SMILECON™
HOUSTON 2022
A JOINT MEETING

Dentistry: Getting Beyond Earth's Orbit

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October 15, 2022

SMILECON™ IS PRESENTED BY

ADA | TDA MEETING | GHDS Star of the South

Toothache in Space

HISTORY

THE RUSSIANS BEAT US INTO SPACE

- FIRST SATELLITE "SPUTNIK"
- FIRST ANIMAL TO ORBIT THE EARTH "LAIKA"
- FIRST MANNED ORBITAL SPACEFLIGHT "YURI GAGARIN"

PRESIDENT JOHN F. KENNEDY

- KNEW THE ONLY WAY FOR US TO GAIN A LEAD IN SPACE WAS A LUNAR LANDING

THE "SPACE RACE" BEGINS

History

To get to the Moon

- **Mercury:** Understand Human Aspects of Spaceflight
- **Gemini:** Master the performance aspects of spaceflight
- **Apollo:** "Land a man on the Moon and return him safely to Earth"

1958

HISTORY

BROOKS AIR FORCE BASE

Headquarters

– School of Aerospace Medicine (SAM)

– Center for Research and Development for

- Aerospace Medicine
  - Standards
- Aerospace Dentistry
  - Standards
    - » Oral health
    - » Examination
    - » Initial disqualification criteria in selection of crewmen (12)


April 9, 1959
U.S. AIR FORCE

FIRST AMERICAN
MANNED SUB-ORBITAL SPACEFLIGHT

Alan Shepherd: Freedom 7
May 5, 1961

DENTISTRY'S ROLE IN PROJECT MERCURY

- Prevention
  - Longest flight 34 hours

1961 -1963

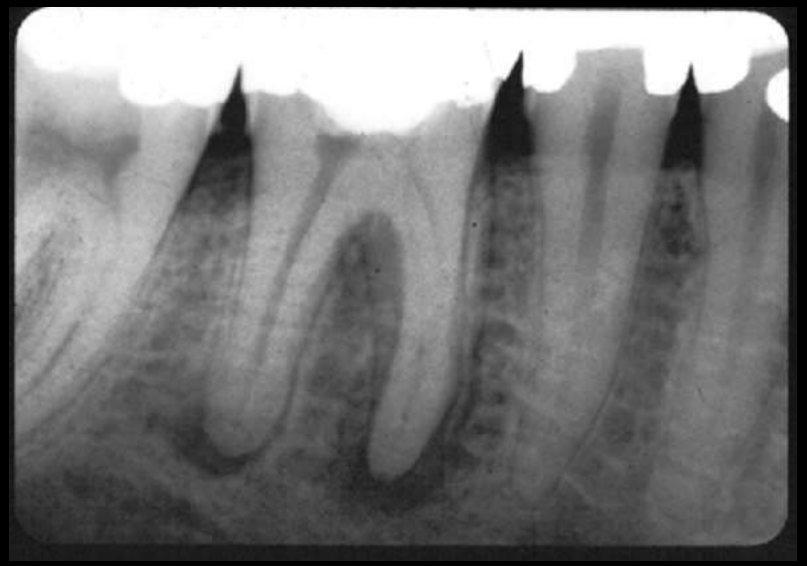
Dentistry's Role in Project Gemini

- Prevention
  - Longest flight 2 weeks

MERCURY/GEMINI

No in-flight dental incidences

– Report: Non-vital tooth flown on 3 separate occasions. (11)



Maj. William F. Frome

Assigned to NASA JSC, in Houston, Texas. (13)

– Treat and maintain the oral health of the astronauts.

– Participated in several dental research projects

1966

Astronauts To Treat Own Dental Emergencies

American astronauts will double as dentists when it comes to treating dental emergencies during prolonged space flights, an Air Force dentist said Sunday.

"As flights tend to get longer the risks of incapacitating dental problems increase. When dental emergencies arise in chamber studies, dental equipment or a dentist have gone into the chamber and the emergencies have been taken care of with no abort of the mission," according to Col. Arthur J. Stumpf, Jr., who is on the staff of the School of Aerospace Medicine at Brooks Air Force Base, Tex.

"To assure the success of long-term extra-terrestrial missions, it is necessary to provide the space crewmen with certain inflight emergency dental care capabilities," he added.

Col. Stumpf told the ADA scientific session that dentists at the School of Aerospace Medicine have developed a dental treatment, repairs and emergencies for which the kit is designed should not be a difficult task for the men who will be required to perform these tasks," he said.

An ingestible dentifrice has been developed to maintain good oral hygiene of space crews under conditions of prolonged isolation.

"It has been employed in chamber flights of 30 days duration and has been found to compare favorably with commercially available dentifrices in maintaining oral hygiene under normal living conditions," the space dental scientist said.

Lt. Col. Jack Hartley (assigned to SAM, Brooks Air Force Base) (12)

Developed a 6” x 12” 1 ½ pound dental kit

– For space flights 30 days or longer

- Universal upper Forceps
- Universal lower Forceps
- Hand instrument with
- 5 interchangeable tips
- Flashlight with clip-on mirror
- Local anesthetic with attached needles
- Plastic syringes
- Antibiotics
- Sedative filling material
- Exodontia sponges

Detroit News Photo

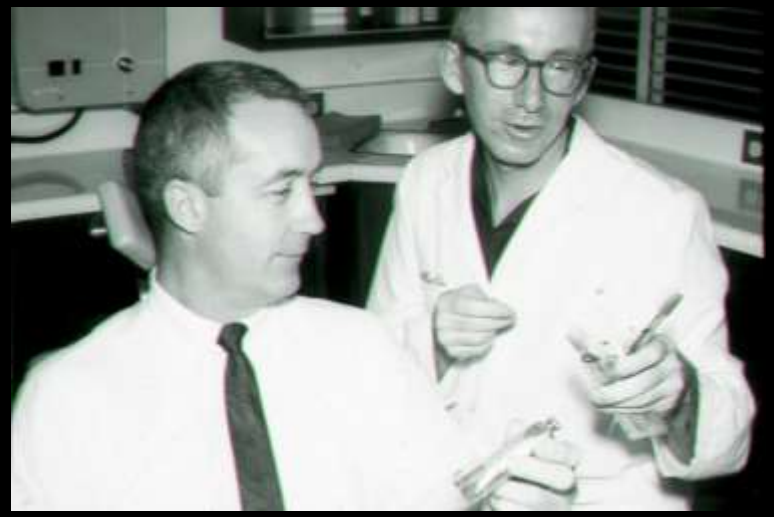
Lt. Col. Jack L. Hartley displays the emergency space dental kit developed at the Air Force's School of Aerospace Medicine.

1966

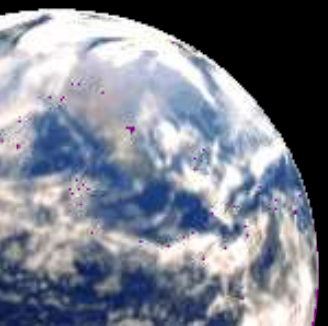
Dr. Ira L. Shannon

Developed a foamless ingestible dentifrice called “Nasadent” (10)

“It tastes better than the space food.”



