

Comparative study on the apical sealing ability according to the obturation techniques

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국문초록

근관충전방법에 따른 치근단부 폐쇄능에 대한 비교연구

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3차원적으로 잘 충전된 근관은 치근단 누출과 재감염을 방지하며, 조직이 잘 치유될 수 있는 생물학적 환경을 제공해 준다. 이 때문에 근관계의 완전한 충전은 근관치료의 중요한 목표 중의 하나이다. 본 연구의 목적은 4가지 방법으로 근관충전 후 디지털 방사선 사진을 촬영하여 근관충전의 질을 평가하고 투명표본을 제작하여 색소침투범위를 측정함으로써, 근관충전방법에 따른 치근단부 폐쇄능을 비교 평가하고자 하는 것이다.

직선형의 단근관을 갖는 80개의 전치를 선택하여 ProFile* 니켈-티타늄 회전식 기구를 사용하여 근관을 성형한 후, 무작위로 20개씩 4군으로 나누었다. 사용된 근관충전법은 다음과 같다: MicroSeal™(Group A), Thermafil*(Group B), Continuous wave 충전법(Group C), 측방가압충전법(Group D). 각 군에서 10개 치아는 Sealapex를, 나머지 10개 치아는 AH26*을 충전용 시멘트로 사용하였다.

근관충전이 끝난 치아는 충전의 질과 깊이를 평가하기 위해, 근원심과 협설방향으로 디지털 방사선 사진을 이용하여 촬영하였다.

각 치아의 치근단부 2mm를 제외한 나머지 부위는 두겹의 nail varnish를 바르고, 2% methylene blue용액에 48시간동안 침잠시켰다. 흐르는 물에 깨끗이 세척한 후, 투명치아를 만들었다. 선상의 색소침투를 관찰하고 치관측 최대깊이를 입체현미경하에서 40배율로 평가하여 다음과 같은 결과를 얻었다.

1. 충전방법에 따른 근단부 폐쇄효과를 비교시, 실험군 모두 비교적 양호한 근단부 폐쇄효과를 보였고 통계학적으로 유의성이 없었다.
2. 충전용 시멘트에 따른 근단부 폐쇄효과를 비교시, AH26*을 사용한 군에서 Sealapex를 사용한 군보다 더 적은 색소침투를 나타냈다($p < 0.05$).
MicroSeal™을 이용한 실험 1군내에서 AH26*을 사용하였을 때 미세누출이 더 적었고($p < 0.05$), 다른 군내에서는 통계학적으로 유의성이 없었다.
3. 근단부 충전상태에 따른 미세누출 비교시, 저충전, 과충전과 색소침투간에는 상관관계가 없었다.
4. 충전방법에 따른 근단부 충전상태 평가시, Thermafil*을 이용한 실험 2군에서 과충전이 많이 나타났다($p < 0.05$).

이상의 결과로, 기존의 측방가압법 및 여러 열가소성 충전법이 유사한 근단부 폐쇄효과를 나타낸 바, 방법에 따른 술자의 숙련도, 충전시간, 재근관치료의 편이성 등을 고려하여 근관충전방법을 선택하는 것이 합리적인 것이라고 사료된다.

I. INTRODUCTION

For good endodontic obturation, a canal system that has been cleaned and shaped in all its dimensions is necessary. However, once this has been

accomplished, the complete seal of the root canal system is an essential component in assuring longterm clinical success as it is this seal that maintains the barrier between the oral environment and the periradicular tissues. The essentials of an excellent barri-

er begin with the assurance that the apical preparation has been properly sealed. This must not only be possible theoretically but also be accomplished in such a manner by the clinician¹⁹⁾. Ingle¹⁴⁾ reported that 59% of endodontic failures are due to incomplete obturation of the root canal system. Naidorf²⁵⁾ indicated that improper obturation allows fluids to enter the root canal space, that may become infected as a result.

Throughout the years, many studies on obturation techniques and filling materials of root canals have been developed for hermetic sealing of root canal system.

