NeuroTrace Academy Study Guide

Domain: Domain II – Performing the EEG Study
Section: Complete Electrode Placement Guide: Standard & Exotic Electrodes
Style: Comprehensive, measurement-based, clinical application, exam-oriented

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1. Core Principles (Must Know)

Standard 10-20 System Is the Foundation

- **10-20 system:** International standard for routine EEG
- **21 standard electrodes:** Fp1, Fp2, F3, F4, F7, F8, Fz, C3, C4, Cz, P3, P4, Pz, T3, T4, T5, T6, O1, O2, Oz, plus ground/reference
- **Based on percentages:** 10% and 20% of head measurements
- **Reproducible:** Consistent placement across patients and studies

Extended Systems for Specialized Applications

- **10-10 system:** Extended system with more electrodes (additional 10% positions)
- **Exotic electrodes:** Additional electrodes for specific clinical needs
- **Invasive electrodes:** For presurgical evaluation (sphenoidal, nasopharyngeal, depth, subdural)

Key Principle

Electrode selection depends on clinical indication

- Routine EEG: Standard 10-20 system
- Temporal lobe epilepsy: Add T1, T2, or sphenoidal electrodes
- Presurgical evaluation: May require invasive electrodes
- Research: May use extended 10-10 system

Practical Application

- Know standard 10-20 system thoroughly
- Understand when to add exotic electrodes
- Know placement techniques for all electrode types
- Understand clinical indications for each

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2. Standard 10-20 System (Review)