PROJECT APOLLO



LUNAR MODULE

-STRICT WEIGHT REDUCTION PROGRAM

HISTORY

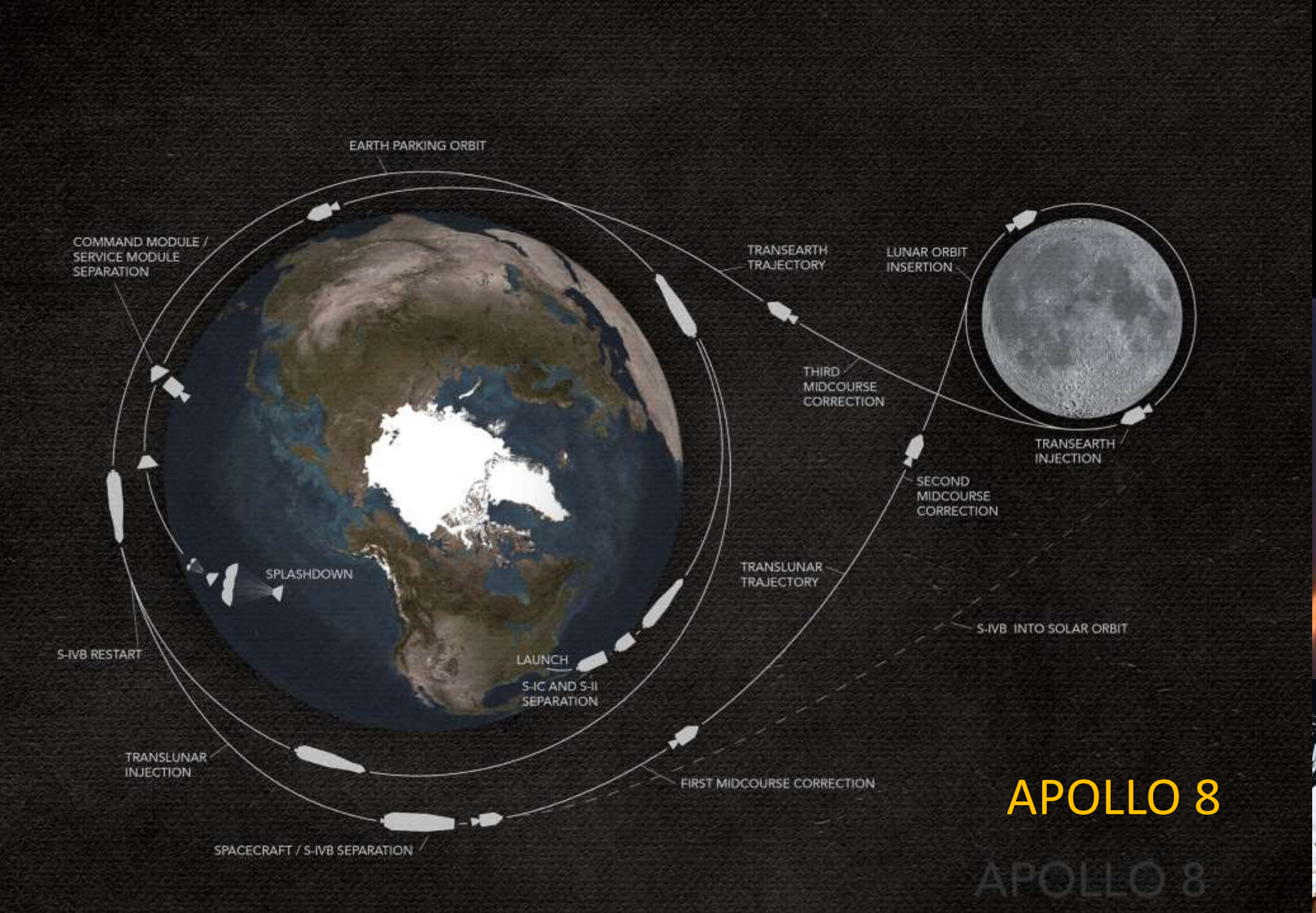
Russian Zond Proton rocket

15 September 1968

Flew on a circumlunar flight around the moon

- Two Russian tortoises
- Two bottles of fine wine
- Meal worms

Russian N-1 Rocket


EARTH PARKING ORBIT
COMMAND MODULE / SERVICE MODULE SEPARATION
TRANSEARTH TRAJECTORY
LUNAR ORBIT INSERTION
THIRD MIDCOURSE CORRECTION
TRANSEARTH INJECTION
SECOND MIDCOURSE CORRECTION
TRANSLUNAR TRAJECTORY
S-IVB INTO SOLAR ORBIT
SPLASHDOWN
S-IVB RESTART
LAUNCH
S-IC AND S-II SEPARATION
TRANSLUNAR INJECTION
FIRST MIDCOURSE CORRECTION
SPACECRAFT / S-IVB SEPARATION


BORMAN LOVELL ANDERS

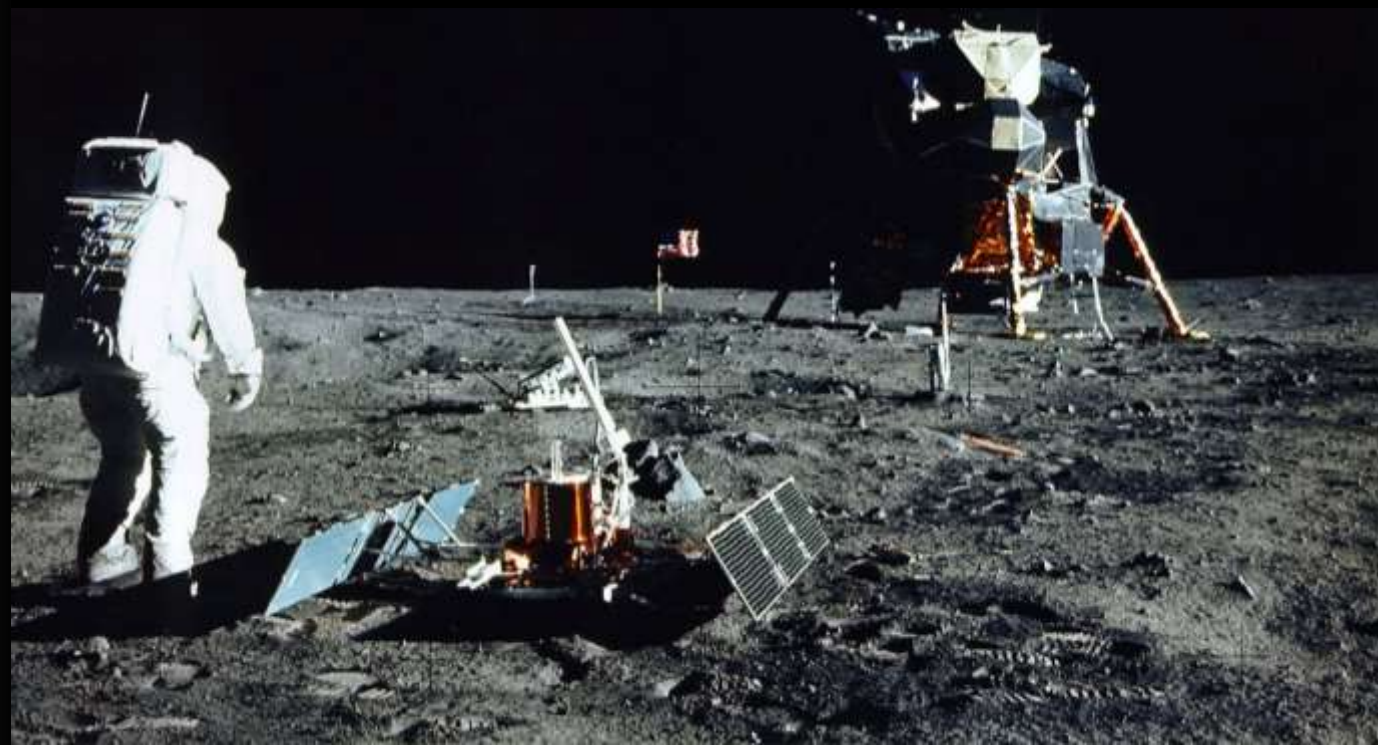
APOLLO 8

Toothbrush Trivia

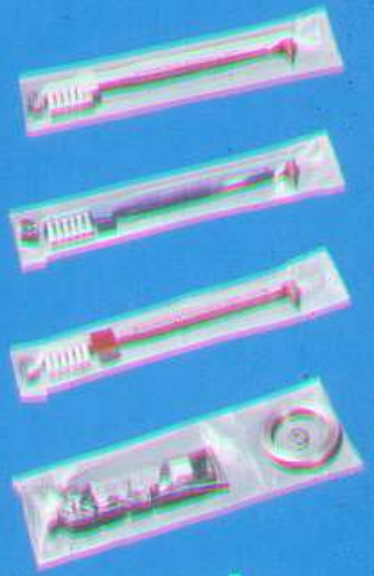
The first known image of a toothbrush flown in space is credited to Bill Anders During Apollo 8 on the first manned circumlunar flight around the moon

APOLLO

one giant leap
for mankind



EVEN ON THE MOON...



...cleaned their teeth

WHY CAN'T YOU!

NASA PREVENTIVE DENTISTRY

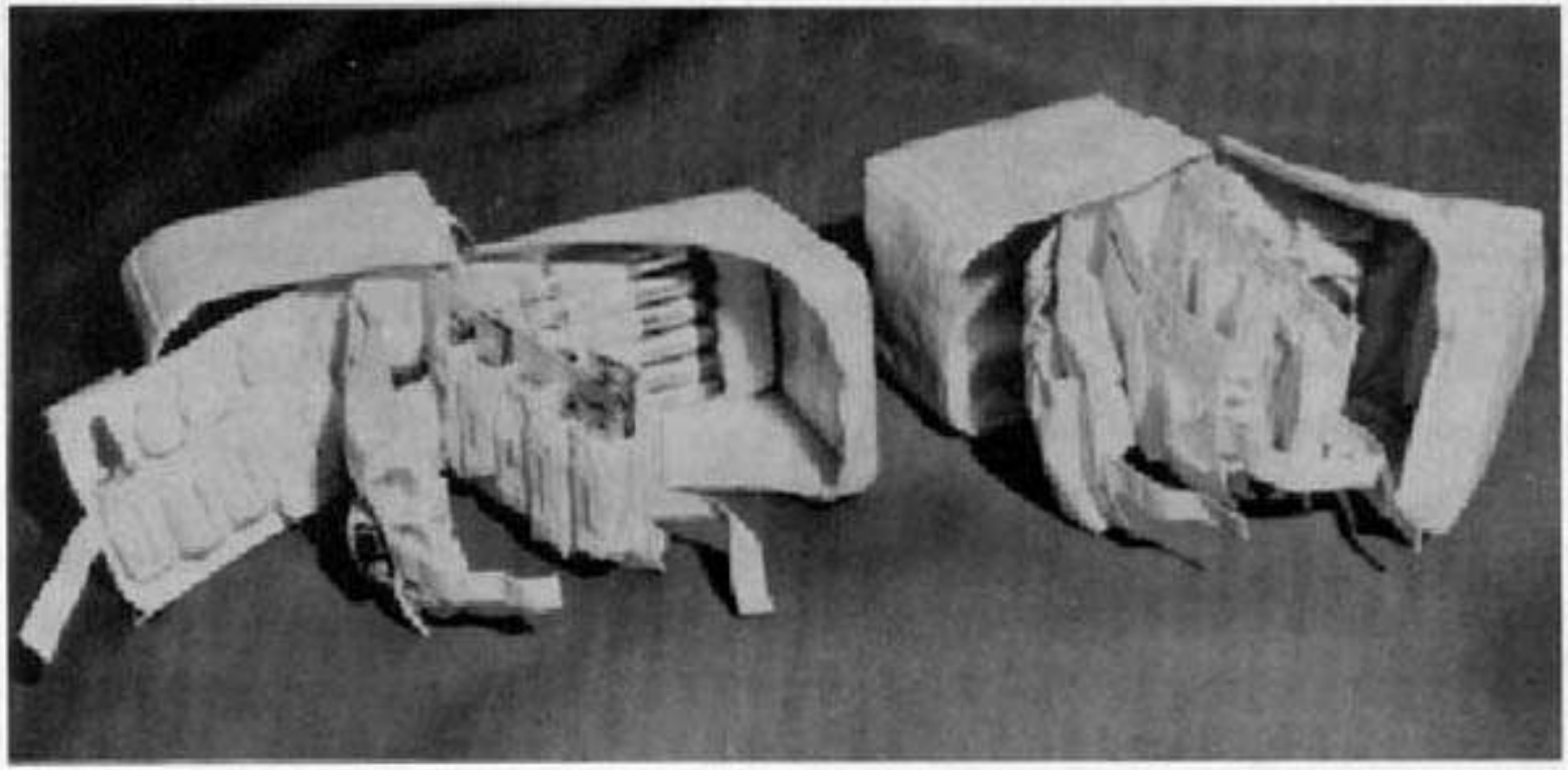


Figure 1. Typical Apollo medical kit.

