# Bacteriological findings and antimicrobial resistance in odontogenic and non-odontogenic chronic maxillary sinusitis

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The main objectives of this study were to estimate the frequency of chronic maxillary sinusitis of dental origin, and to evaluate the microbiology of odontogenic and non-odontogenic chronic maxillary sinusitis. Aspirates from 59 patients with chronic maxillary sinusitis (47 non-odontogenic, 12 odontogenic), collected during a 3-year period, were microbiologically processed for aerobic and anaerobic bacteria. Moreover, antimicrobial susceptibility was evaluated in the isolated bacteria. In this study, 20 % of chronic maxillary sinusitis cases were associated with a dental origin, and sinus lift procedures were the main aetiological factor. Our microbiological findings showed that all specimens from chronic maxillary sinusitis were polymicrobial. Sixty aerobes and 75 anaerobes were recovered from the 47 cases of non-odontogenic sinusitis (2.9 bacteria per specimen); 15 aerobes and 25 anaerobes were isolated from the 12 patients with odontogenic sinusitis (3.3 bacteria per specimen). The predominant aerobes were *Staphylococcus aureus* (27) and *Streptococcus pneumoniae* (16), while the more frequent anaerobes were *Peptostreptococcus* species (31) and *Prevotella* species (30). *Haemophilus influenzae* and *Moraxella catarrhalis* were absent in sinusitis associated with a dental origin. Overall, 22 % of *Staphylococcus aureus* isolates were oxacillin-resistant, and 75 % of *Streptococcus pneumoniae* isolates were penicillin-resistant and/or erythromycin-resistant; 21 % of anaerobic Gram-positive bacteria were penicillin-resistant, and 44 % of anaerobic Gram-negative bacteria were $\beta$-lactamase-positive. Vancomycin and quinopristin–dalfopristin had the highest *in vitro* activity against *Staphylococcus aureus* and *Streptococcus* species, respectively; amoxicillin–clavulanate and cefotaxime showed the highest *in vitro* activity against aerobic Gram-negative bacteria; and moxifloxacin, metronidazole and clindamycin were the most active against anaerobic bacteria.

## INTRODUCTION

Maxillary sinusitis is defined as symptomatic inflammation of the paranasal maxillary sinuses, and is further classified as chronic when its duration exceeds 12 weeks, with or without acute exacerbations. Chronic maxillary sinusitis is one of the most common health-care problems in the world (Benninger *et al.*, 2000). The sinusitis is primarily rhinogenous, but because of the anatomical juxtaposition of the teeth and the maxillary sinus sometimes it can be associated with a predisposing odontogenic condition (Kretzschmar & Kretzschmar, 2003).

Sinusitis arising from dental disease differs in its microbiology and management from sinusitis due to other causes. Many studies have examined the bacterial pathogens associated with chronic sinusitis, but the great majority of them included only a small, or indeterminate, number of patients with odontogenic infection (Kremer *et al.*, 2001; Finegold *et al.*, 2002; Aral *et al.*, 2003; Niederfuhr *et al.*, 2009), or did not test the antimicrobial susceptibility of these bacteria (Brook, 2005). While it is reported that the sinusitis of dental origin is polymicrobial and caused by bacteria from the oral cavity and from the upper airways (Mehra & Jeong, 2009), some aspects, such as the role of anaerobic bacteria in this infection, are not well studied and would need to be elucidated.

The objectives of this study were to detect aerobic and anaerobic bacteria involved in the aetiopathogenesis of chronic maxillary sinusitis, secondary or not to odontogenic

Abbreviation: CLSI, Clinical and Laboratory Standards Institute.

predisposing factors, to evaluate the antimicrobial susceptibility of these bacteria, and to investigate which odontogenic causes can lead to chronic maxillary sinusitis.

## METHODS

**Patients.** A total of 59 patients (31 male and 28 female; 45–82 years old; mean age 57 years) with a history of chronic maxillary sinusitis, who were referred to an ear, nose and throat surgeon at the 'Azienda Policlinico-Universitaria Policlinico-Vittorio Emanuele' for endoscopic sinus surgery, were studied between October 2007 and September 2010.

