



CODE

GQ-TSR: Guarded Query Teacher-Student Retrieval for CBCT-to-Clinical Record Prediction

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CHALLENGE

Method Overview

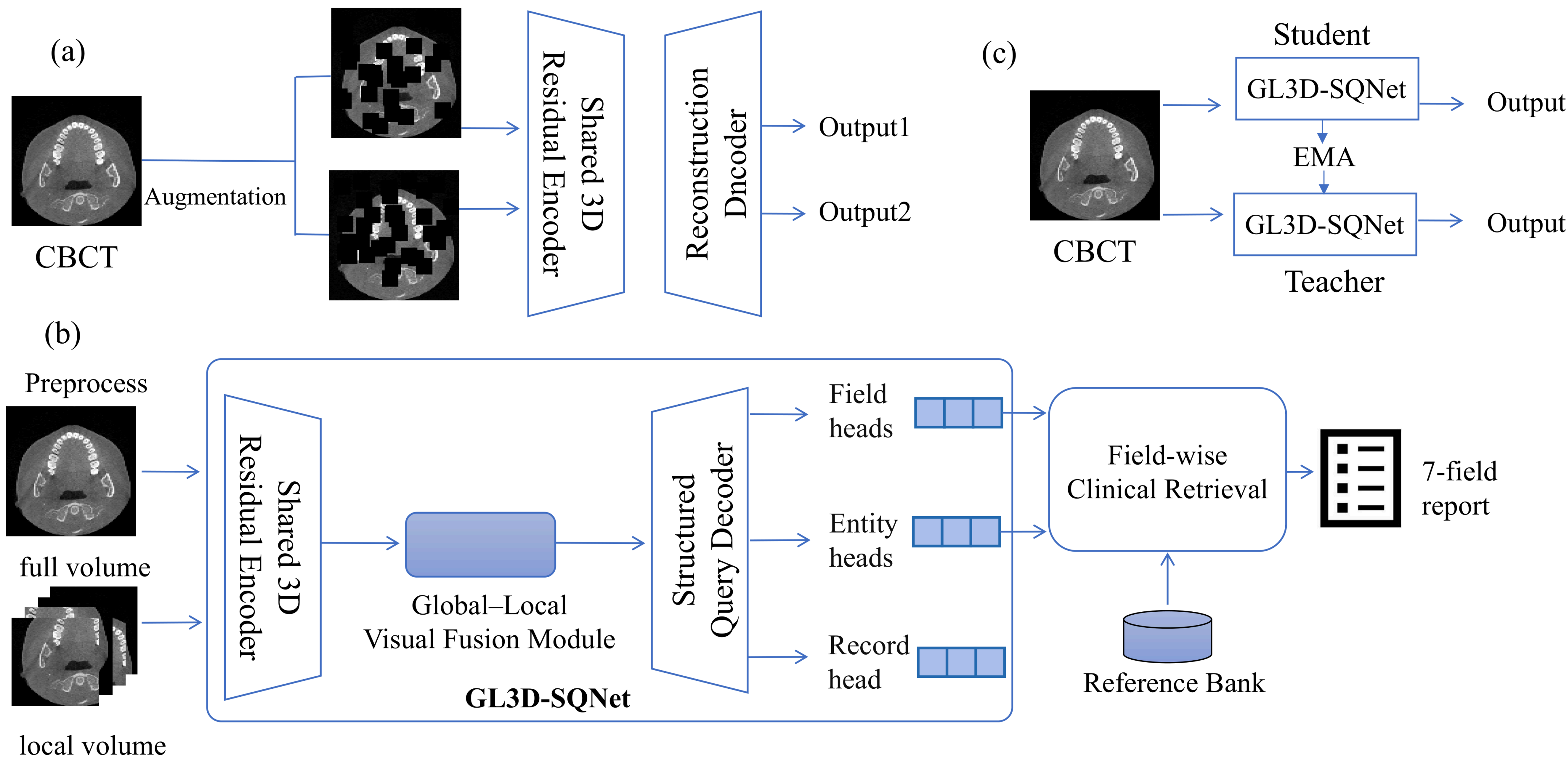


Fig. 1. GQ-TSR. (a) Masked-volume pre-training initialises the shared 3D encoder from all training CBCT, labeled and unlabeled. (b) GL3D-SQNet fuses the full volume with overlapping local views; structured queries emit field, entity and record representations, which are matched against a fixed Reference Bank by field-wise retrieval. (c) A homogeneous student and EMA teacher share GL3D-SQNet and learn from unpaired scans under a model guard.

Clinical Problem

A dental record contains **seven fields**: main appeal, present medical history, oral check, diagnosis, treatment plan, handle and doctor advices. GQ-TSR predicts all seven **from a CBCT volume alone**.