APOLLO

No inflight dental issues.

– One prefight occurrence of pulpitis.
– One post-flight occurrence of pulpitis
– Both within 90 days of flight

APOLLO

The End of the Space Race

The beginning of a new era


C. CONRAD
J. KERWIN
P. WEITZ
A. BEAN
O. GARRIOTT
E. GIBSON
G. CARR

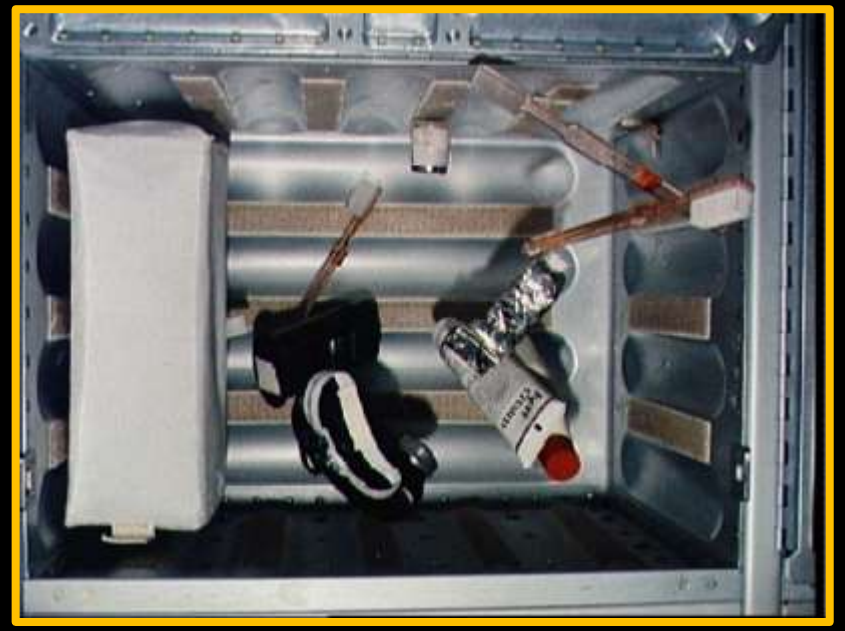

Skylab
UNITED STATES OF AMERICA

1973-1974

SKYLAB ORAL HEALTH

Provision for in flight dental care

Lighted mirror
Upper ant. forceps
Upper post. forceps
Lower ant. Forceps
Lower post. Forceps
Elevator
Gigli saw
Anesthetic/syringe
Scaler/curette
File
Applicator
Sedative filling
Guaze



SKYLAB CONTINGENCY TRAINING

2 days of intensive “hands on” dental training

- Anesthetic delivery
- Instruments and medications
- Radiographs
- Extractions

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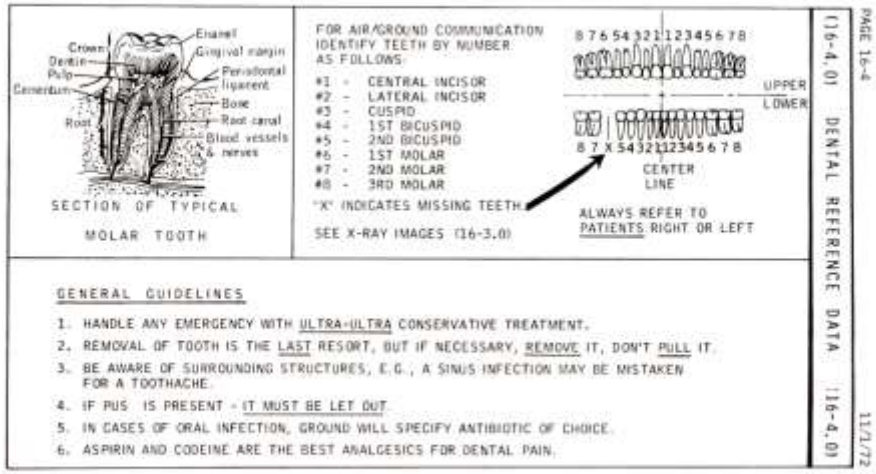
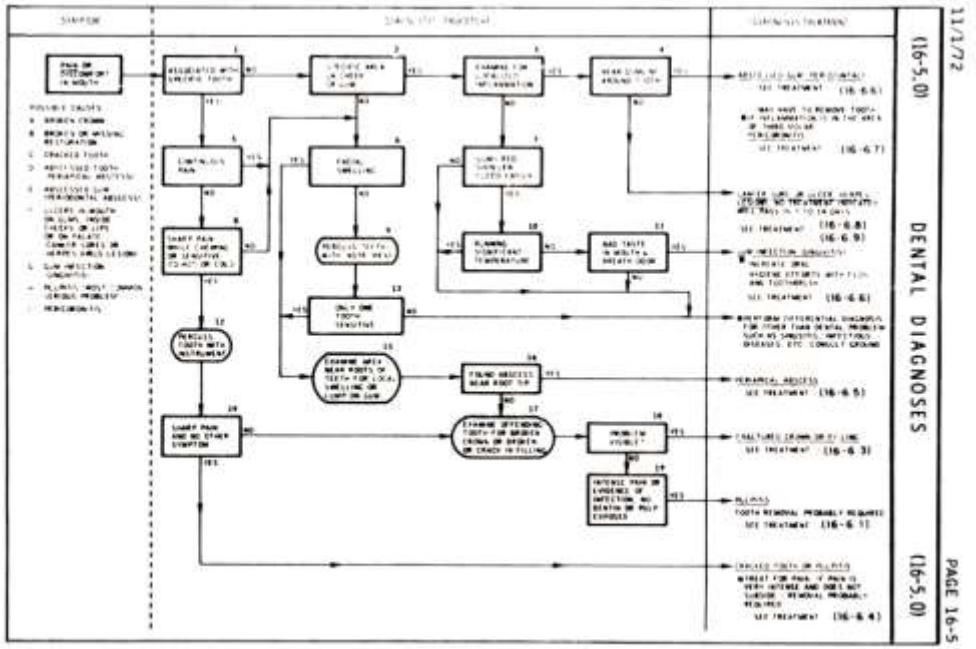


GENERAL GUIDELINES

1. HANDLE ANY EMERGENCY WITH ULTRA-ULTRA CONSERVATIVE TREATMENT.
2. REMOVAL OF TOOTH IS THE LAST RESORT, BUT IF NECESSARY, REMOVE IT, DON'T PULL IT.
3. BE AWARE OF SURROUNDING STRUCTURES, E.G., A SINUS INFECTION MAY BE MISTAKEN FOR A TOOTHACHE.
4. IF PUS IS PRESENT - IT MUST BE LET OUT.
5. IN CASES OF ORAL INFECTION, GROUND WILL SPECIFY ANTIBIOTIC OF CHOICE.
6. ASPIRIN AND CODEINE ARE THE BEST ANALGESICS FOR DENTAL PAIN.



SKYLAB ORAL HEALTH

Ground based flight physician

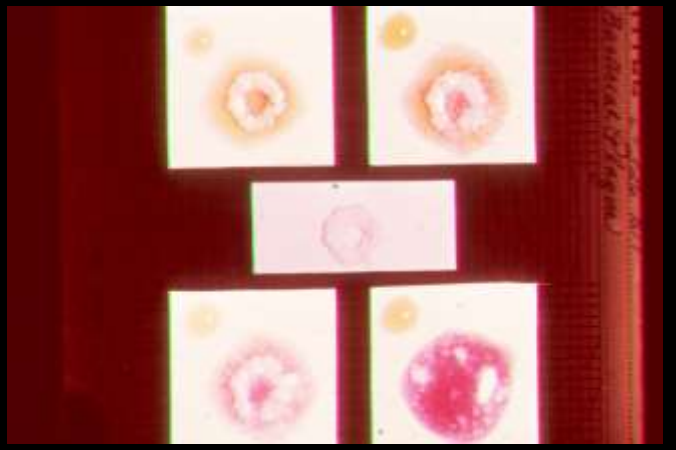
- Records
- X-rays
- Models
- Access to Dental Professional

Skylab Oral Health Studies

Four oral health studies in preparation

Skylab Mission Study

- Results
  - Increased bacterial counts
  - Increased calculus and gingival inflammation
  - Increases in salivary IgA
- Concluded
  - Diet rather than flight related



Skylab Oral Health Issues

No in-flight dental issues

- Six crew-members required treatment 9 months prior to flight.
  - Periapical abscess
  - One case of severe gingival inflammation
  - Recurrent aphthous ulcer

1973-1974

1978

Toothache in Space

Cosmonaut Yuri Romanenko

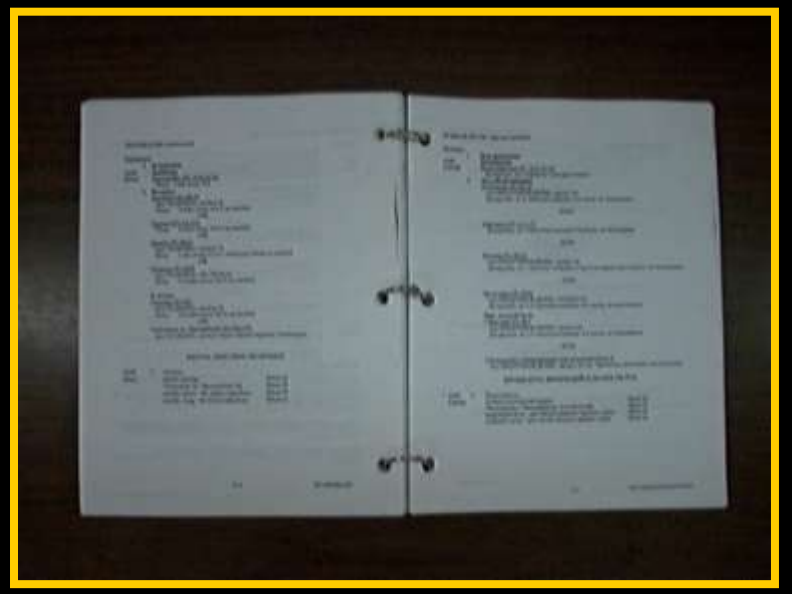
- Suffered excruciating dental pain on his last two weeks aboard Salyut 6
- No provisions for “In Flight Dentistry”
  - Took pain pills, but there was no relief

