylar bone changes observed in temporomandibular joints with internal derangement (24). The degree of synovitis observed arthroscopically in both an animal model (25) and the human TMJ was found to correlate with the level of IL-6 (31-33). The degree of synovitis was measured by the vascularity and redundancy of the synovial lining of the TMJ. Synovial hyperplasia of the TMJ was observed one sample in an area infected

with *C. trachomatis* by immunostaining (6).

The inflammatory response with the production of cytokines occurs as a consequence of the reaction of the host to foreign antigens such as *Chlamydophila sp*. by regulating the growth, mobility, and differentiation of leukocytes and other cells (34). Therefore, it appears that the presence of *Chlamydophila sp*. within the TMJ are not innocent bystanders but can be a persistent source of inflammation if not identified and treated. Even during the remitting phase of chronic Chlamydophila-induced reactive arthritis are metabolically active in the synovial tissues (36).

Subjects with sexually acquired reactive arthritis have increased local production of antibodies against *C. trachomatis* in synovial fluid in comparison to serum antibody levels (35). An increased frequency of serum antibodies against *C. trachomatis* in subjects with internal derangement of the TMJ has been reported (37, 38). Antibodies against *C. psittaci* were detected in 1 patient with monoarthritis, 2 patients with chronic closed lock, and 1 control subject, but no statistically significant differences between the subjects and controls were detected (38). Clinicians faced with patients having temporomandibular joint symptoms should explore a more thorough medical history including possible exposure to birds. Avian *C. psittaci* is classically associated with psittacine birds, *e.g.*, parrots, parakeets, cockatiels, macaws. In addition, columbiform birds such as pigeons and doves can be important reservoirs in urban and wild environments (37). Galliformes (landfowl) that includes chickens and turkeys, have been the source of human infections at slaughter facilities and farms. For patients living in northeastern US, Lyme disease caused by *Borrelia burgdorferi*, should be a part of a differential diagnosis. The inflammatory arthritis and arthralgia of the TMJ, headaches, trismus, may be misdiagnosed as TMD instead of Lyme disease. Lyme disease affecting the TMJ is reported as the fourth most frequently affected joint (38). The presence of serum antibodies against *C. trachomatis, C. psittaci, Mycoplasma genitalium, B. burgdorferi,* or other bacteria associated with ReA may be diagnostic for determining current or past infections (39-40).

The clinical findings of systemic arthropathy, internal derangement, synovitis, capsulitis, fibrous adhesions, and osteoarthritis of the mandibular condyle, most likely represent a common pathway that involves inflammation (41). Inflammatory mediators have been measured in the serum, and synovial fluid, and are shown by immunological staining of the synovium of the TMJ. The known proinflammatory nature of *Chlamydophila sp*. infections supports our clinical and laboratory findings (42). An upstream inciting infection may be an important etiological factor resulting in inflammation and TMJ tissue degradation of the posterior ligament allowing disc dislocation. Our study does not establish a causative role of *C. psittaci* in TMJ disease, however the presence of *C. psittaci* in the TMJ of subjects exposed to birds suggests for some patients an association may exist and additional studies are warranted.

Conclusion

The results of this study show a significant risk of zoonotic transmission of *C. psittaci* can occur in households with birds. *C. psittaci* was identified in patients with the ID of the TMJ. Future studies will be needed to understand the challenges to the normal health of the TMJ microenvironment as a consequence of bacterial presence and host induced responses.

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