The diagnosis of chronic sinusitis was based on a thorough medical history assessment and physical examination, and on radiological findings, including a paranasal sinus CT scan. Clinical examination of the teeth and adjacent tissues was also performed on all patients. Chronic maxillary sinusitis was considered to be of rhinogenous origin when the dental examination was normal. When the examination of dental status showed clinical disease of the periodontal tissues, or of endodontically involved teeth, dental radiological examination (orthopantomography) was also performed. Chronic maxillary sinusitis was considered to be of dental origin when the dental examination and the radiograph showed a close connection between the diseased maxillary sinus mucosa and an inflammatory periodontal or periapical lesion.

All patients were treated with functional endoscopic sinus surgery.

This study conformed to the guidelines of the Ethical Committee of the University of Catania (Italy). All patients gave informed consent to the work.

**Specimen collection and microbiological procedures.** Specimens were aseptically obtained from sinus during surgery by antral puncture of the canine fossa or the lateral nasal cavity wall, before the patient had undergone perioperative antibiotic prophylaxis. Specimens were transported in a sealed syringe or in an anaerobic transport vial (BBL Port-A-Cul Vial) to the microbiology laboratory within 30 min of collection.

Microbiological assessments were started on the arrival of the sample at the laboratory. All samples were inoculated on Columbia agar with 5 % sheep blood (BD Becton Dickinson), *Haemophilus* Test Medium (HTM) agar (BD Becton Dickinson) and *Brucella* blood agar with haemin and vitamin $K_1$ (BD Becton Dickinson). Columbia blood and HTM agar plates were incubated under aerobic conditions and in an atmosphere of 10 % $CO_2$ at 35 °C for 24–48 h. Supplemented *Brucella* agar plates were incubated anaerobically in GasPak 100 Jars (BD Becton Dickinson) at 35 °C for 72 h; the incubation was continued for at least 7 days, even in the absence of bacterial growth (Blandino *et al.*, 2007). From each bacterial plate, representative colonies of each morphological type were subcultured on selective media (Murray *et al.*, 2007). Identification of bacteria was made by colony and cellular morphology, staining characteristics and commercially available microbiological identification systems, such as API 20 Strep, API 20 E, API 20 NE, API NH, API 20 A, Rapid ID 32 A and API ZYM (bioMérieux) (Summanen *et al.*, 1993; Blandino *et al.*, 2007; Murray *et al.*, 2007).

**Antibiotics.** We studied the antimicrobial susceptibility of aerobic Gram-positive bacteria to the following antibiotics: penicillin, oxacillin (only for staphylococci), vancomycin (only for staphylococci), clindamycin, erythromycin, quinopristin–dalfopristin and moxifloxacin (except for β-haemolytic group streptococci). We studied the antimicrobial susceptibility of aerobic Gram-negative bacteria to the following antibiotics: ampicillin, amoxicillin–clavulanate, cefotaxime, ceftazidime (only for members of the *Enterobacteriaceae*), moxifloxacin

and trimethoprim–sulfamethoxazole (co-trimoxazole). We tested the antimicrobial susceptibility of anaerobic bacteria to the following antibiotics: penicillin, clindamycin, metronidazole and moxifloxacin.

**Antimicrobial susceptibility and β-lactamase testing.** The antimicrobial susceptibility of aerobic bacteria was determined by evaluating the MIC by the broth microdilution method, as recommended by the Clinical and Laboratory Standards Institute (CLSI) (CLSI, 2009). The strains were defined as susceptible or resistant to the tested antibiotics according to the MIC breakpoints suggested by the CLSI (CLSI, 2010a, b). For moxifloxacin against members of the *Enterobacteriaceae* and *Moraxella catarrhalis*, since the CLSI has not established breakpoints, the definitions were based on the European Committee on Antimicrobial Susceptibility Testing breakpoint tables for interpretation of MIC (http://www.eucast.org/fileadmin/src/media/PDFs/EUCAST_files/Disk_test_documents/EUCAST_breakpoints_v1.1.xls). *Staphylococcus aureus* ATCC 29213, *Streptococcus pneumoniae* ATCC 49619 and *Haemophilus influenzae* ATCC 49247 were used for quality-control purposes.