Shuttle/ISS Dental Armamentarium

Mirror
Carver/file
Orangewood sticks
Syringe
Needles Long 27G, 1.25mm (6)
Short 30G, 0.75mm (6)
2% Lidocaine w/1:100,000 epinephrine (10 Carpules)
0.5% Bupivicaine w/1:200,000 epinephrine (6 carpules)
Cavit G temporary filling material
Toothache kit
Eugenol anesthetic drops
Tweezers
Cotton pellets
Dycal (catalyst and base)
Dental floss (individual packs)
Universal upper and lower forceps
Small and large elevators

Shuttle/ISS Dental Armamentarium

Dental Sub-pack



Medical Checklist-Dental

Medication Sub-pack


NASA

Dental Issues

Mir Space Station

- 2 incidences of caries
  - Filled with temporary filling material
    - No further complications

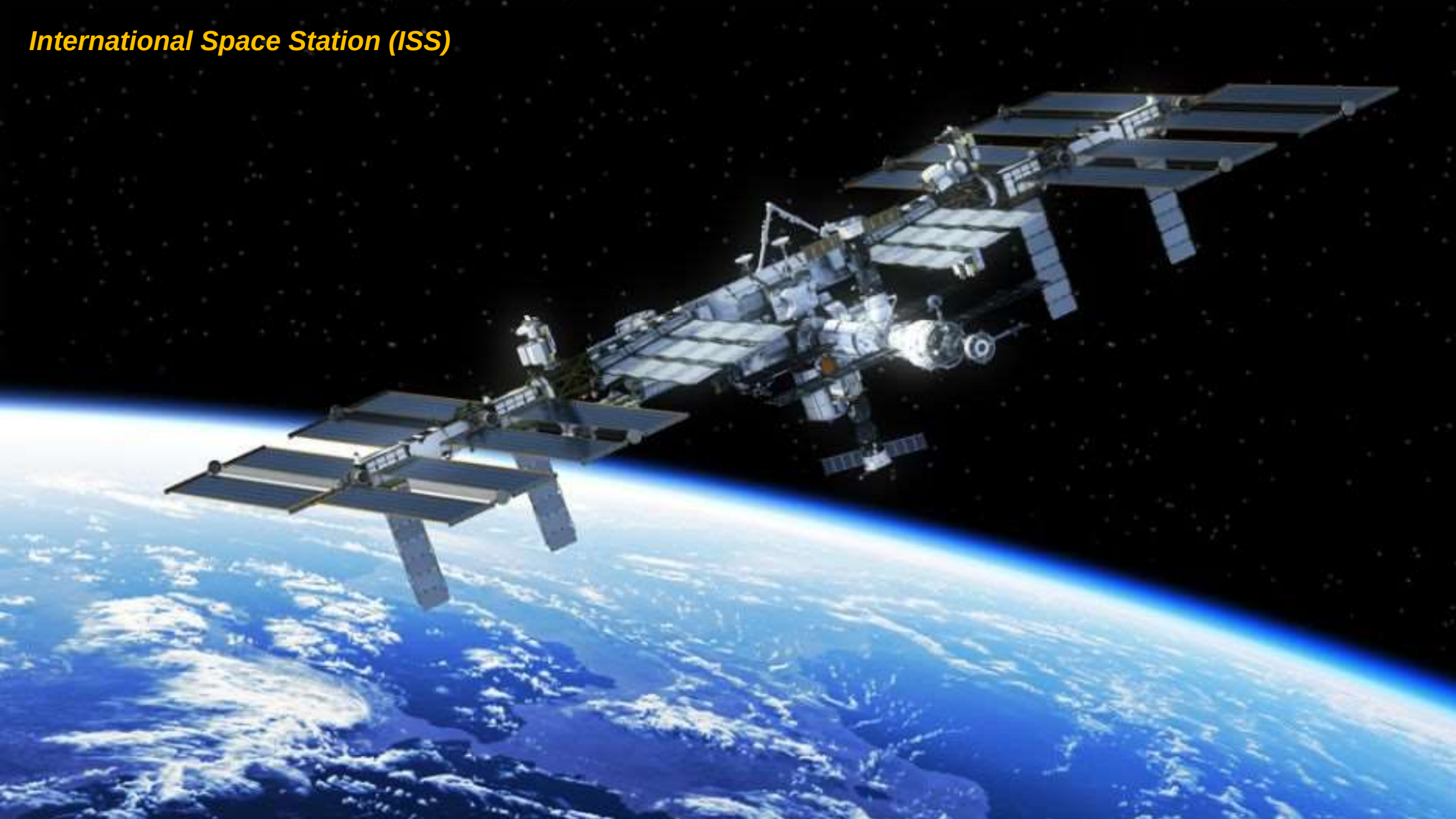
Soyuz

- Crown dislodged by forces during launch

Shuttle

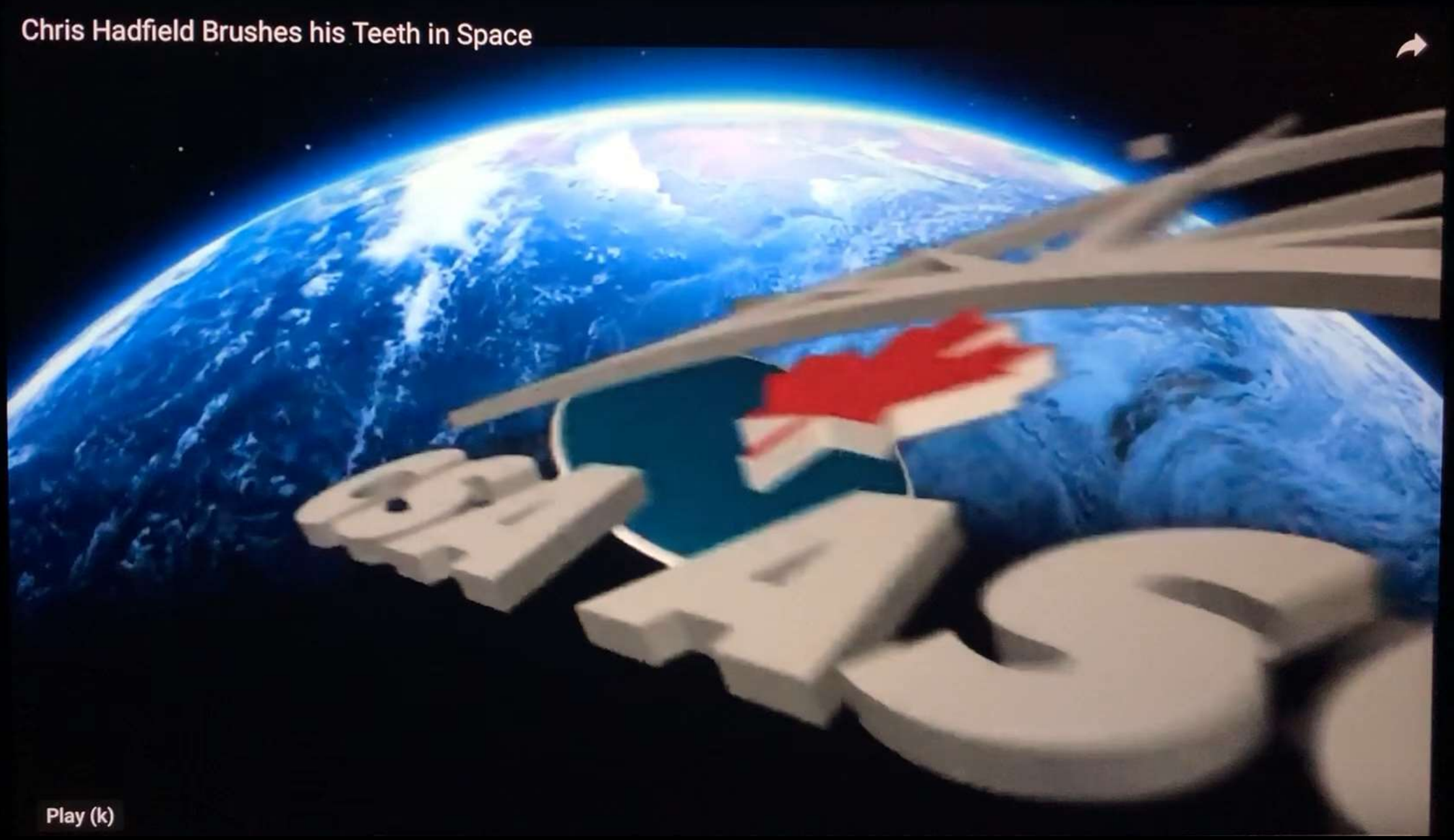
- Temporary crown dislodged
  - Luted with CaOH. No complications

International Space Station (ISS)




No In-flight Dental issues

Prevention aboard the International Space Station


Chris Hadfield Brushes his Teeth in Space
Play (k)


SPACEFLIGHT
PREPAREDNESS

MILITARY DENTAL CLASSIFICATIONS

Based on a 12-month period

Class I: Patient has good oral health

Class II: Patient has some minor oral conditions

Class III: Needs treatment

PRE-LAUNCH SCHEDULING

- Semi-annual physicals regardless of flight status
- L-6 months Complete oral exam.
- L-3 months Dental treatment completed.
- L-14 days Crew quarantined.
- Post flight exam prn.

(L = Launch)

Current Methods of Handling Dental Emergencies in LEO

"Buddy Care" Dentistry

Considerations for Treating Dental Emergencies

- **Limitations**
  - **Stowage**
  - **VOC's** (volatile organic compounds)
  - **Transport**
    - » Every pound carried requires 1000 pounds of thrust
  - **Specialized training**
  - **Harsh environment of space**
    - » Radiation -vs- medications/materials.
  - **Budget**
    - » **$10,000 per lb.**

Considerations for Treating Dental Emergencies

- Microgravity environment
  - For every action/opposite and equal reaction.
  - Three-point stability to work.
  - Aspiration is a concern.