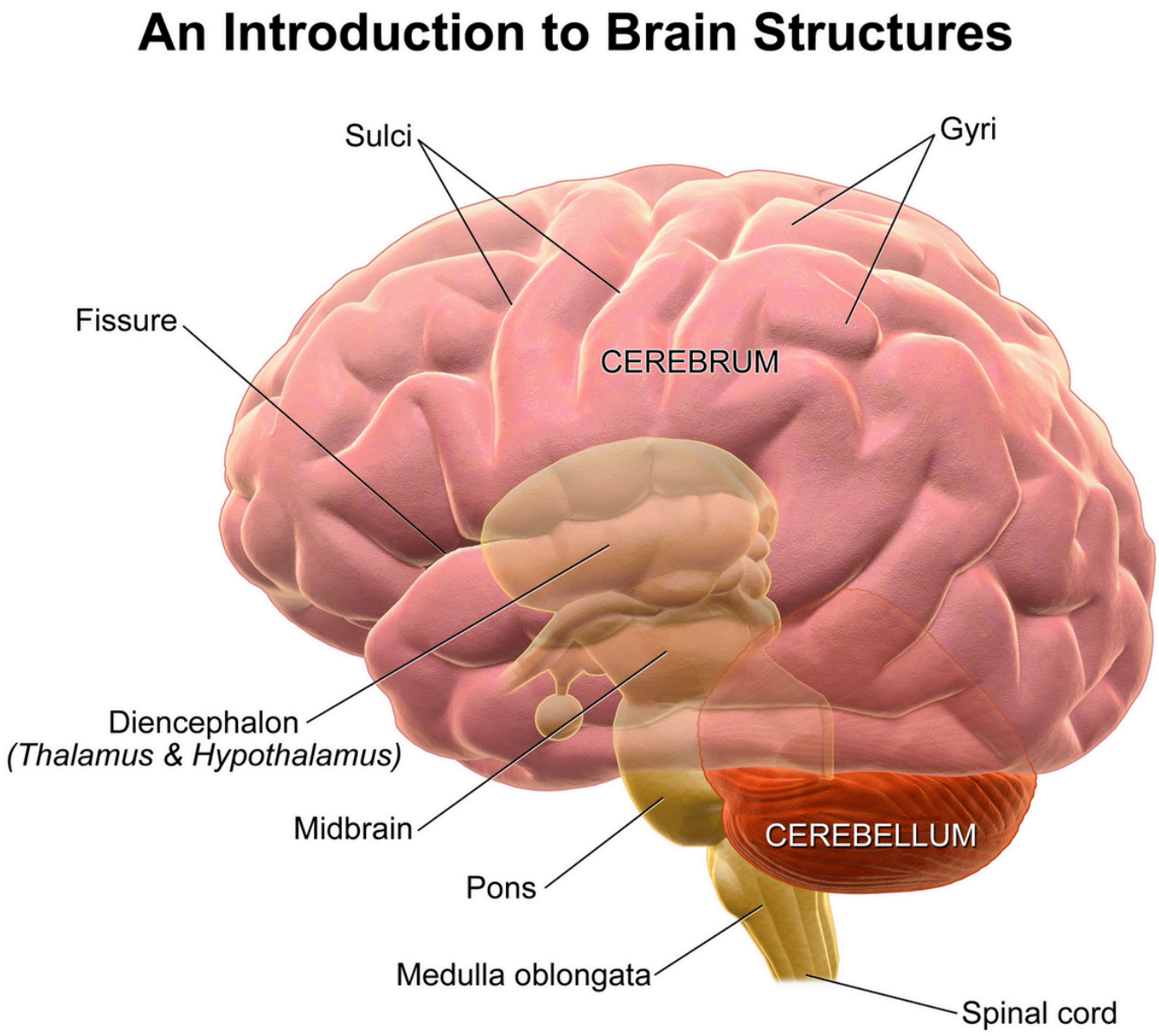

Figure 1: Lateral view of the brain showing the relationship between brain anatomy and EEG electrode placement. The precentral gyrus (motor cortex, red) corresponds to C3/C4 electrodes. The postcentral gyrus (sensory cortex, blue) also corresponds to C3/C4. Frontal electrodes (Fp1, F3, F7) overlie the frontal lobe, temporal electrodes (T3, T5) overlie the temporal lobe, and occipital electrodes (O1, O2) overlie the occipital lobe.

Standard Electrode Set (21 Electrodes)

Frontal:

- Fp1, Fp2: Frontal poles (10% above nasion)
- F3, F4: Frontal regions (20% from midline)
- F7, F8: Anterior temporal/frontal (10% above Fp, at temporal line)
- Fz: Frontal midline

Central:

- C3, C4: Central regions (20% from midline)

- Cz: Central midline (vertex)

Parietal:

- P3, P4: Parietal regions (20% from midline)
- Pz: Parietal midline

Temporal:

- T3, T4: Mid-temporal (at temporal line)
- T5, T6: Posterior temporal

Occipital:

- O1, O2: Occipital regions (10% above inion, 20% from midline)
- Oz: Occipital midline

Reference:

- A1: Left ear (mastoid or earlobe)
- A2: Right ear (mastoid or earlobe)

Ground:

- G: Ground electrode (typically Fpz or separate site)

Naming Conventions

- **Letters:** F=Frontal, T=Temporal, C=Central, P=Parietal, O=Occipital
- **Numbers:** Odd=Left, Even=Right
- **"z":** Midline electrodes (Fz, Cz, Pz, Oz)

Measurement Reference Points

1. **Nasion:** Indentation at top of nose (between eyebrows)
2. **Inion:** Most prominent point of occipital bone
3. **Preauricular points:** Indentations anterior to tragus of each ear
4. **Cz (Vertex):** Midpoint of nasion-inion and preauricular lines

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3. Extended 10-10 System

Additional Electrode Positions

10-10 system adds electrodes at 10% intervals between standard 20% positions:

Additional Frontal:

- AF3, AF4, AF7, AF8, AFz: Anterior frontal positions
- FC1, FC2, FC3, FC4, FC5, FC6, FCz: Frontal-central positions

Additional Central:

- C1, C2, C5, C6: Additional central positions

Additional Parietal:

- CP1, CP2, CP3, CP4, CP5, CP6, CPz: Central-parietal positions
- P1, P2, P5, P6, P9, P10: Additional parietal positions

Additional Temporal:

- FT7, FT8, FT9, FT10: Frontal-temporal positions
- TP7, TP8, TP9, TP10: Temporal-parietal positions

Additional Occipital:

- PO3, PO4, PO7, PO8, POz: Parietal-occipital positions

Clinical Use

- **Research:** High-density EEG studies
- **Source localization:** More electrodes improve spatial resolution
- **Presurgical evaluation:** Better localization of epileptogenic zones
- **Not routine:** Typically used in specialized settings

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4. Exotic Electrodes: T1 and T2

T1 and T2 Electrodes

Location:

- **T1:** Left inferior temporal (1 cm above left ear canal, 1/3 distance from T3 to external auditory meatus)
- **T2:** Right inferior temporal (1 cm above right ear canal, 1/3 distance from T4 to external auditory meatus)

Placement Technique:

1. Locate T3 (T7) or T4 (T8) position
2. Locate external auditory meatus (ear canal)
3. Place electrode 1/3 of distance from T3/T4 toward ear canal
4. Approximately 1 cm above ear canal

Clinical Indication:

- **Temporal lobe epilepsy:** Better detection of mesial temporal activity
- **Presurgical evaluation:** Improved localization of temporal foci
- **When standard T3/T4 miss activity:** Add T1/T2 for better coverage

Advantages:

- Closer to temporal lobe than T3/T4
- Better detection of mesial temporal activity
- Non-invasive (surface electrode)
- Easy to apply

Disadvantages:

- May pick up more muscle artifact (near temporalis muscle)
- May pick up more EKG artifact
- Not as sensitive as sphenoidal electrodes

ABRET Exam Focus:

- T1/T2 are inferior temporal electrodes
- Used for temporal lobe epilepsy
- Placement: 1/3 distance from T3/T4 to ear canal

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5. Exotic Electrodes: F9 and F10

F9 and F10 Electrodes

Location:

- **F9:** Left inferior frontal (below F7, near left temple)
- **F10:** Right inferior frontal (below F8, near right temple)

Placement Technique:

1. Locate F7 (left) or F8 (right) position
2. Place electrode inferior (below) F7/F8
3. Approximately at level of zygomatic arch
4. Near temple region

Clinical Indication:

- **Frontal lobe epilepsy:** Better detection of inferior frontal activity
- **Orbitofrontal seizures:** Improved coverage of orbitofrontal cortex
- **When standard F7/F8 miss activity:** Add F9/F10 for better coverage

Advantages:

- Closer to inferior frontal cortex
- Better detection of orbitofrontal activity
- Non-invasive (surface electrode)

Disadvantages:

- May pick up more muscle artifact (temporalis, masseter)
- May pick up more eye movement artifact
- Less commonly used than T1/T2

ABRET Exam Focus:

- F9/F10 are inferior frontal electrodes
- Used for frontal lobe epilepsy, especially orbitofrontal
- Placement: Below F7/F8, near temple

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6. Exotic Electrodes: P9 and P10

P9 and P10 Electrodes

Location:

- **P9:** Left inferior parietal (posterior to T5, near left mastoid)
- **P10:** Right inferior parietal (posterior to T6, near right mastoid)

Placement Technique:

1. Locate T5 (left) or T6 (right) position
2. Place electrode posterior and inferior to T5/T6
3. Near mastoid region
4. Posterior temporal/inferior parietal location

Clinical Indication:

- **Posterior temporal/parietal epilepsy:** Better detection of inferior parietal activity
- **Presurgical evaluation:** Improved coverage of posterior regions

- **Less commonly used:** Not as common as T1/T2 or F9/F10

Advantages:

- Better coverage of inferior parietal cortex
- Non-invasive (surface electrode)

Disadvantages:

- Less commonly needed
- May pick up more muscle artifact
- Less sensitive than specialized electrodes

ABRET Exam Focus:

- P9/P10 are inferior parietal electrodes
- Used for posterior temporal/parietal epilepsy
- Placement: Posterior and inferior to T5/T6

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7. Sphenoidal Electrodes (Sp1, Sp2)

Sphenoidal Electrodes

Location:

- **Sp1:** Left sphenoidal (inserted through cheek, near foramen ovale)
- **Sp2:** Right sphenoidal (inserted through cheek, near foramen ovale)

Placement Technique:

1. **Insertion site:** Through cheek, anterior to mandibular condyle
2. **Depth:** Advanced to near foramen ovale (medial to mandible)
3. **Method:** Needle electrode inserted percutaneously
4. **Position:** Near mesial temporal structures

Clinical Indication:

- **Temporal lobe epilepsy:** Gold standard for mesial temporal detection
- **Presurgical evaluation:** Essential for temporal lobe epilepsy surgery
- **When surface electrodes miss activity:** Sphenoidal electrodes are more sensitive

Advantages:

- **Most sensitive for mesial temporal activity**
- Closer to hippocampus and amygdala
- Better detection of temporal lobe seizures
- Gold standard for temporal lobe epilepsy