For anaerobic bacteria, MICs were determined by the agar dilution method, in accordance with the guidelines of the CLSI (CLSI, 2007). The strains were defined as susceptible or resistant to the tested antibiotics according to the MIC breakpoints suggested by the CLSI (CLSI, 2007). *Bacteroides fragilis* ATCC 25285 was used as a reference strain for quality control.

Gram-negative aerobic bacteria and penicillin-resistant anaerobic isolates were tested for β-lactamase production using a chromogenic cephalosporin-based method (CLSI, 2007, 2009).

All experiments were repeated two or three times.

**Statistical analysis.** The differences in the number of bacteria recovered, and the number of resistant strains between odontogenic and non-odontogenic chronic sinusitis patients, were assessed with a $\chi^2$ test or Fisher's exact test, as appropriate. *P*-values <0.05 were considered significant.

## RESULTS

### Odontogenic causes of chronic maxillary sinusitis

Based on the symptoms and the instrumental tests performed, 20.3 % of the sinusitis cases (12 cases of 59) were odontogenic. All 12 cases (eight female and four male) were associated with one or more oro-antral communications, and in two of them the presence of sinus polyps was also observed. Oro-antral communications were related to sinus lift procedures (five patients), third molar extractions (three patients), improper endosseous implant placement (two patients), excision of cysts (one patient) and presence of foreign bodies (fragments of teeth, one patient).

### Bacterial isolates

Sixty aerobes and 75 anaerobes were recovered from the 47 cases of non-odontogenic sinusitis (2.9 bacteria per specimen); 15 aerobes and 25 anaerobes were isolated from the 12 patients with odontogenic sinusitis (3.3 bacteria per specimen) (Table 1). Mixed aerobic–anaerobic infections were found in 27 of 47 (57 %) cases of non-odontogenic sinusitis, and 9 of 12 (75 %) cases of odontogenic sinusitis. Aerobes and anaerobes alone were recovered in 9 (19 %) and

**Table 1.** Number of bacterial isolates in non-odontogenic (47 patients) and odontogenic (12 patients) chronic sinusitis

| Bacteria | Non-odontogenic sinusitis | Odontogenic sinusitis |
|---|---|---|
| **Aerobic** | | |
| *Staphylococcus aureus* | 23 | 4 |
| *Streptococcus pneumoniae* | 12 | 4 |
| *Escherichia coli* | 7 | 3 |
| *Haemophilus influenzae* | 7 | |
| *Moraxella catarrhalis* | 5 | |
| *Streptococcus pyogenes* | 3 | |
| *Klebsiella* species* | 2 | 1 |
| *Pseudomonas aeruginosa* | 1 | |
| *Acinetobacter baumannii* | | 1 |
| *Citrobacter koseri* | | 1 |
| *Streptococcus constellatus* | | 1 |
| Subtotal | 60 | 15 |
| **Anaerobic** | | |
| *Peptostreptococcus* species† | 24 | 7 |
| *Prevotella* species‡ | 22 | 8 |
| *Porphyromonas* species§ | 11 | 4 |
| *Fusobacterium nucleatum* | 10 | 4 |
| *Propionibacterium acnes* | 7 | 1 |
| *Bacteroides fragilis* | 1 | 1 |
| Subtotal | 75 | 25 |
| **Total** | 135 | 40 |

*Non-odontogenic: *K. oxytoca* 1, *K. pneumoniae* 1; odontogenic: *K. pneumoniae* 1.

†Non-odontogenic: *P. anaerobius* 20, *P. prevotii* 4; odontogenic: *P. anaerobius* 6, *P. prevotii* 1.

‡Non-odontogenic: *P. intermedia* 11, *P. buccae* 4, *P. melaninogenica* 4, *P. oralis* 3; odontogenic: *P. intermedia* 4, *P. melaninogenica* 2, *P. buccae* 1, *P. oralis* 1.

§Non-odontogenic: *P. asaccharolytica* 7, *P. gingivalis* 4; odontogenic: *P. asaccharolytica* 3, *P. gingivalis* 1.