Dental Contingencies

- Trauma
  - Tooth fracture or luxation
- Undiagnosed caries
  - X-rays (Two-dimensional picture of three-dimensional object.)
- Infections
  - Periodontal or periapical abscess
- Inflammation
  - Pulpitis
- Bruxism
  - Can cause fractures, cracked teeth, and headaches

Astronaut's training for Dental Emergencies in LEO

- Anesthetic delivery
- Temporary filling placement
- Handling of pulpal exposure
- Placement of crown with temporary cement
- Antibiotics
- Extraction

Dental Emergencies

Anesthetic delivery

- Inferior Alveolar
- Infiltration

Dental Emergencies

Trauma

Luxation

– Put tooth back in place and monitor

Avulsion

- May have to stow tooth away

Dental Emergencies

TRAUMA

Crown Fracture: Uncomplicated

Enamel only

- Smooth enamel with file

Enamel and dentin

- Rub in temporary filling material

Dental Emergencies

Exposed Vital Pulp

- Anesthetize
- Extirpate pulp
- Place oil of clove & eugenol mixture
- Monitor

Dental Emergencies

Exposed Pulp

Dry necrosis

- Leave open & monitor

Dental Emergencies

LOST FILLING

- Explore floor of tooth
- Place temporary filling
- Adjust bite

Dental Emergencies

Dislodged crown

- "Stow it away"
- Sensitivity: Lute with CaOH paste

Dental Emergencies

DENTAL INFECTIONS

- 1st order of care
  - » Antibiotics and NSAIDS
  - » Monitor

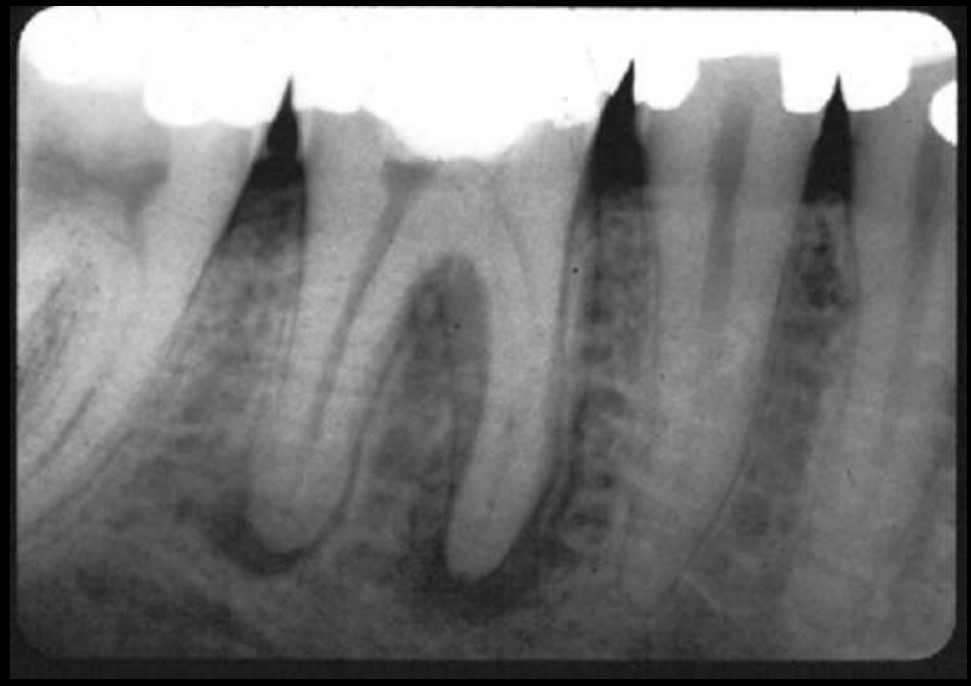
- 2nd order of care
  - » Return to Earth
  - » Extraction & monitor

Dental Emergencies

Dental Infection

Cannot be resolved with antibiotics alone

- No blood supply
- Bacteria protected and free to grow
- Pushes out into bone

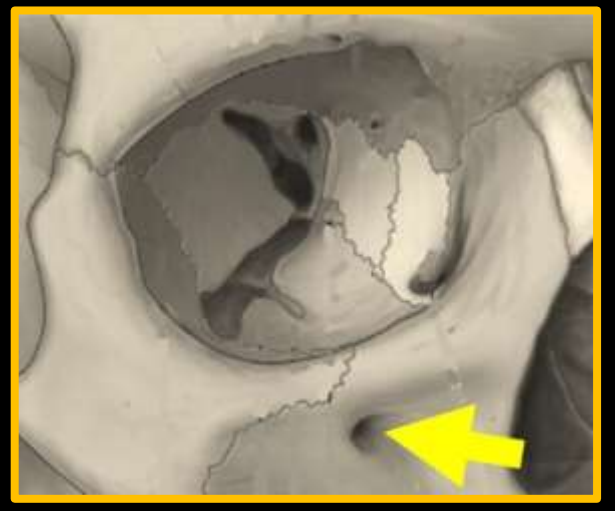


Dental Emergencies

Lower Infections

Ludwig’s angina

Upper Infections



Infraorbital foramen

Dental Emergencies

- Symptomatic Irreversible Pulpitis
  - Intermittent or spontaneous pain
  - Heightened and prolonged pain to stimulation
  - Pain can be severe, sharp, dull, localized or diffuse

AQUARIUS/NEEMO


AnnArbor
FireDept.

Rapid Barometric Pressure Changes

As you ascend
- Go slow
- Breathe in and out
- Make a ”Safety Stop”

Barotrauma

Decompression Sickness (DCS)

Type I “the bends”

Type II neurological

Type III neurological & AGE

Make a Safety Stop

Oro-facial pain during changes in barometric pressure

Barotitis

Barosinusitis

Barotrauma related headache

Barodontalgia

Dental Barotrauma

Barotitis

- 3 types
  - Externa
  - Media (most common)
  - Interna (most serious)

Symptoms

- Earache, vertigo, nausea, hearing loss.

Incidence

- As high as 8%
- Occurs during descent, twice as often as ascent.
- Pain usually continues after landing.

Caution with cold or sinus issues.

Barosinusitis

Symptoms

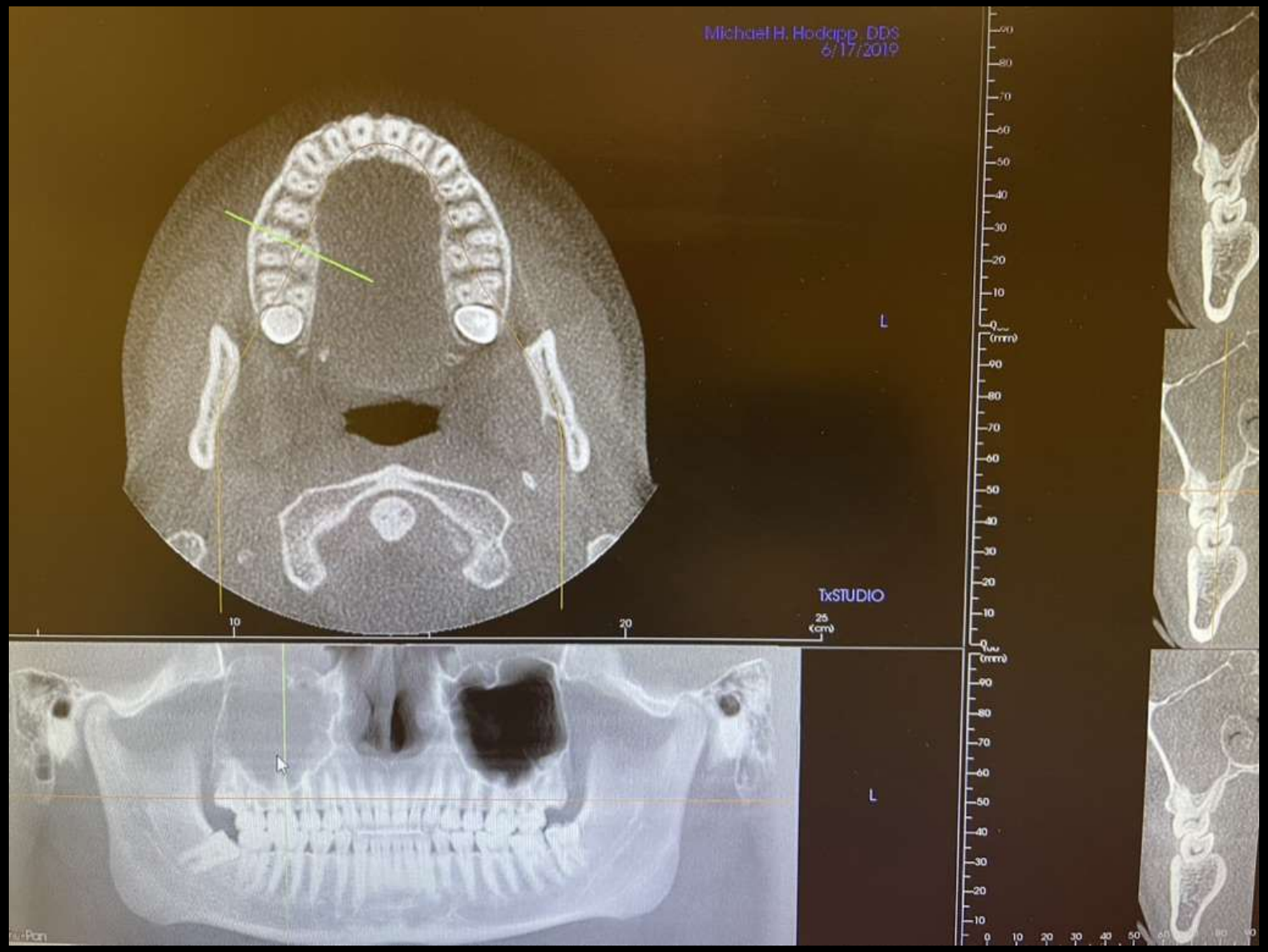
- Headache, sinus pain, and dental pain .

Incidence:

- 7-8% of air travelers
- Occurs during descent, twice as often as ascent.
- Pain usually continues after landing.
- Can refer pain to the upper molar and premolar area

Caution with Cold or Sinus issues. Especially when diving!