Lateral gutta-percha condensation is currently the most accepted canal obturation method. Advantages of this technique include its predictability, relative ease of use, conservative preparation, and controlled placement of materials. But disadvantages include a lack of homogeneity of the gutta-percha mass, increased number of voids and sealer pools, and less adaptation to canal walls and irregularities⁹⁾.

Therefore, a number of different filling techniques based on preheated gutta-percha have been introduced with the aim of enhancing three-dimensional filling of the root canal.

Johnson(1978)¹⁶⁾ demonstrated a simple method of carrying thermoplasticized gutta-percha to the extent of the prepared canal. A flexible metal or plastic carrier the same size as the final apical instrument is coated with alpha-phase gutta-percha. Recently, this method of obturation was commercialized under the name of Thermafil Endodontic Obturators(Tulsa Dental Product, U.S.A).

Schilder(1967)³¹⁾ popularized the use of warm vertical compaction of gutta-percha and sealer. Based on this techniques, Buchanan (1996)⁵⁾ developed a new method of vertical compaction of warm gutta-percha and called it, "continuous wave of condensation technique".

Recently, MicroSeal endodontic obturation technique(TYCOM, USA) is based on the combination of different types of gutta-percha : α -, β -phase gutta percha. Sealer and master cone is placed in the root canal, and then remaining space of root canal is filled with MicroSeal condenser coated with warm thermo-plasticized gutta-percha.

A study by Beatty et al.³⁾ showed Thermafil was

more effective than laterally condensed gutta-percha techniques in restricting apical dye penetration. In contrast, studies by Lares and ElDeeb²³⁾ and Chohayeb⁷⁾ reported that leakage was significantly less with the lateral condensation technique than with Thermafil. In Scott's study³³⁾, there was no significant difference between them.

Gutmann¹²⁾ showed that Thermafil and continuous wave technique were not significantly different in the overall canal obturation and in the apical third adaptation.

As appears from the above, the apical sealing ability of these obturation techniques was different in each report. Therefore many studies have been accomplishing. However, it has not been decided yet and is still controversial.

These different obturation techniques still needs to be performed in combination with root canal sealer. With the development of obturation techniques, many sealers have been developed. And the sealing ability of root canal sealer have been investigated. There have been, however, few study reported on the sealing ability of different root canal sealer used in conjunction with various obturation techniques. Also, the evaluation of relationship between the obturation quality and sealing ability has been confined to a few studies.

Therefore, the purpose of this study is to evaluate and compare the apical sealing capacity of four different obturation techniques (MicroSeal™, Thermafil®, Continuous wave technique, and Cold lateral condensation) in conjunction with root canal sealer (Sealapex, AH26®). Criteria of evaluation include linear dye leakage, presence or absence of material extrusion

II . MATERIALS AND METHODS

Eighty recently extracted human permanent anterior teeth with straight single canal and complete apex were used in this study. Adherent soft tissue on root surface were removed by periodontal curette.

Uniform access preparation were made with high speed burs. After access, the coronal and middle third of the canals were enlarged with size ISO 050, 070 or 090 Gates Glidden burs.

A #15 K-file (Dentsply-Maillefer, Ballaigues, Switzerland) was introduced into the canal and advanced until it appeared at the apical foramen. The working length of each root was established by substacting 1mm from this measurement.

The apical preparation was then completed with ProFile[®] instruments(Dentsply-Maillefer, Ballaigues, Switzerland). First, yellow 0.04 taper ProFile[®] was used at the working length, and then yellow 0.06 taper ProFile[®] was used at the same length. Red 0.04, 0.06 taper, blue 0.04, 0.06 taper and green 0.04, 0.06 taper ProFile[®] were used sequently at the working length. According to the initial apical file size of each teeth, final apical instrument was determined. Each ProFile[®] instrument was introduced into the canal at a constant speed of 300 rpm with gentle push-pull motion.

During canal cleaning and shaping, RC-PREP[™](Premier, Philadelphia, U.S.A.) was used as lubricant with each size instrument. After using each size of instrument, canals were irrigated with 5.25% NaOCl. Patency of apical foramen was determined and maintained by passing a size 15K-file through the apex.