11 (23 %) of the non-odontogenic sinusitis specimens, respectively, and in 0 (0 %) and 3 (25 %) of the odontogenic sinusitis specimens, respectively. In both non-odontogenic and odontogenic sinusitis, the predominant aerobes were *Staphylococcus aureus* (23 and 4, respectively) and *Streptococcus pneumoniae* (12 and 4, respectively), while the most frequent anaerobic isolates were *Peptostreptococcus* species (24 and 7, respectively) and *Prevotella* species (22 and 8, respectively) (Table 1). *H. influenzae* and *M. catarrhalis* were absent in odontogenic sinusitis (Table 1). Regarding the more common aerobic bacteria, *Staphylococcus aureus* was recovered from 46 % (27/59) of the patients (49 % and 33 % of the non-odontogenic and of the odontogenic sinusitis specimens, respectively) and represented 36 % (27/75) of the aerobic bacteria isolated, while *Streptococcus pneumoniae* was recovered from 27 % (16/59) of the patients (26 % and 33 % of the non-odontogenic and of the odontogenic sinusitis specimens, respectively) and represented 21 % (16/75) of the aerobic bacteria isolated. Anaerobic bacteria were isolated

from 85 % (50/59) of the patients, and, in particular, in 81 % (38/47) of the non-odontogenic and 100 % (12/12) of the odontogenic sinusitis patients.

There were no significant differences in the number of bacteria recovered between odontogenic and non-odontogenic sinusitis specimens ($P>0.05$).

## Antimicrobial resistance of the isolated bacteria

Overall, 22 % (6/27) of the *Staphylococcus aureus* isolates were oxacillin-resistant, and 48 % (13/27) were erythromycin-resistant, while only 4 % (1/27) were resistant to moxifloxacin or quinupristin–dalfopristin, and no isolate was resistant to vancomycin (Table 2).

Fifty-six per cent (9/16) of the *Streptococcus pneumoniae* isolates were penicillin-resistant and 56 % (9/16) were erythromycin-resistant (Table 2). In particular, 38 % (6/16) of the *Streptococcus pneumoniae* isolates were resistant both to penicillin and to erythromycin. Only 6 % (1/16) of the *Streptococcus pneumoniae* isolates were resistant to moxifloxacin, while no isolate was resistant to quinupristin–dalfopristin (Table 2).

Many of the Gram-negative isolates were ampicillin-resistant, but almost all were susceptible to moxifloxacin and co-trimoxazole, and none were resistant to amoxicillin–clavulanate or cefotaxime (Table 3). All ampicillin-resistant isolates were β-lactamase producers (Table 3).

Thirty-five of the 100 anaerobic isolates (35 %) were resistant to penicillin (Table 4). In particular, 27 of the 61 (44 %) anaerobic Gram-negative isolates were penicillin-resistant, all for β-lactamase production (Table 4). All bacteria were susceptible to metronidazole, with the relevant exception of the eight *Propionibacterium acnes* isolates, which were all resistant (Table 4). The great majority of *Peptostreptococcus* species (94 %, 29/31), *Prevotella* species (90 %, 27/30) and *Fusobacterium nucleatum* (93 %, 13/14) isolates and all the isolates of the other species were susceptible to moxifloxacin (Table 4). The rate of resistance to clindamycin was low for *Peptostreptococcus* species (10 %, 3/31), *Prevotella* species (13 %, 4/30) and *Porphyromonas* species (13 %, 2/15); no isolate of the other species was resistant to this antibiotic (Table 4).

The differences in the number of resistant strains between odontogenic and non-odontogenic sinusitis specimens were not significant ($P>0.05$).