Barosinusitis



Barotrauma Related Headache

- 5.7% of air travelers
- Rated as 6 (1-10 scale)
- 15 to 20-minute duration

Putnam et al. (14,50)

Barodontalgia

"Dental pain" associated with barometric changes in atmospheric pressure.

Pain reported

- Severe 75%
- Moderate 25%

1940's "Aerodontalgia"

- Ranked 5th of in-flight physiologic complaints of US Pilots. (7)
- Ranked 3rd as causative factor in premature landings. (7)

1940’s

Greatest body of research during this period.

- Healthy pulps not affected

- Primary Causes
  - **Defective restorations**
  - Covert **pre-existing pulpal disease**
  - Barosinusitis

1940’s

Dental Section added

– Air Surgeon’s Office, Army Air Corps, Washington DC (5)

“The Symposium on Problems of Aviation Dentistry”

Chicago Midwinter Meeting; Feb 12, 1946

ADA Journal, Vol. 33, No 13, (827-844), 1946.

Research presented

– Incidence rate: 9.7%
– Majority of cases due to **undiagnosed pulpal and apical pathology**

Parting Statement:

“Aviation Dentistry will not only be part of clinical practice, but research in it’s many phases will affect everyday dental procedures”

“Aerodontalgia” (Barodontalgia)

Controlled group studies

- Based on single or small number of simulated flights
- Incidence rate: 0.26 – 3.0 %

Barodontalgia

In-flight barodontalgia reports 1940’s

- 10% Military
- 11% Civilian (11,12).

Since 1940's What has changed?

Airline Cabins are pressurized

Dental materials and techniques have improved

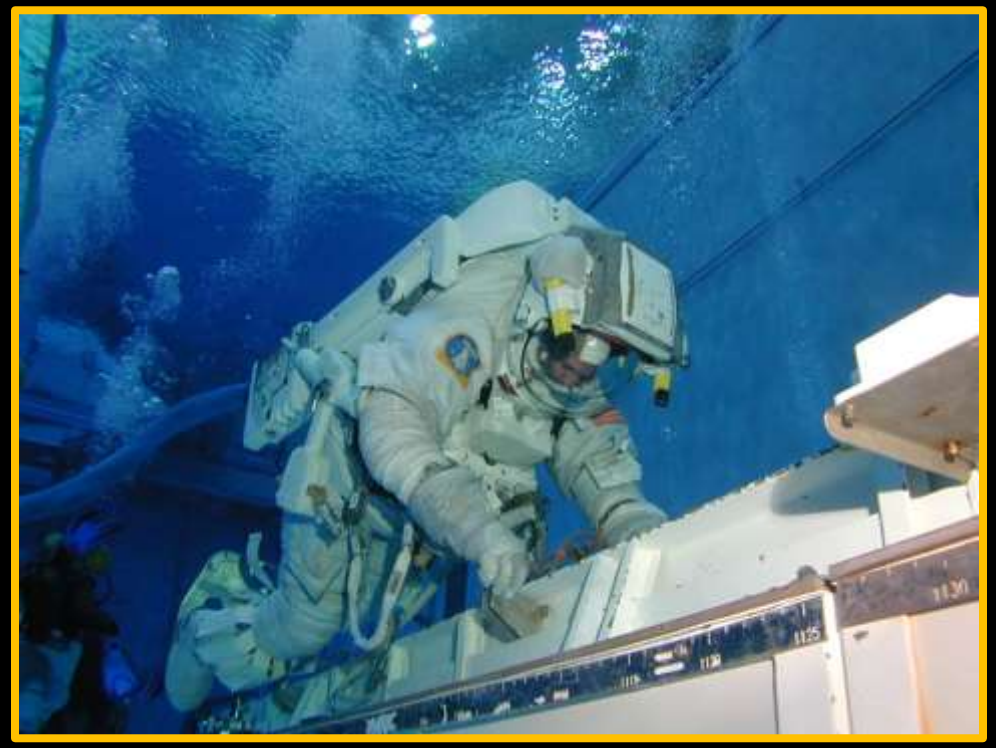
Flights have grown exponentially

SCUBA diving is an everyday event

Awareness and diagnosis in this field has declined

Barodontalgia

Astronauts deal with barometric issues too



- ***7.4% incidence during training***

Barodontalgia/Barotrauma

No reported cases during space flight

Barodontalgia

Induced (new) pain from “Odontoclasis”

Usually an exacerbation of preexisting ~~subclinical~~ oral disease.

Indirect (referred pain)

- Otitis media (lower posterior teeth)
- Barosinusitis (upper posterior teeth)

Barodontalgia

Most common associated pathologies

– 29.6% Recent restorative dental procedures (47)

– 18.5% Pulpal necrosis/apical periodontitis (47)

– 18.5% Barosinusitis

Barodontalgia

Ferjentsik, et.al.

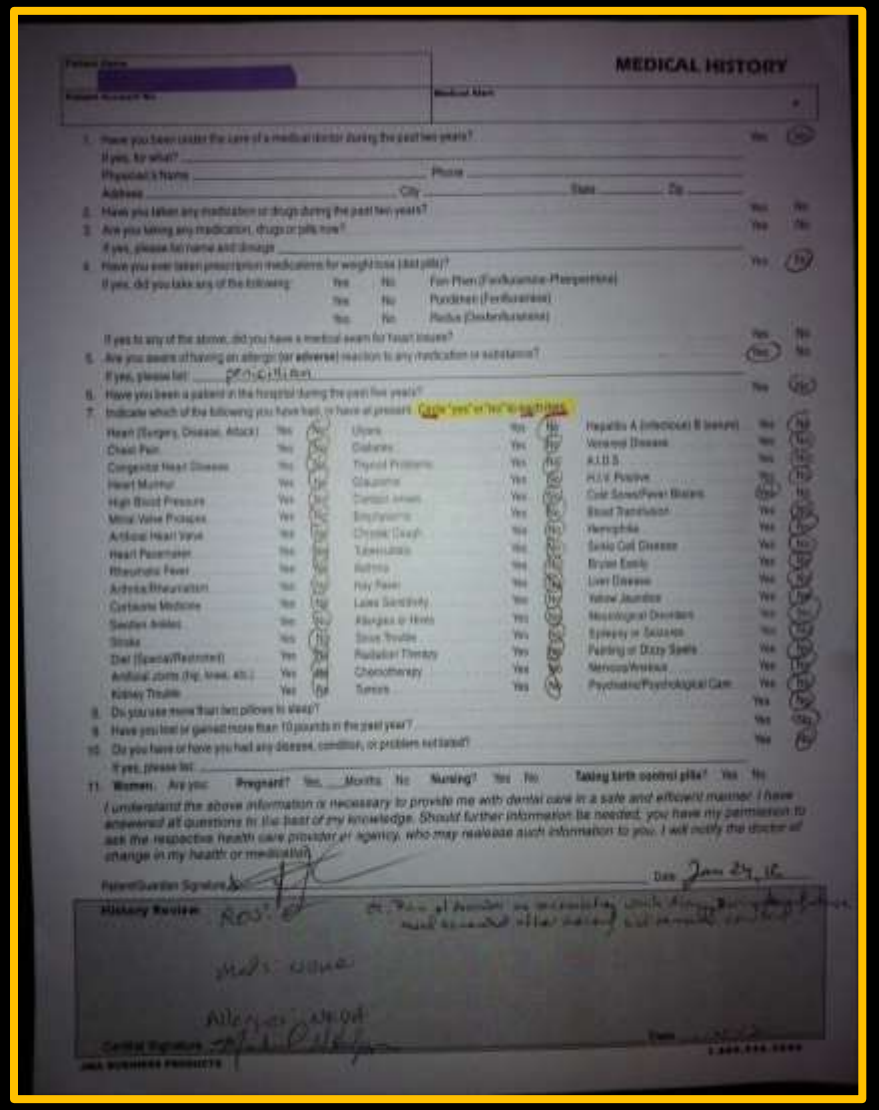
– 86% Faulty restorations (20)

Caries consists of billions of cells that can expand or compress in unison

Cracks and defective margins are usually associated with recurrent decay

Barodontalgia

- Diagnosis
  - Cannot reproduce trigger factor (barometric change)
  - History becomes increasingly important
    - » Location of pain
    - » Description of pain: (sharp, dull)
    - » Intensity of pain
    - » Altitude or depth of onset
    - » Altitude or depth that pain resided
    - » Previous symptoms
    - » Recent dental treatment
    - » Recent cold, flu, or sinus issues



Barodontalgia

- Diagnosing Barodontalgia

Pulp testing
- Electronic pulp test (EPT)
- Cold Test
- Heat Test
- Percussion test
- Tooth sleuth or cotton stick
- Palpation test
- Probing

Crack and caries detection
- Transillumination (cracks)
- 780 nm near infrared transillumination
- Intraoral camera

Diagnosing Barodontalgia

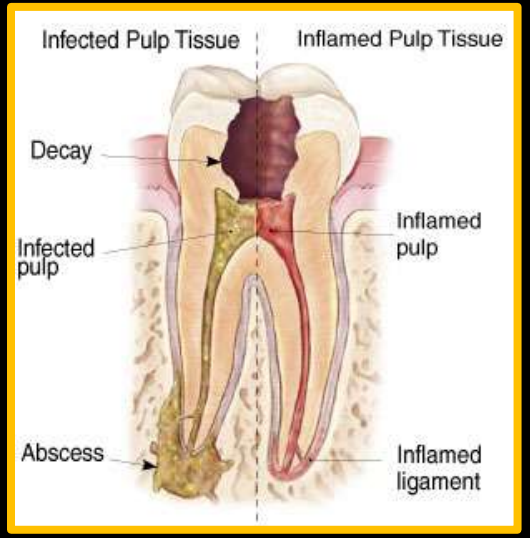
Look for:

- » Faulty restorations with recurrent decay
- » Deep or large restorations
- » Apical lesions

Remember

- Recent Treatment
  - » 48 to 72-hour for healing (29)
  - » High in occlusion

- Multiple rooted teeth may be in transient disease state
  - » One root with necrosis
  - » Another root with pulpitis
  - » Another root vital



LASER Technology to Enhance Diagnosis

780 nm Near-Infrared Transillumination (NIT)

- Porous lesions absorb the light and appear dark.