Disadvantages:

- **Invasive:** Requires needle insertion
- **Discomfort:** Patient may experience pain or discomfort
- **Risk:** Small risk of infection, bleeding
- **Not routine:** Only for specialized evaluations

Placement Details:

- Inserted through cheek (percutaneous)
- Advanced to near foramen ovale

- Positioned medial to mandible
- Near mesial temporal structures

ABRET Exam Focus:

- Sphenoidal electrodes are invasive
- Used for temporal lobe epilepsy (presurgical evaluation)
- Most sensitive for mesial temporal activity
- Inserted through cheek, near foramen ovale

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8. Nasopharyngeal Electrodes (NP1, NP2)

Nasopharyngeal Electrodes

Location:

- **NP1:** Left nasopharyngeal (inserted through nostril, advanced to nasopharynx)
- **NP2:** Right nasopharyngeal (inserted through nostril, advanced to nasopharynx)

Placement Technique:

1. **Insertion:** Through nostril, advanced to nasopharynx
2. **Depth:** Advanced until tip is in nasopharynx (behind soft palate)
3. **Method:** Flexible wire electrode with tip
4. **Position:** Near mesial temporal structures (via nasopharynx)

Clinical Indication:

- **Temporal lobe epilepsy:** Alternative to sphenoidal electrodes
- **Presurgical evaluation:** When sphenoidal not available or contraindicated
- **Less invasive than sphenoidal:** But less sensitive

Advantages:

- Less invasive than sphenoidal
- Better than surface electrodes for mesial temporal activity
- Can be used when sphenoidal contraindicated

Disadvantages:

- **Less sensitive than sphenoidal:** Not as close to mesial temporal structures
- **Discomfort:** Patient may experience nasal discomfort
- **Artifact:** May pick up swallowing, respiratory artifact
- **Less commonly used:** Sphenoidal preferred when possible

Placement Details:

- Inserted through nostril
- Advanced to nasopharynx (behind soft palate)
- Flexible wire electrode
- Near mesial temporal structures

ABRET Exam Focus:

- Nasopharyngeal electrodes are less invasive than sphenoidal
- Used for temporal lobe epilepsy
- Inserted through nostril to nasopharynx

- Less sensitive than sphenoidal but better than surface

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9. Additional Specialized Electrodes

EOG (Electrooculogram) Electrodes

Location:

- **EOG1:** Above left eye (for vertical eye movements)
- **EOG2:** Below left eye (for vertical eye movements)
- **EOG3:** Lateral to left eye (for horizontal eye movements)
- **EOG4:** Lateral to right eye (for horizontal eye movements)

Purpose:

- Detect eye movements
- Distinguish eye movement artifact from brain activity
- Monitor eye movements during sleep studies

EMG (Electromyogram) Electrodes

Location:

- **Chin EMG:** Under chin (for muscle tone during sleep)
- **Limb EMG:** On limbs (for movement detection)

Purpose:

- Monitor muscle activity
- Detect movements during sleep
- Distinguish muscle artifact from brain activity

EKG (Electrocardiogram) Electrodes

Location:

- **EKG:** On chest or limb (for heart rate monitoring)

Purpose:

- Monitor heart rate
- Detect EKG artifact in EEG
- Essential for long-term monitoring

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10. Clinical Indications Summary

When to Use Standard 10-20 System

- **Routine EEG:** Standard evaluation
- **Initial seizure evaluation:** First-line assessment
- **Follow-up studies:** Comparison with previous studies
- **Most clinical indications:** Standard system is sufficient

When to Add T1/T2

- **Temporal lobe epilepsy:** Suspected or confirmed
- **Mesial temporal activity suspected:** When T3/T4 miss activity

- **Presurgical evaluation:** Before temporal lobe surgery
- **Refractory temporal seizures:** When standard electrodes insufficient

When to Add F9/F10

- **Frontal lobe epilepsy:** Suspected or confirmed
- **Orbitofrontal seizures:** Suspected inferior frontal activity
- **When F7/F8 miss activity:** Add for better coverage

When to Use Sphenoidal Electrodes

- **Temporal lobe epilepsy (presurgical):** Essential for surgery planning
- **Refractory temporal seizures:** When surface electrodes insufficient
- **Mesial temporal sclerosis:** Suspected or confirmed
- **Presurgical evaluation:** Before temporal lobe resection

