NATIONAL CENTER FOR CASE STUDY TEACHING IN SCIENCE

Fizz, Sugar, and Teeth:

An Integrated Case Study in Dental Pathology



by

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Part I – The Examination

As Sini sat quietly in the dental chair, she clutched her phone nervously, scrolling through texts she had no intention of responding to. She'd postponed her dentist appointment five times already. "No more excuses," her dad had said, "just go see Dr. Cheng!" Sini tried to keep herself calm, but the wires being clipped into the kid's teeth next to her made her nervous. Sini tried settling into the chair, feeling her palms grow damp against the fabric of her jeans as sunlight streamed through the large glass windows.

Dr. Cheng came in, greeted her with a reassuring smile, and started with some small talk about work and the local art activities taking place, putting her at ease. He adjusted his gloves and mask, then tilted the chair back until Sini was almost lying down. He angled a large overhead light and turned it on as he asked her to open her mouth. The light above felt like a spotlight, and she was the star; although she would have preferred not to be on stage today.

Dr. Cheng counted her teeth and then began a more detailed examination. Suddenly he focused on her back teeth and asked his assistant to confirm. "Hmm, looks like you have several cavities here," he said, his tone kind yet informative. Sini's heart sank. She'd hoped to walk out with a clean bill of dental health, but the word "cavity" felt like a weight.

The assistant typed Dr. Cheng's notes on the computer while he examined Sini's mouth.

Mandible:

- Crescent shaped lesions are present on the cervical region of the facial (buccal) surfaces of number 17–19, 31–29, 14, 15, 2 and 3 teeth. Erosive brown colored and leathery lesions and carious dentin appeared on the lingual, palatal, and occlusal surfaces.
- Cavities noted on cusps of 17–19 and 31–29.
- Patient reported pain when teeth 17–19 and 31–29 were palpated and cold tested.

Maxillary teeth: asymptomatic on percussion, palpation, and cold testing.

Periodontal examination: no attachment loss.

Plaque deposit and calculus: mandibular incisors.

Oral mucosa: asymptomatic, moist appearance, pink and without lesions.

Salivary glands: no enlargement.

Saliva: clear and flowing bilaterally from salivary ducts. Normal pooling on floor of mouth

Questions

1. Given Sini's age, how many teeth would she be expected to have?

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2. On Figure 1 below, number the teeth according to the Universal Numbering System. Then complete Table 1 with the type of teeth, corresponding number, and function. (Hint: find the midline.)

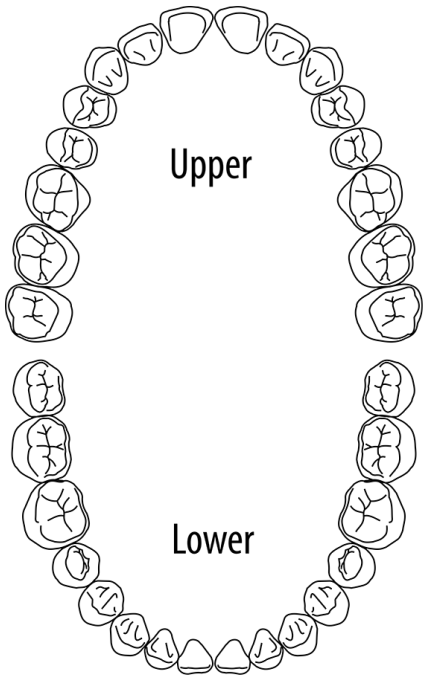


Figure 1. Upper and lower dental arches. *Credit:* Kaligula, CC BY-SA 3.0.

Table 1. Number and function of teeth.

Type of Tooth	*Numbers*	*Function*
Central incisor		
First premolar		

3. When Dr. Cheng examined Sini's teeth:
   a. What part of the teeth would be visible?

      (A) Crown (B) Root (C) Dentine (D) Pulp cavity

   b. What structures would not be visible?

      (A) Crown (B) Root (C) Enamel (D) Pulp cavity

   c. Which of Sini's teeth were affected? (See Dr. Cheng's notes.) Name them and the bone (maxilla or mandible) they are associated with.

   d. Dr. Cheng mentioned lesions and cavities. What are the differences between the two?

   e. Which areas of Sini's teeth were affected?

4. Why are mandibular teeth more likely than maxillary teeth to experience decay?

5. In what tooth layer did Sini's cavities originate? As decay progresses, in what order will other tooth layers be affected?

6. Why would Sini report pain when teeth 17–19 and 31–29 were palpated and cold tested but not the others with lesions? (See Dr. Cheng's notes.)

7. Dr. Cheng conducted a periodontal examination; what would be the purpose of this examination? What structures are examined? What dental conditions can be identified with a periodontal examination?

8. Dr. Cheng examined the salivary glands and saliva. What is the role of saliva in maintaining dental health?

9. If Sini's teeth were loose, what main structure(s) would be affected?

Part II – Her Story

Dr. Cheng explained that the lesions and cavities found in Sini's lower jaw could be filled that same day to prevent them from getting worse. Sini took a deep breath, reminding herself that it was better to take care of it now than to have a more painful issue later. She nodded, agreeing to the quick procedure.