- Detects caries around existing restorations.

- Software places bitewing images up for side-by-side comparison.

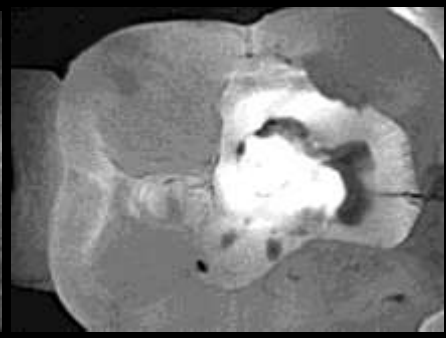
780nm (NIT) wavelength system.

Imaging around an existing restoration

Pre-op x-ray # 19

(NIT) #19

caries detection

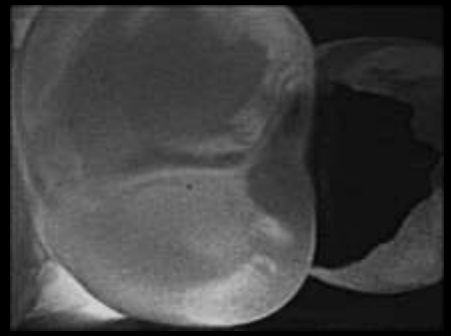


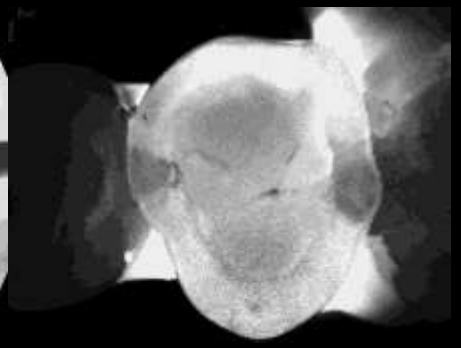
crack detection

780nm (NIT) wavelength system.

Radiograph

780 nm image





Diagnosing Barodontalgia

If pain occurs during

ASCENT; the teeth are usually ALIVE

- Pulpitis
  - Recent treatment (sharp transient pain)
  - Acute (sharp transient pain)
  - Chronic (dull throbbing pain)
- Periodontal abscess (dull throbbing pain)

DESCENT; the teeth are usually DEAD

- Periapical disease or cyst (severe persistent) *Occurs during ascent or descent
- Pulpal necrosis (Dull throbbing)

Referred Pain:

- Barosinusitis: upper molar and premolars
- Otitis: the lower posterior teeth

Diagnosing Barodontalgia

ASCENT/ALIVE

- » Radiographically: No apical lesion
- » Pulp test teeth: usually (+)
- » Suspect: Pulpitis or periodontal abscess

DESCENT/DEAD

- » Radiographically: Usually an apical lesion
- » Pulp test teeth: usually (-)
- » Suspect: Pulpal necrosis, apical cyst or referred pain

DECENT/REFERRED PAIN

Barosinusitis (upper posterior teeth)

Otitis (lower posterior teeth)

FDI Classifications of Barodontalgia

CLASSIFICATION	SUBJECTIVE FINDINGS	OBJECTIVE FINDINGS	ASSESSMENT
Class I	ASCENT: Sharp momentous pain DESCENT: Asymptomatic thereafter	Vital tooth Caries or defective restoration No apical pathosis	Acute pulpitis
Class II	ASCENT: Dull throbbing pain DESCENT: Asymptomatic thereafter	Vital or non-vital tooth Deep caries or restoration No apical pathosis	Chronic pulpitis
Class III	ASCENT: Asymptomatic DESCENT: Dull throbbing pain	Non-vital tooth Deep caries or restoration Periapical pathosis	Pulpal necrosis
Class IV	ASCENT: Severe persistent pain DESCENT: Severe persistent pain	Non-vital tooth Deep caries or restoration Periapical pathosis	Periapical abscess or cyst

Barodontalgia and Dental Barotrauma

What has not changed?

Percentages:

- Average: 11% (5, 41, 56)
- One study: averaged of 49.6%) (48,49,54)

- Report:
  - Higher incidence rate in pressurized cabins (37)
    - Modern airlines cabins hold a pressure of 7,000 feet
    - Only requires 2,000 feet for barodontalgia to occur.

Barodontalgia and Dental Barotrauma

May 2022 Journal of Aerospace Medical Association

- Survey by The French Federation of Underwater Sports (FFESSM) (55)
  - 684 Divers
    - Barodontalgia 18.7%
    - Dental Barotrauma (Odontocrexis) 10.1%

Barodontalgia and Dental Barotrauma

What has not changed?

"Dentists need to be educated and aware of these conditions" (1,5,7,25,27,51, 52, 53, 54,55)

Dental Barotrauma

Odontocrexis (44) (Calder and Ramsey, 1983)

"Tooth explosion"

Odontoclasis (19) (Gunepin, Florence, Derachbe, Audoual, 2010)

"Tooth fracture"

Dental Barotrauma

Presentation

- Loss of filling or section of tooth
  - Usually occurs during descent
    - (increased pressures)

Concerns

- Aspiration of the fragments
- Lack of concentration due to pain

Dental Barotrauma

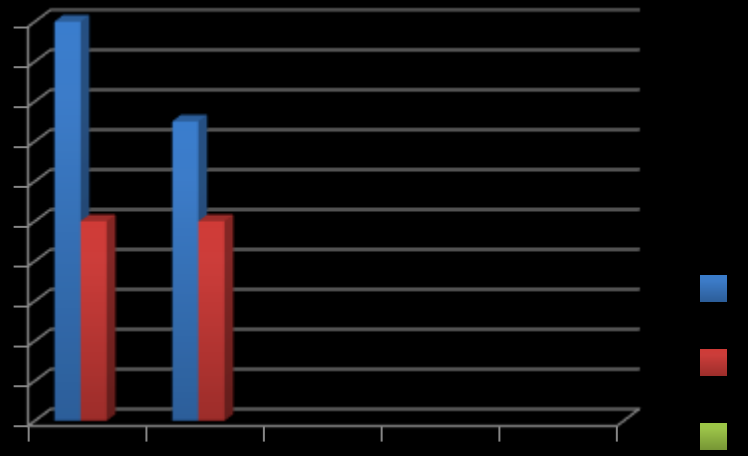
Jagger *et al*.

125 divers surveyed

- One diver had a tooth shatter “odontocrexis”
- Two divers had dislodged restorations

10-year longitudinal study German Navy

- Divers that dove on average 200-300 hours annually.
  - The number of crowns placed were double (2 X)
  - 25% increase in missing teeth



Dental Barotrauma

Calder and Ramsey in vitro decompression study of extracted teeth

- Non-restored teeth even with carious lesions were not affected.
- All damaged teeth had defective restorations with open margins, or recurrent decay.

Concluded: Cause is poor quality restorations with recurrent decay

Dental Barotrauma

Defective amalgams with recurrent decay may have asymptomatic cracks below the existing restoration.

Dental Barotrauma

Composites are bonded to tooth structure so cracks will usually be visible in the restoration.

Additional Considerations for Pilots and Divers

Cements

Lyons et al. studied the effects of pressure cycling (up to 3 atm) on the crowns of extracted teeth.

- Zinc phosphate cement had 90% reduction in retention
- Glass ionomer cement had a reduced retention by 50%
- Resin cement had no reduction in retention

ADDITIONAL CONSIDERATIONS FOR PILOTS AND DIVERS

Pulp caps

Pulp capping is contraindicated for pilots and divers and should be avoided.

- Root canal is recommended (1,11,35,42,43)

Risk
- Barodontalgia
  - Pulpitis
  - Infection

Dental Infections

Alder HF: reports a case during training in a pressurized cabin where a periapical abscess burst resulting in long term hospitalization. (24)

Self-Grounding Notifications

Dental Procedures

- Restorative procedures requiring anesthetic
  - No flying or diving for 12-24 hours (1,2,3,4,7,9,10, 12, 30)

- Usually takes one week for acute inflammation to subside.
- Chronic inflammation can remain for several weeks

Self-Grounding Notifications

Medications

- Analgesics
  - Other than aspirin or acetaminophen
    - No flying or diving for minimum of 12 hours (1,4)

- Antihistamines, sedatives, or muscle relaxant drugs
  - No flying or diving for 24 hours after cessation of treatment (3, 4, 12, 16, 24)
  - Diphenhydramine 60 hours (23)

- Antibiotics
  - Flying or diving may resume 24 hours after initiation of treatment. (4)
    - Diarrhea
    - Abdominal pain

Self-Grounding Notifications

- Exodontia or surgery
  - No flying or diving for 7 days
    - Re-examined prior to flying or diving.
      - Symptoms subside
      - Stabilized clot
      - 24 hours after cessation of all analgesics
    - If oroantral communication suspected
      - No flying or diving for 2 weeks
      - Referral for closure

Self-Grounding Notifications

- Endodontic procedures
  - When a necrotic tooth is diagnosed needing a root canal, no flying or diving until treatment is completed and symptoms subside. (5)

Exploration Class Missions

Space Exploration: ISS to the Artemis Program

Orion: How to Define the Medical System?