Root canals were dried with an endodontic irrigation probe(Max-i-Probe[®], 30 gauge/dark blue, Dentsply) and sterile standardized paper points.

Eighty teeth were randomly divided into 4 groups of 20 teeth each, according to obturation techniques. 10 teeth of each group used Sealapex(KERR[®], Sybron, U.S.A) and in 10 other teeth of each group, AH 26[®] sealer(Dentsply, Konstanz, Germany) was used(Table 1).

Table 1. Group Classification

Group	Sealer	Obturation technique
Group A(n=20)	Sealapex AH26 [®]	MicroSeal [™]
Group B(n=20)	Sealapex AH26 [®]	Thermafil [®]
Group C(n=20)	Sealapex AH26 [®]	Continuous wave technique
Group D(n=20)	Sealapex AH26 [®]	Cold lateral ondensation

A. Canal Obturaion

Group A : MicroSeal[™] obturation (n=20)

First, MicroSeal[™] customized master cone was inserted into the root canal with sealer. Then MicroSeal[™] spreader was inserted 1mm short from the working length. The gutta-percha-coated MicroSeal[™] condenser was immediately carried to the void previously created in the canal by spreader and then rotation of the condenser started at a speed of 6000rpm. After approximately 2 seconds, the MicroSeal[™] condenser was removed slowly from root canal.

Group B: Thermafil[®] obturation (n=20)

Before obturation, the walls of the canal were coated with a small amount of sealer using a file. Thermafil[®] obturators of the same size as the master apical file were selected. The Thermafil[®] obturator was heated by ThermaPrep Plus oven according to manufacturer's recommendations, and the Thermafil[®] obturator was inserted in the canal to the full working length. The carrier was left in place. After obturation, an inverted cone bur was used to cut through the shank of each carrier at the level of the root canal orifice. The gutta-percha around the carrier shaft then was vertically condensed with a hand plugger.

Group C: Continuous wave technique (n=20)

A Buchanan's plugger, a Schilder's plugger, and Obtura II tip all to 3mm short from the working length were pre-fitted. A nonstandardized master gutta-percha cone was selected and cut at its apical third to the size of the master apical file of each preparation, using a gutta-percha gauge(Dentsply-Maillefer, Ballaigues, Switzerland) and a sharp scalpel.

Following placement of the master gutta-percha cone and sealer, the pre-fitted Buchanan's plugger was activated by the System B[™](Analytic Tec., U.S.A) and inserted into the root canal for obturat-

ing the apical 3mm according to the Continuous wave obturation technique. Then the Schilder's plugger was inserted steadily at the 3mm level for vertical condensation. Next, the Obtura II (Obtura Co., U.S.A) was used for backfill at 200°C.

Group D: Cold lateral condensation (n=20)

This group was the control. A standard-sized gutta-percha cone of the same size as the master apical file was coated with the sealer and seated in the root canal. A finger spreader and accessory gutta-percha cones were used for lateral condensation. Cones were added until the spreader would not penetrate beyond the coronal third of the canal.

In all groups, the access cavity were restored with Ariston pHc (Vivadent, Liechtenstein) following the obturation. The teeth were taken a digital radiograph (Biomedysis CO., Korea) in mesiodistal and buccolingual directions to study the quality of the obturation. The teeth were kept in an incubator at 37°C at 100% humidity for 48 hrs to ensure that AH26* sealer had set. The teeth were coated with two layers of nail varnish, except the apical 2mm that were left exposed. The roots were immersed in 2% methylene blue for 48hrs at 37°C. Afterward, the teeth were rinsed under running tap water to remove the dye on the external root surface. The nail varnish was gently removed with a scalpel blade. Samples were then decalcified in 5% nitric acid for 48 hr (changing the solution every 24 hr), dehydrated in ascending concentrations of alcohol (80, 90, 100%), and rendered transparent with methyl salicylate.