When to Use Nasopharyngeal Electrodes

- **Temporal lobe epilepsy:** When sphenoidal contraindicated
- **Alternative to sphenoidal:** When sphenoidal not available
- **Less invasive option:** For patients who cannot tolerate sphenoidal

When to Use Extended 10-10 System

- **Research studies:** High-density EEG
- **Source localization:** Precise localization needed
- **Presurgical evaluation:** Advanced cases
- **Not routine:** Specialized applications only

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11. Placement Techniques

Standard 10-20 System Placement

1. **Measure head:**
    - Nasion to inion (sagittal)
    - Left to right preauricular (coronal)
    - Head circumference
2. **Calculate positions:**
    - Use 10% and 20% increments
    - Mark electrode positions
3. **Apply electrodes:**
    - Prepare skin (abrade if needed)
    - Apply conductive paste/gel
    - Secure electrodes
    - Check impedance (<5 kΩ, ideally <2 kΩ)

T1/T2 Placement

1. **Locate T3 (T7) or T4 (T8):** Standard mid-temporal position
2. **Locate external auditory meatus:** Ear canal opening
3. **Measure distance:** From T3/T4 to ear canal
4. **Place electrode:** 1/3 distance from T3/T4 toward ear canal

5. **Verify:** Approximately 1 cm above ear canal

F9/F10 Placement

1. **Locate F7 (left) or F8 (right):** Standard anterior temporal/frontal position
2. **Place electrode:** Inferior (below) F7/F8
3. **Position:** Near zygomatic arch, temple region
4. **Verify:** Below F7/F8, near temple

P9/P10 Placement

1. **Locate T5 (left) or T6 (right):** Standard posterior temporal position
2. **Place electrode:** Posterior and inferior to T5/T6
3. **Position:** Near mastoid region
4. **Verify:** Posterior temporal/inferior parietal location

Sphenoidal Electrode Placement

1. **Identify insertion site:** Through cheek, anterior to mandibular condyle
2. **Insert needle:** Percutaneous insertion through cheek
3. **Advance electrode:** To near foramen ovale (medial to mandible)
4. **Verify position:** Near mesial temporal structures
5. **Secure:** Tape or secure externally
6. **Monitor:** Check for complications (bleeding, infection)

Note: Sphenoidal placement requires specialized training and is typically performed by physicians or specially trained technologists.

Nasopharyngeal Electrode Placement

1. **Prepare electrode:** Flexible wire with tip
2. **Insert through nostril:** Gently advance through nasal passage
3. **Advance to nasopharynx:** Behind soft palate
4. **Verify position:** Tip in nasopharynx
5. **Secure:** Tape to nose/face externally
6. **Monitor:** Check for discomfort, displacement

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12. Artifact Considerations

T1/T2 Artifacts

- **Muscle artifact:** Temporalis muscle (near electrode)
- **EKG artifact:** Heart activity may be detected
- **Movement artifact:** Jaw movements

Mitigation:

- Proper placement (away from muscle)
- Patient instruction (relax jaw)
- Filtering if necessary

F9/F10 Artifacts

- **Muscle artifact:** Temporalis, masseter muscles
- **Eye movement artifact:** Blinks, eye movements
- **Jaw movement artifact:** Talking, chewing

Mitigation:

- Proper placement
- Patient instruction
- Filtering if necessary

Sphenoidal Artifacts

- **Muscle artifact:** Less than surface electrodes
- **Movement artifact:** Jaw movements may affect
- **Swallowing artifact:** May be detected

Mitigation:

- Proper placement
- Patient instruction
- Less artifact than surface electrodes

Nasopharyngeal Artifacts

- **Swallowing artifact:** Common
- **Respiratory artifact:** Breathing may affect
- **Movement artifact:** Head movements

Mitigation:

- Proper placement
- Patient instruction
- Secure placement

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13. ABRET Exam High-Yield Topics

Must-Know Facts

1. **T1/T2:** Inferior temporal electrodes, 1/3 distance from T3/T4 to ear canal
2. **F9/F10:** Inferior frontal electrodes, below F7/F8
3. **P9/P10:** Inferior parietal electrodes, posterior to T5/T6
4. **Sphenoidal:** Invasive, through cheek, near foramen ovale, most sensitive for mesial temporal
5. **Nasopharyngeal:** Less invasive, through nostril, less sensitive than sphenoidal
6. **Clinical indications:** Know when to use each electrode type