- Mission duration: launch to landing/recovery (10-20 days)
- Crew Size (4)
- Mission Design: Lunar orbit without extravehicular activity
- Mission Architecture: vehicle volume/config, exercise equipment, nutrition system, etc.
- Astronaut Fitness
- Training time for crew

Spacecraft Limitations Considered Up Front

- Total mass allowed for medical system (including dental) is ~ 30 lbs
- Total volume allowed is roughly the size of an average carry-on suitcase
- Imaging capability constrained by small mass volume allowance
- Cabin pressure and flammability limits use of oxygen therapy
- Complex procedures out of scope

Risk Analysis is Key to Dental Resources

Conditions	Case	Probability of Occurrence
DENTAL: ABSCESS	Best Case	0.0015
DENTAL: ABSCESS	Worst Case	0.0004
DENTAL: AVULSION (TOOTH LOSS)	Best Case	0.0005
DENTAL: AVULSION (TOOTH LOSS)	Worst Case	0.0002
DENTAL: CARIES	Best Case	0.0014
DENTAL: CARIES	Worst Case	0.0008
DENTAL: CROWN LOSS	Best Case	0.0003
DENTAL: CROWN LOSS	Worst Case	0
DENTAL: EXPOSED PULP	Best Case	0.0036
DENTAL: EXPOSED PULP	Worst Case	0.001
DENTAL: FILLING LOSS	Best Case	0.0011
DENTAL: FILLING LOSS	Worst Case	0.0001

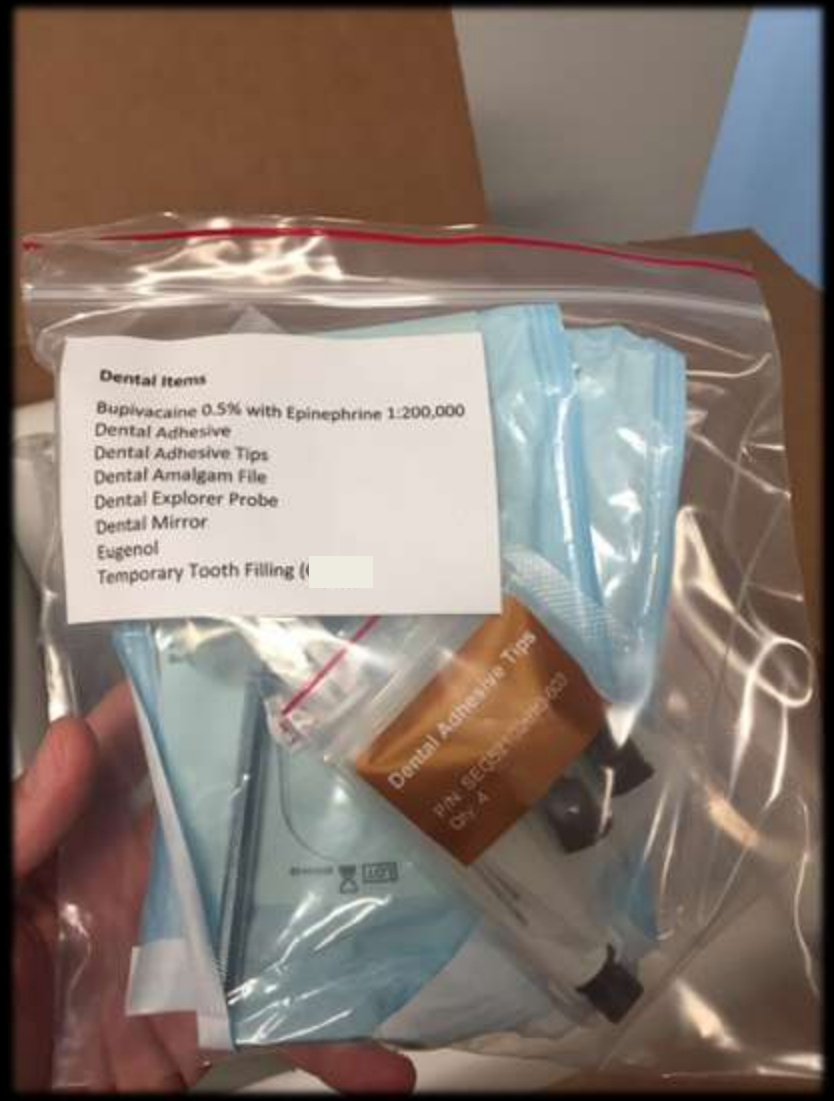
$$Exclusion\ Score = \frac{Complexity * Futility}{Probability}$$

- Less likely to include resources to address condition that is: low likelihood, require high amount of resources, and low chance for treatment success in spaceflight.

Communication with Ground

- Audio/video between crew and flight surgeon for medical/dental issues
- Imaging/video exam is a possibility
- Phone an expert – that's you!
- Ability for real-time consultation or remote guidance a possibility
- "Mind the Gap" – Comm Delays!

Orion Spacecraft Dental Subpack



- Current dental capability is small
- Reducing risk of dental issues in-flight prior to flight will be key
- All risk cannot be mitigated
- As lunar mission durations increase, dental capabilities will need to be revisited

Making Trades

- Dental probe would best be served by a double ended explorer combination instrument
- Dental Mirror (can be plastic)
- Imaging capability (video/photos)

Making Trades

- No dental forceps, amalgam file, and dental elevator, and magnifying loupes
- Possibility remains to add more tools for future missions and with addition of more vehicles

How to Handle a Dental Infection?

- Not planning on performing I&D in flight unless absolutely necessary
- First steps will likely include
  - Oral antibiotics (amoxicillin)
  - Topical pain medication (eugenol)
- Bupivacaine reserved for extended anesthesia for a tooth
  - Dual purpose medication: medical and dental
- Crewmember may have to fashion a tongue depressor to place between the teeth until antibiotics reduce any swelling

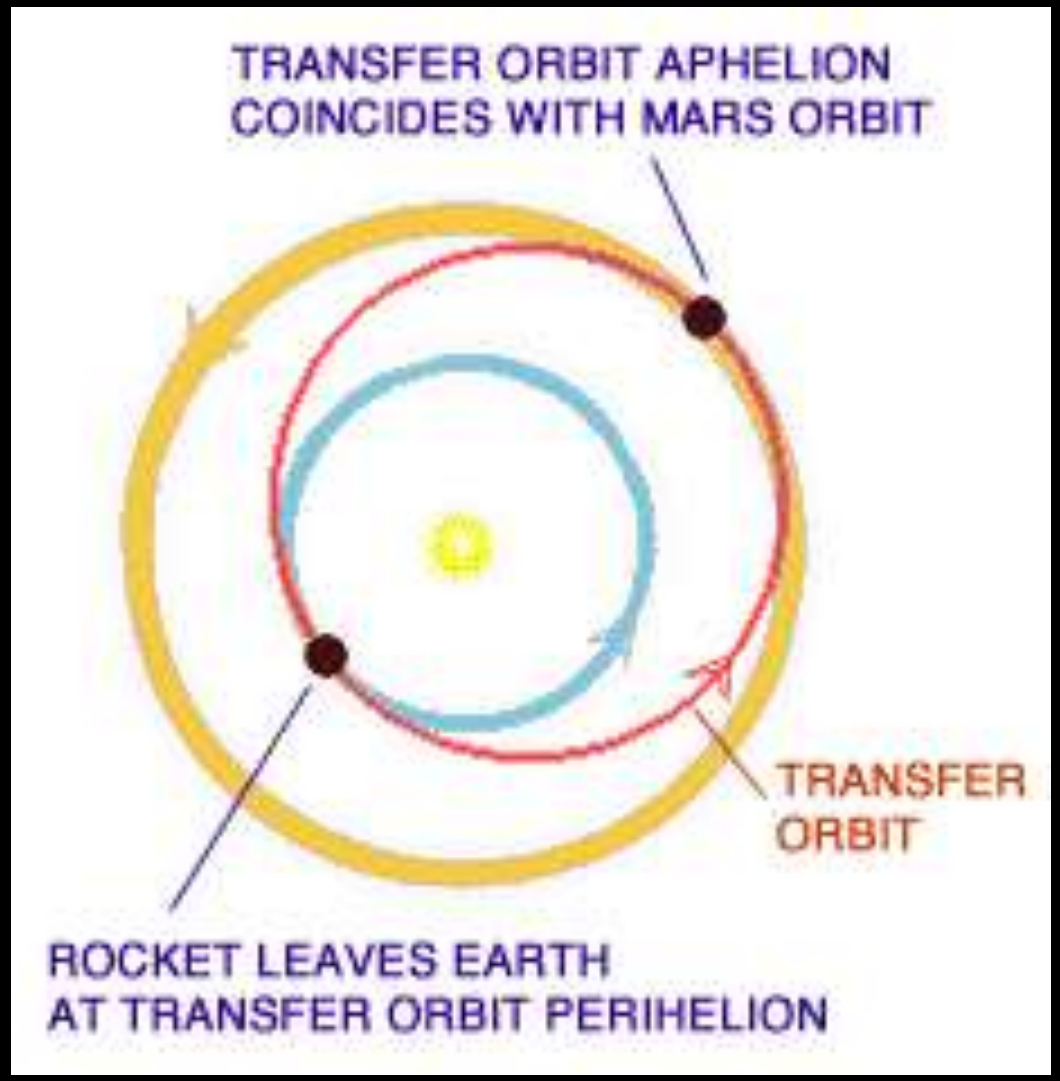
Are Tooth/Prosthetic Failures an Option?

- Dental mirror and dental explorer/probe instrument come into play
  - To trim excess calcium hydroxide in the event a crown had to be recemented in flight
  - No other option that would enable access to the areas around and between the teeth
- A diamond fingernail file included in case of sharp tooth edge
- Temporary tooth filling material included

Pharmaceuticals & Spaceflight

- Mission time for medications can start 6 months+ prior to flight
  - Need to consider launch delays and mission duration
  - Packaging/dispensing timelines
- Acetaminophen can degrade to toxic byproducts past expiration date
- Augmentin degraded in the spaceflight environment
  - Observed after 28 months
  - Also sensitive to atmospheric humidity

Mars Exploration Class Missions



Mission to Mars

- 3-year mission
- No rapid return
- Delayed communications
20 minutes each way

Exploration Class Missions

"Buddy Care"
Incorporate annual exams and cleanings

Computer based procedural video's

Modern diagnostics are getting smaller

Intra-oral camera

Battery operated curing light and bonding materials

780 nm transillumination

Handheld x-ray unit

New Technology to Consider for Exploration Class Missions

Battery Operated Dental Hand piece

Intraoral imaging and 3D Printing

Space Exploration is Our Future

Dental preparedness must be present to ensure crew safety

Thank You!

To learn more…

Aerospace Medical Association (AsMA)

http://www.asma.org

International Association of Aerospace Dentistry (IAAD)

http://www.aerospacedentistry.com

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