Table 3. Criteria for evaluating the obturation quality

OBTURATION QUALITY	CRITERIA
Underfilling	above 1.0mm
Filling up to apical constriction (FAC)	0.5mm to 1.0mm
Overfilling	under 0.5mm or extrusion of G-P beyond the apex

B. Evaluation

Linear Dye Penetration Measurement

The cleared specimens were examined independently by two observers at 40 magnification with a stereomicroscope (Olympus, Japan). A grid calibrated in millimeters was used to determine the extent of leakage. To minimize possible bias in measurements, two examiners measured the linear dye leakage for each sample and the average was recorded. Dye impregnation was measured for each tooth from all four surfaces (mesial, distal, buccal and lingual-palatal) and scored the most coronal extent of dye visible along the gutta-percha filling material according to the criteria in Table 2.

Table 2. Scoring System.

SCORE	CRITERIA
0	no leakage detected
1	up to 1.0mm
2	1.0mm to 2.0mm
3	2.0mm to 3.0mm
4	above 3.0mm

Presence or absence of material extrusion

Any extrusion of gutta-percha or sealer during obturation was noted.

On digital image of all teeth bucco-lingually and mesio-distally, length between end of gutta-percha obturated and radiographic apex was measured. After this measurement, underfilling, filling up to apical constriction (FAC), and overfilling were evaluated according to the criteria in Table 3.

III. RESULTS

A total of 72 teeth were tested. eight teeth were eliminated during evaluation because, vertical root fracture or apical perforation were noticed and determined to have occurred before exposure to the ink; 72 teeth remained.

The linear dye penetration measurements for each group are listed in Table 4. The mean leakage scores were as follows; 1.11 ± 1.52 in Microseal™, 2.10 ± 1.82 in Thermafil®, 1.21 ± 1.40 in Continuous wave technique, and 1.67 ± 1.65 in Cold lateral condensation group.

Statistical analysis was carried out using the Kruskal-Wallis test for nonparametric data to determine whether there were significant difference among the groups. There were no significant difference in linear dye penetration among four obturation techniques.

But Microseal™ produced the smallest amount of mean linear dye penetratin score followed order from smallest to largest by Continuous wave technique, Cold lateral condensation, and Thermafil®.

Table 4. The linear dye penetration measurements for each groups.

Group	leakage score					Mean±SD	N
	0	1	2	3	4		
A(n=18)	7	7	1	0	3	1.11 ± 1.52	}
B(n=18)	6	3	1	0	8	2.10 ± 1.82	
C(n=18)	10	2	3	0	3	1.21 ± 1.40	
D(n=18)	6	4	3	0	5	1.67 ± 1.65	

A: MicroSeal™, B: Thermafil®, C: Continuous wave

D: Cold lateral condensation

N: No significant difference by Kruskal-Wallis test.

From the statistical analysis using Kruskal-Wallis test, it revealed significant difference in the degree of dye penetration between the two sealers. The mean leakage score of all samples using AH26® (0.92 ± 1.42) was lower than Sealapex (2.14 ± 1.60) ($p < 0.05$).

The mean leakage scores for each sealer in four group, were shown in Fig. 1. In MicroSeal™ group, samples using AH26* were less leakage than Sealapex. This revealed statistically significant differ-

ence by Wilcoxon signed rank test ($p < 0.05$).

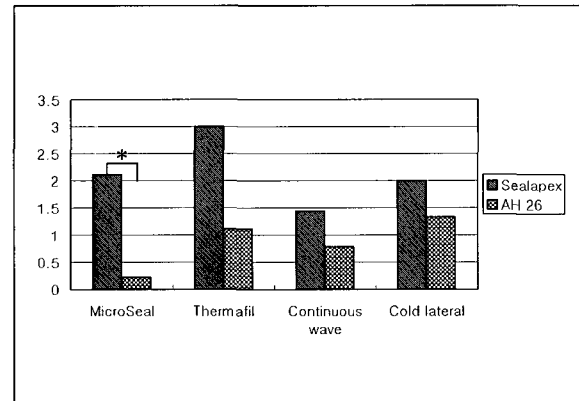


Fig. 1. The mean leakage scores for each sealer in four group.