As she waited for the assistant to prepare the materials, Dr. Cheng empathetically asked her about her eating habits and oral hygiene routine. Sini explained that during college, she developed a habit of drinking sweetened, caffeinated beverages to stay awake while studying. For all four years of college, she had been consuming one to two liters of soda daily and typically brushed her teeth only once in the morning. Over the last two years, this habit continued.

Sini added that she also enjoyed holding the soda in her mouth for several seconds to feel the bubbles tingle before swallowing. She reported nothing unusual in her diet or medical history, nor did she have a family history of dental issues. She also denied experiencing symptoms like gastroesophageal reflux, xerostomia, or bruxism. The tooth pain began a month ago when she drank coffee or ate something cold like ice cream. However, during the past week she had been deliberately chewing slowly and carefully when eating to avoid pain.

Questions

1. Dr. Cheng asked Sini a number of questions during her exam. Give a brief explanation of how each of these factors could affect Sini's oral health.
   a. Eating habits and oral care:

   b. Gastroesophageal reflux:

   c. Xerostomia:

   d. Bruxism:

2. What is the likely cause behind the lesions and cavities in Sini's teeth?

Part III – Demineralization and Remineralization

Dr. Cheng noticed that Sini was genuinely curious about what was happening to her teeth. He asked Sini if she recalled any of her chemistry course; she nodded in affirmation. He told her that most sodas contain phosphoric acid and carbonic acid, both of which lower the pH and create a highly acidic environment in the mouth. When soda comes into contact with enamel, these acids begin dissolving the tooth's mineral structure through a process known as demineralization.

Enamel, he explained, is primarily made of hydroxyapatite ($Ca_5(PO_4)_3(OH)$). The hydrogen ions (H^+) from the acids attack this mineral, breaking it down into soluble calcium and phosphate ions.

In addition, he explained that if the soda also contains sugar, the situation becomes worse. Bacteria such as *Streptococcus mutans* ferment the sugars and create additional acids, including lactic acid, which drive the pH even lower and speed up the demineralization process. Over time, repeated exposure to these acids causes enamel to lose minerals faster than saliva can replace them. This leads to enamel erosion, increased tooth sensitivity, and a higher risk of cavities.

Dr. Cheng looked at Sini, and as he wrote out the simplified reaction, he asked her if she could complete it.

Question

1. Help Sini complete the reaction below, and don't forget to balance the reaction.

   $Ca_5(PO_4)_3(OH) + 4H^+ \text{ ----> }$

"Based on this reaction, can you see how effective soda is at weakening tooth enamel from a chemistry standpoint?" Dr. Cheng stated.

"But isn't there fluoride in water?" Sini asked. "How does that help my teeth if acids are breaking them down?"

Dr. Cheng smiled and explained that fluoride protects teeth through another chemical reaction; one that strengthens enamel instead of weakening it. He wrote down the next reaction and asked her to complete it.

Question

2. Help Sini complete the reaction below, and don't forget to balance the reaction.

   $Ca_5(PO_4)_3(OH) + F^- \text{ ----> }$

"You see, the more you keep your teeth clean with fluoride, the better your teeth are protected," added Dr. Chen, nodding with approval at Sini's response.

Part IV – Pain

Sini previously mentioned that her tooth pain began a month ago when she drank coffee or ate something cold like ice cream.

Questions

1. Where in Sini's teeth would pain be detected?

2. The next set of questions concerns how the pain would be detected in Sini's teeth and how that information would be taken to the brain. Answer the following:
   a. Which pathway, the ascending or descending pathway, would carry tooth pain information to the brain?

   b. How many neurons would typically be in this pathway?

   c. Would the information stay on the same side of the brain as the tooth?

   d. Where would crossing over occur? Which lobe of the brain would the information go to?

   e. On Figure 2 below, draw in and label the neurons and their branches using the following terms:
      - First-order neuron
        - trigeminal nerve, CN V
        - maxillary branch, CN V2
        - mandibular branch CN V3
      - Second-order neuron (trigeminothalamic tract)
      - Third-order neuron