## DISCUSSION

The close anatomical relationship of the maxillary sinus with the dental region means that dental infections and other odontogenic diseases can affect the maxillary sinus. Odontogenic infections that may involve the maxillary sinus include mainly acute and chronic periapical diseases, periodontal diseases and poorly performed endodontic treatments. Infection and sinusitis may also result from

**Table 2.** *In vitro* activity of antimicrobial agents against aerobic Gram-positive isolates

| Bacteria | No. isolates* | Antimicrobial agent | No. resistant isolates* | MIC (mg l$^{-1}$) | | |
| --- | --- | --- | --- | --- | --- | --- |
| | | | | MIC$_{50}$ | MIC$_{90}$ | MIC range |
| *Staphylococcus aureus* | 27 (23/4) | Penicillin | 20 (18/2) | 1 | 8 | 0.06–>32 |
| | | Oxacillin | 6 (6/0) | 0.25 | 4 | 0.03–16 |
| | | Vancomycin | 0 | 0.25 | 1 | ⩽0.015–2 |
| | | Erythromycin | 13 (11/2) | 0.5 | 16 | 0.03–>32 |
| | | Clindamycin | 9 (9/0) | 0.25 | 16 | 0.03–>32 |
| | | Quinopristin–dalfopristin | 1 (1/0) | 0.25 | 0.5 | ⩽0.015–4 |
| | | Moxifloxacin | 1 (1/0) | 0.12 | 0.25 | ⩽0.015–4 |
| *Streptococcus pneumoniae* | 16 (12/4) | Penicillin | 9 (6/3) | 2 | >32 | ⩽0.015–>32 |
| | | Erythromycin | 9 (6/3) | 1 | >32 | ⩽0.015–>32 |
| | | Clindamycin | 7 (5/2) | 0.25 | 32 | ⩽0.015–>32 |
| | | Quinopristin–dalfopristin | 0 | 0.12 | 0.5 | ⩽0.015–1 |
| | | Moxifloxacin | 1 (1/0) | 0.12 | 1 | ⩽0.015–4 |
| *Streptococcus pyogenes* | 3 (3/0) | Penicillin | 0 | – | – | ⩽0.015–0.03 |
| | | Erythromycin | 1 (1/0) | – | – | 0.06–8 |
| | | Clindamycin | 0 | – | – | ⩽0.015–0.12 |
| | | Quinopristin–dalfopristin | 0 | – | – | ⩽0.015–0.03 |

*The numbers within parentheses indicate the number of isolates from patients with non-odontogenic/odontogenic sinusitis.

**Table 3.** *In vitro* activity of antimicrobial agents against aerobic Gram-negative isolates

| Bacteria | No. isolates* | Antimicrobial agent | No. resistant isolates* | MIC (mg l$^{-1}$) | | |
| --- | --- | --- | --- | --- | --- | --- |
| | | | | MIC$_{50}$ | MIC$_{90}$ | MIC range |
| *Escherichia coli* | 10 (7/3) | Ampicillin† | 4 (4/0) | 8 | 32 | ⩽0.03–>64 |
| | | Amoxicillin–clavulanate | 0 | 2 | 4 | ⩽0.03–4 |
| | | Cefotaxime | 0 | 1 | 2 | ⩽0.03–4 |
| | | Ceftazidime | 0 | 0.12 | 1 | ⩽0.03–2 |
| | | Moxifloxacin | 1 (1/0) | 0.12 | 0.5 | ⩽0.03–2 |
| | | Co-trimoxazole | 2 (2/0) | 0.5 | 8 | 0.12–32 |
| *Klebsiella* species | 3 (2/1) | Ampicillin† | 3 (2/1) | – | – | 32–>64 |
| | | Amoxicillin–clavulanate | 0 | – | – | 0.25–4 |
| | | Cefotaxime | 0 | – | – | ⩽0.03–0.5 |
| | | Ceftazidime | 0 | – | – | ⩽0.03–0.25 |
| | | Moxifloxacin | 0 | – | – | 0.06–0.25 |
| | | Co-trimoxazole | 0 | – | – | 0.5–2 |
| *Haemophilus influenzae* | 7 (7/0) | Ampicillin† | 2 (2/0) | 0.5 | – | ⩽0.03–32 |
| | | Amoxicillin–clavulanate | 0 | 0.12 | – | ⩽0.03–2 |
| | | Cefotaxime | 0 | 0.25 | – | ⩽0.03–1 |
| | | Moxifloxacin | 0 | 0.25 | – | ⩽0.03–0.5 |
| | | Co-trimoxazole | 0 | 0.5 | – | 0.06–2 |
| *Moraxella catarrhalis* | 5 (5/0) | Ampicillin† | 5 (5/0) | 32 | – | 16–>64 |
| | | Amoxicillin–clavulanate | 0 | 0.12 | – | ⩽0.03–1 |
| | | Cefotaxime | 0 | 0.06 | – | ⩽0.03–0.5 |
| | | Moxifloxacin | 0 | 0.06 | – | ⩽0.03–0.5 |
| | | Co-trimoxazole | 0 | 0.25 | – | 0.12–1 |