* Statistically significant ($p < 0.05$) by Wilcoxon signed rank test.

The relationship between obturation quality (underfilling, FAC, overfilling) and mean linear dye penetration analyzed statistically using Kruskal-Wallis test. There was no correlation between the obturation quality and microleakage.

Fig. 2 showed frequency of underfilling, FAC, and overfilling for each obturation technique. The Thermafil® group showed the higher frequency of overfilling compared with the other obturation by Chi-square test ($p < 0.05$).

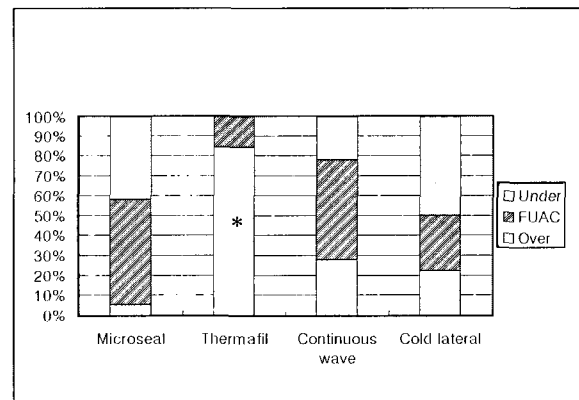


Fig. 2. Frequency of underfilling, FAC, overfilling for each group.

* Statistically significant ($p < 0.05$) by Chi-square test.

IV. DISCUSSION

Various methods have been used for evaluating the apical sealing property of root canal filling materials and associated obturation techniques. Examples of such methods are dye penetration tests³⁴, radioactive isotope studies⁴, electrochemical leakage tests²⁷, bacterial penetration tests⁶, and scanning electron microscopic analysis³⁷. Among these methods, dye penetration studies are the most common, although published findings reveal large standard deviations⁹.

Dye penetration studies are vertical, cross sectioning and clearing of the roots. Among these methods, clearing method is much time to consume, difficult to know the decalcification degree, and uncleared area can be appeared by incomplete dehydration. But, the examiner is able to evaluate dye penetration level and adaptation of the filling material in a three-dimensional manner^{20,26} unlike the other methods¹¹. In this study, the leakage patterns around the tooth were observed by rotating the tooth²¹.

On measurement of the apical leakage using dye penetration tests, the maintenance of patency is important. Adams et al.¹³ reported that dentinal plug can influence the apical leakage. Therefore, not dentinal plug but filling material must seal apical stop². In this study, dye penetration was only assessed when extending coronally beyond the end of gutta-percha obturated and not at the apical end⁶.

Matloff et al.²¹ showed that methylene blue penetrates in greater depth than other tracing dyes. Whereas, Edmund et al.¹⁰ reported other inks that might provide better contrast showed that they dissolved during the decalcification and clearing processes. Also, he reported that there was no evidence of this problem with india ink. In this study, methylene blue was used as dye. The dissolution of methylene blue during the decalcification and clearing processes might happen and affect the dye penetration level.

Pitt Ford(1983)³⁰ reported that the sealing effect in vitro have not relation to tissue reaction in vivo. In order to evaluate the sealing ability, several in vitro methods have been designed. Among these methods, the results of dye penetration studies, however, are sometimes confusing and often result in variable con-

clusion. The lack of agreement has been discussed by Wu & Wesslink³⁹ who questioned the validity of leakage studies and recommended that more research should be devoted to leakage methodology.

It is known that most root canal sealers shrink during setting²¹, and dissolve with time²⁸. The seal can be destroyed by dissolution of sealer components. In this study, we used Sealapex and AH26 as root canal sealer in conjunction with four obturation techniques. AH26 was originally developed as a sole obturating material or for single-cone techniques³². It is, however, commonly used for more complex obturation techniques such as lateral and vertical condensation. We found the excellent adherence of the sealer to the canal walls and gutta-percha in AH26 group. This finding is agreement with Limkangwalmongkol²³, Schroeder³². Tagger and coworkers³⁶ reported no leakage of the dye when α -acting gutta-percha or lateral condensation with AH26⁴⁸ sealer were used. Sealapex may possess significant solubility, which accounts for its biological activity at the root apex³⁵. AH26⁸ expand initially, Which might result in the reduction of microleakage¹⁷. One main disadvantage observed with blue dye penetration studies was the dark color that resulted from the oxidized silver content. This may sometimes mistakenly be interpreted as leakage⁹.