- **Supervision is scarce.** 50 paired CBCT-record cases against 200 unpaired volumes.
- **Fields are only partly observable.** Complaint, history and treatment choice are not determined by the image.
- **Free generation is unreliable.** At this data scale it overfits and states findings the scan does not support.

Method — GQ-TSR

- Image-only pre-training.** Two masked, augmented views of every training volume drive a foreground-weighted reconstruction loss and a stop-gradient view-consistency loss. Only the shared 3D encoder is transferred.
- Supervised GL3D-SQNet.** The full volume and up to four local crops are fused into a visual memory that record, field and entity queries read. Heads are aligned to TF-IDF/SVD text targets by cosine loss, with entity BCE and count CE.
- Guarded teacher-student.** An EMA teacher takes a weak view and the student a strong view; field and record embeddings are matched by a consistency loss. Entity pseudo-labels are kept only outside an uncertainty interval, and offline targets require cross-model agreement.

Field-wise Clinical Retrieval

- Each field queries a **fixed Reference Bank** built from the labeled records of its own fold. No unpaired scan enters the bank.
- **Hubness correction** subtracts a reference's mean similarity to its nearest queries from the semantic cosine score.
- **Soft entity agreement**, a Dice-style overlap between predicted and reference entity families, reranks candidates per field.
- **Exact-text voting** over the 5 folds selects the final text. Every output stays traceable to a labeled record.

Training Protocol

COMPONENT	SETTING
Input & local views	96×160×160 volume; up to four 64×112×112 crops
Visual network	3D ResNet-34; width 512; 2 visual + 4 query layers
Text targets	Character TF-IDF (2–5 grams), truncated SVD, 64-d
Pre-training	20,000 steps; mask ratio 0.45; AdamW; peak LR 2×10^{-4}
Fold protocol	5 folds; $\leq 1,000$ supervised + 1,000 joint steps per fold
Optimisation	LR $1/5 \times 10^{-5}$ supervised, $2 \times 10^{-6}/1 \times 10^{-5}$ joint; AMP; grad clip 1.0
EMA & model size	Momentum 0.990 $\rightarrow$ 0.9995; 39.96 M parameters per branch

Results — STS 2026 Public Validation (50 cases)

0.26

Weighted Score

1.00Field completion
(references: 0.90)**0**

Missing predictions

STRUCTURED CLINICAL METRIC	PRECISION	RECALL	F1 / MATCH
Tooth notation	0.09	0.70	0.15
Diagnosis code	0.05	0.12	0.07
Treatment action	0.27	0.47	0.32
Medication	0.64	0.64	0.64
Diagnosis exact / partial	–	–	0.00 / 0.12
Treatment plan recall	–	0.53	–

Text metrics. BLEU-1 0.13 · BLEU-2 0.04 · BLEU-3 0.02 · BLEU-4 0.01 · METEOR 0.18 · ROUGE-L 0.17 · CIDER 0.04. The clinical metrics show a recall bias: tooth notation reaches 0.70 recall at 0.09 precision, and exact diagnosis match is 0.00.

Qualitative Prediction



Field	Model inference text
Main appeal	Biting discomfort on the right back tooth for several weeks
Present medical history	The patient had a dental implant today and had preoperative scaling before coming to our hospital for treatment.
Oral Check	There are deep and large caries holes in the crown. When probing and percussing, the teeth are not loose. The teeth are sensitive and painful to cold stimulation. ...
Diagnosis	Acute pulpitis Impacted tooth Dental caries
Treatment plan	It is recommended to remove the restoration and perform root canal retreatment and crown restoration. Filling treatment. removal.
Handle	The patient was informed of the plan and agreed. The patient chose ITI pure titanium implants and made an appointment for surgery.
Doctor advices	Follow-up for discomfort.

Fig. 2. Public validation case 19. Top: axial, coronal and sagittal CBCT views. Bottom: the seven fields inferred by GQ-TSR. Ground truth is not shown because the public validation records are hidden.

Conclusion & Limitations

GQ-TSR produces complete seven-field records from CBCT alone, and every field remains traceable to a labeled record. Unpaired scans are used only when the guard confirms that they help.

- The closed reference bank cannot express an unseen diagnosis or treatment, and independent field selection may combine statements from different patients.
- Without tooth or lesion annotation, spatial grounding stays weak; tooth-notation precision is 0.09.
- The 0.64 medication F1 is optimistic, since many medication fields are empty; on non-empty references it is 0.00.

Future work. Case-level retrieval, structured tooth supervision and compact medical text representations, under the same data isolation and model guard.