*The numbers within parentheses indicate the number of isolates from patients with non-odontogenic/odontogenic sinusitis.
†All the ampicillin-resistant strains were also *β*-lactamase-positive.

**Table 4.** *In vitro* activity of antimicrobial agents against anaerobic isolates

| Bacteria | No. isolates* | Antimicrobial agent | No. resistant isolates* | MIC (mg l$^{-1}$) | | |
|---|---|---|---|---|---|---|
| | | | | MIC$_{50}$ | MIC$_{90}$ | MIC range |
| *Peptostreptococcus* species | 31 (24/7) | Penicillin | 7 (4/3) | 0.25 | 16 | ⩽0.03–32 |
| | | Clindamycin | 3 (2/1) | 1 | 4 | ⩽0.03–16 |
| | | Metronidazole | 0 | 1 | 4 | ⩽0.03–8 |
| | | Moxifloxacin | 2 (1/1) | 0.5 | 2 | ⩽0.03–16 |
| *Propionibacterium acnes* | 8 (7/1) | Penicillin | 1 (1/0) | 0.12 | − | ⩽0.03–4 |
| | | Clindamycin | 0 | 0.12 | − | ⩽0.03–1 |
| | | Metronidazole | 8 (7/1) | >64 | − | >64 |
| | | Moxifloxacin | 0 | 0.12 | − | ⩽0.03–1 |
| *Prevotella* species | 30 (22/8) | Penicillin | 11 (8/3)† | 0.25 | >64 | ⩽0.03–>64 |
| | | Clindamycin | 4 (4/0) | 0.5 | 8 | ⩽0.03–32 |
| | | Metronidazole | 0 | 0.5 | 4 | ⩽0.03–8 |
| | | Moxifloxacin | 3 (2/1) | 0.25 | 4 | ⩽0.03–32 |
| *Porphyromonas* species | 15 (11/4) | Penicillin | 8 (6/2)† | 2 | 8 | ⩽0.03–32 |
| | | Clindamycin | 2 (1/1) | 0.12 | 8 | ⩽0.03–8 |
| | | Metronidazole | 0 | 0.25 | 4 | ⩽0.03–4 |
| | | Moxifloxacin | 0 | 0.25 | 1 | ⩽0.03–2 |
| *Fusobacterium nucleatum* | 14 (10/4) | Penicillin | 6 (4/2)† | 0.5 | 32 | 0.06–64 |
| | | Clindamycin | 0 | 0.12 | 1 | ⩽0.03–1 |
| | | Metronidazole | 0 | 0.12 | 1 | ⩽0.03–1 |
| | | Moxifloxacin | 1 (0/1) | 0.12 | 2 | ⩽0.03–8 |
| *Bacteroides fragilis* | 2 (1/1) | Penicillin | 2 (1/1)† | − | − | 8–16 |
| | | Clindamycin | 0 | − | − | 0.12–0.5 |
| | | Metronidazole | 0 | − | − | 0.5 |
| | | Moxifloxacin | 0 | − | − | 0.06–0.12 |

*The numbers within parentheses indicate the number of isolates from patients with non-odontogenic/odontogenic sinusitis.
†$\beta$-Lactamase-positive strains.

trauma to the dentition or from surgery in the posterior maxilla, including removal of teeth, alveolectomy, tuberosity reduction or other invasive surgical procedures that cause communications between the oral cavity and the maxillary sinus, such as maxillary sinus augmentation and implantology (Mehra & Jeong, 2009).