Common Exam Questions

Question Type 1: Electrode Location

- "T1 electrode is placed..."
- Answer: 1/3 distance from T3 to ear canal, inferior temporal

Question Type 2: Clinical Indication

- "Sphenoidal electrodes are used for..."
- Answer: Temporal lobe epilepsy, presurgical evaluation, mesial temporal activity

Question Type 3: Sensitivity

- "Which electrode is most sensitive for mesial temporal activity?"
- Answer: Sphenoidal electrodes

Question Type 4: Invasiveness

- "Which is less invasive: sphenoidal or nasopharyngeal?"

- Answer: Nasopharyngeal (but less sensitive)

Question Type 5: Placement Technique

- "F9 electrode is placed..."
- Answer: Below F7, near temple, inferior frontal

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14. Comparison Table

Electrode	Location	Invasiveness	Sensitivity (Temporal)	Clinical Use
T3/T4	Mid-temporal	Non-invasive	Low-Moderate	Standard, routine
T1/T2	Inferior temporal	Non-invasive	Moderate	Temporal epilepsy
F7/F8	Anterior temporal/frontal	Non-invasive	Low-Moderate	Standard, routine
F9/F10	Inferior frontal	Non-invasive	Moderate	Frontal epilepsy
Sphenoidal	Near foramen ovale	Invasive	**Highest**	Presurgical, temporal
Nasopharyngeal	Nasopharynx	Less invasive	Moderate-High	Alternative to sphenoidal

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15. Exam Readiness Checklist

Use this checklist to verify your understanding:

- [ ] Know standard 10-20 system (all 21 electrodes)
- [ ] Understand extended 10-10 system (additional positions)
- [ ] Know T1/T2 placement (1/3 distance from T3/T4 to ear canal)
- [ ] Know F9/F10 placement (below F7/F8, near temple)
- [ ] Know P9/P10 placement (posterior to T5/T6)
- [ ] Understand sphenoidal electrodes (invasive, through cheek, near foramen ovale)
- [ ] Understand nasopharyngeal electrodes (through nostril, less invasive)
- [ ] Know clinical indications for each electrode type
- [ ] Understand sensitivity differences (sphenoidal > nasopharyngeal > T1/T2 > T3/T4)
- [ ] Know artifact considerations for each electrode type
- [ ] Understand when to use exotic electrodes vs standard system

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16. Study Tips

1. **Memorize standard 10-20 system first:** Foundation for all electrode placement
2. **Learn exotic electrode locations:** T1/T2, F9/F10, P9/P10 placement techniques
3. **Understand invasiveness:** Sphenoidal (invasive) vs nasopharyngeal (less invasive) vs surface (non-invasive)
4. **Know sensitivity:** Sphenoidal > nasopharyngeal > T1/T2 > T3/T4 for temporal activity
5. **Learn clinical indications:** When to use each electrode type
6. **Understand placement techniques:** Measurement methods for each electrode
7. **Know artifacts:** Common artifacts for each electrode type
8. **ABRET focus:** Expect questions on T1/T2, sphenoidal, nasopharyngeal, and clinical indications

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17. Internal Cross-Links

Workflow

- **Electrode Application & 10-20 System:** Standard placement techniques
- **Electrodes & Impedance:** Electrode types and materials
- **Montages & Referencing:** How electrodes are connected

Patterns

- **Epileptiform Discharges:** Localization using exotic electrodes
- **Temporal Lobe Epilepsy:** When to use T1/T2, sphenoidal, nasopharyngeal

Cases

- **Temporal lobe epilepsy cases:** Requiring exotic electrodes
- **Presurgical evaluation cases:** Using sphenoidal or nasopharyngeal electrodes

Quizzes

- **Electrode placement MCQs:** Questions on standard and exotic electrodes
- **Temporal lobe epilepsy questions:** Questions on electrode selection
- **Presurgical evaluation questions:** Questions on invasive electrodes

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End of Study Guide

For additional practice, complete quiz questions tagged: electrode-placement, 10-20, exotic-electrodes, T1-T2, sphenoidal, nasopharyngeal, temporal-epilepsy