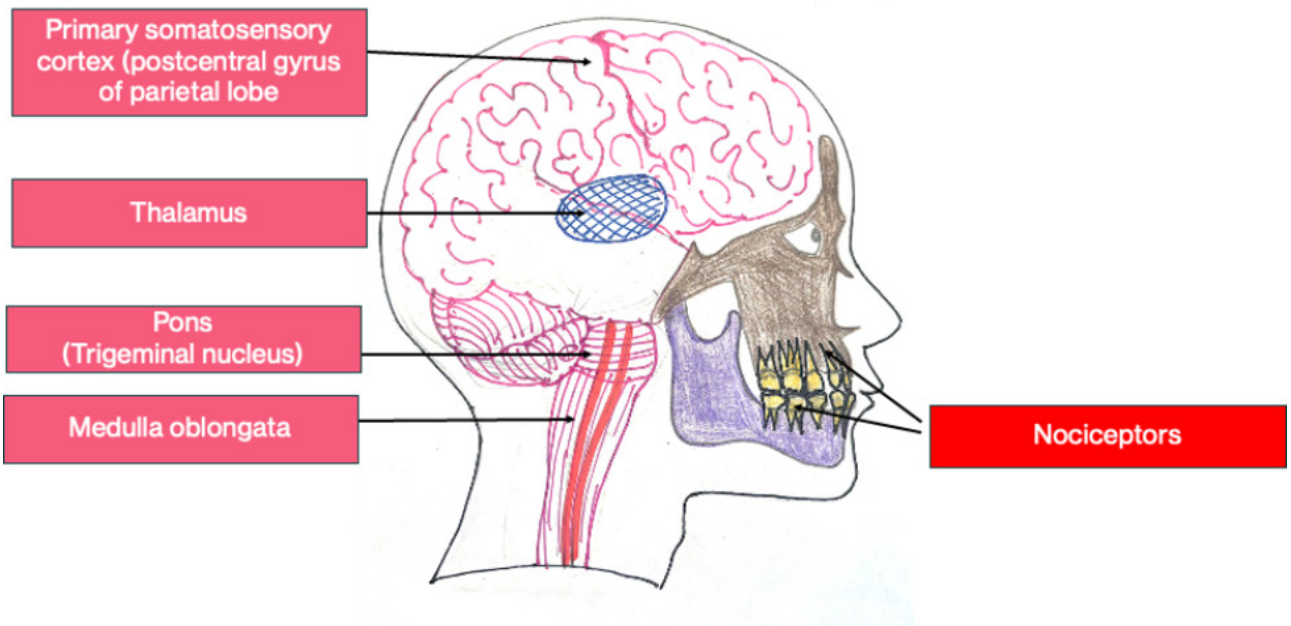


Figure 2. The trigeminal sensory pathway.

3. Given that Sini felt pain in and around the tooth, causing her to chew delicately, what pathways would be responsible for affecting the chewing muscles? Answer the following:
   a. Would this involve an ascending or descending pathway? Name the tract.

   b. How many neurons would make up the descending pathway? Label Figure 3 below with these neurons.

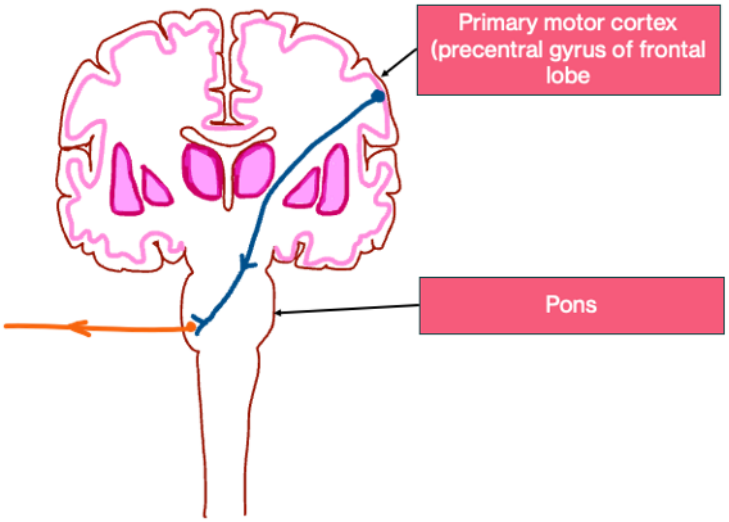


Figure 3. The trigeminal motor pathway.

   c. Would the information stay on the same side of the brain as the effector? If not, where would crossing-over occur?

   d. What are the effectors in this pathway? Name the muscles.

Part V – Fluoridation

Noting Sini's anxiety, Dr. Cheng reassured her, explaining each step of the procedure before proceding. He applied a numbing gel, and after a few moments, he gently injected the anesthetic, assuring Sini that she'd feel only a pinch. True to his word, the numbness set in quickly, and soon her mouth felt strange but comfortable.

The actual filling process went faster than she'd expected. Dr. Cheng worked with steady hands, and Sini found herself feeling almost relaxed as he explained what he was doing, making her feel involved rather than just a passive patient. Soon, he was done, and the assistant helped her rinse out her mouth.

"All finished!" Dr. Cheng said cheerfully. "You did great, Sini. Just keep up with brushing and flossing twice a day, and you'll be all set."

As Sini walked out, she realized that the experience wasn't as scary as she'd imagined. She felt a mixture of relief and pride; she'd faced her fear and taken care of her health in the process. As a reward she went shopping for something for her dad, and a little something for herself.

Question

1. Leaving the office, Sini's thoughts drifted to what she'd just learned. She began to wonder how fluoride gets into drinking water, how much fluoride is needed to help prevent tooth decay, and what happens when too much of it is used. Can you assist Sini with these answers supported with credible sources?