It is reported that 5–40 % of sinusitis cases occur through a dental cause (Björk, 1954; Maloney & Doku, 1968; Melén et al., 1986), but the true incidence is difficult to determine accurately, and, as far as we know, in the last 20 years the incidence of a dental origin in chronic maxillary sinusitis has been rarely evaluated (Ugincius et al., 2006). In our study, 20.3 % of the chronic maxillary sinusitis cases were of dental origin.

A recent meta-analysis (Arias-Irimia et al., 2010) evaluated the frequency of the different odontogenic conditions that may lead to maxillary sinusitis, which most commonly manifests itself as chronic maxillary sinusitis. According to the findings, iatrogenic conditions, and in particular tooth extractions, are more frequent than other aetiological factors, such as chronic periodontitis, although some authors (Melén et al., 1986; Nishimura & Iizuka, 2002; Nimigean et al., 2006) have considered periodontal disease to be the most common way of spreading oral pathogens to

the maxillary sinus. In our study, the causes of odontogenic sinusitis were always iatrogenic, and sinus lift procedures were the main aetiological factor, followed by tooth extractions.

Our microbiological findings showed that all specimens from chronic maxillary sinusitis were polymicrobial, and anaerobes were present in the great majority of specimens. According to Brook (2006), Gram-negative anaerobic bacteria, *Peptostreptococcus* species, *Staphylococcus aureus* and members of the *Enterobacteriaceae* were the commonest bacteria isolated, while *H. influenzae* and *M. catarrhalis*, which historically have an important role in the aetiology of acute sinusitis, were isolated with lower frequency. In contrast, we observed a higher frequency of *Streptococcus pneumoniae*, which in this study was recovered more frequently than was recently reported (Merino et al., 2003).

The microbiology of maxillary sinusitis associated with odontogenic infection is still little known. Data from the literature (Brook, 2005) showed that the most common organisms are anaerobic Gram-negative bacilli, *Peptostreptococcus* species, viridans streptococci and *Staphylococcus aureus*. Our results confirmed the high frequency of anaerobic bacteria and *Staphylococcus aureus*, but not of viridans streptococci. Moreover, in our study,

comparing the microbiological findings of odontogenic with non-odontogenic sinusitis, a higher rate of recovery of Gram-negative anaerobes in odontogenic (43 %, 5/12 patients) than in non-odontogenic (32 %, 15/47 patients) sinusitis was noted.

These data confirm that anaerobic bacteria predominate not only in dental diseases, such as periodontal or periapical abscesses, but also in chronic maxillary sinusitis, associated or not with a dental origin. Moreover, anaerobic bacteria deserve more attention in the aetiopathogenesis of chronic sinusitis, since the frequency of β-lactamase-producing Gram-negative anaerobes is very high (Brook, 2005). Indeed, in our study, the rate of isolation of β-lactamase-producing Gram-negative anaerobes was 44 %.

We also evaluated the susceptibility of the pathogenic bacteria isolated to many of the most commonly used antibiotics. In a recent study (Brook et al., 2008), the rate of recovery of meticillin-resistant Staphylococcus aureus in patients with chronic maxillary sinusitis was 12 %, while in our study, in keeping with the findings of Manarey et al. (2004), the rate was lower than 10 %.

The choice of antimicrobial treatment should be guided by properly collected bacterial culture results and local antibiotic resistance patterns. The frequent recovery of anaerobes, often β-lactamase-positive, and of meticillin-resistant Staphylococcus aureus in chronic maxillary sinusitis suggests the use of antimicrobial agents effective against these organisms and with adequate sinus and oral bacteria coverage. The results of this study confirm that moxiflox-acin, as previously reported (Milazzo et al., 2002; Speciale et al., 2002), has a good antibacterial activity against anaerobic pathogens and a wide activity against Gram-positive and Gram-negative aerobes.

Many clinical studies have shown the efficacy of moxiflox-acin in the treatment of acute maxillary sinusitis (Arrieta et al., 2007; Gehanno et al., 2003; Johnson et al., 2008; Rakkar et al., 2001; Zhou et al., 2010). In our opinion, the microbiological results of this study suggest that clinical trials should be designed to investigate the clinical usefulness of moxifloxacin in the treatment of chronic maxillary sinusitis also.

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