The Thermafil obturation technique showed a predisposition for material extrusion beyond the apical foramen in 84.2% of the specimens(Fig 2), and It showed the higher frequency of overfilling compared with the other obturation techniques($p < 0.05$). This finding is in agreement with other studies(Haddix et al.¹⁵, Gutmann et al.¹², Pathomvanich & Edmunds²⁸). This can increase postoperative pain.

There are many studies about the apical sealing ability according to the obturation techniques. LaCombe et al.²¹ found that laterally condensed gutta-percha showed less linear leakage than low-temperature and high-temperature thermoplasticized gutta-percha. But, Hata et al.¹³ and Goldberg et al.¹¹ founded that thermoplasticized filling techniques and cold lateral condensation were not significant difference.

This study suggests that all four obturation techniques evaluated here may be equally effective in

obturation of well-instrumented root canals under ideal conditions, and sealed well with no statistically significant differences between them. This result were agreement with study showed above.

In this study, we used single root with straight canal. Lares and ElDeeb²²⁾ speculated that there was the difference between single rooted and multi-rooted teeth. Therefore, further work is also needed to determine the apical sealing ability between single-rooted and multi-rooted teeth, curved root and straight root.

V. CONCLUSION

This study evaluated the apical sealing ability of four obturation techniques. In this study, eighty teeth were instrumented using ProFile[®] and randomly divided into 4 groups of 20 teeth each, according to obturation techniques

The canals were obturated by four obturation techniques: Group A- Microseal[™]. Group B- Thermafil[®]. Group C- Continuous wave technique, Group D- Cold lateral condensation. 10 teeth of each group used Sealapex and in 10 other teeth of each group, AH26[®] sealer, was used.

After obturation, the teeth were taken a digital radiograph in mesiodistal and buccolingual directions to study the quality of the obturation (underfilling, filling up to apical constriction, or overfilling). Afterward, the teeth were coated with two layers of nail varnish, and immersed in 2% methylene blue and subsequently cleared. The most coronal extent of dye penetration was measured using stereomicroscope (X40).

Results obtained from the study above were as follows:

1. There was no statistically significant difference among groups. All four obturation techniques showed the similar results in the apical sealing ability.
2. The mean leakage score of all samples using AH26[®] were lower than Sealapex(p<0.05). In Micro Seal[™] group, samples using AH 26[®] were less leakage than Sealapex(p<0.05).
3. There was no corelation between the quality of

obturation and microleakage.

4. The Thermafil[®] group showed the higher frequency of overfilling compared with the other obturation(p<0.05).

As a result, there are no significant difference for apical sealing ability among four obturation techniques. Therefore, the other advantages must be considered such as operator's experience, obturation time, the ease of retreatment etc. It is reasonable to choose the obturation method with careful consideration about these points.

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사진부도 ①

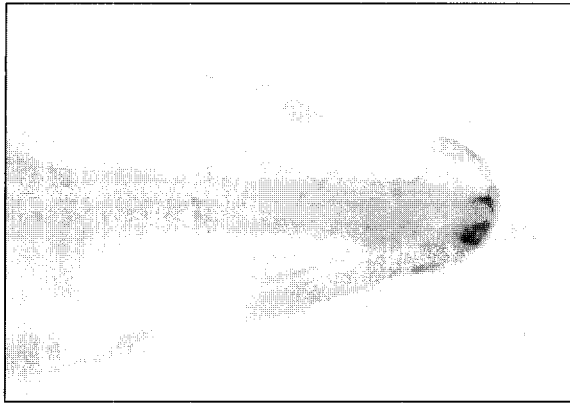


Fig. 3. The representative image showing score 0



Fig. 4. The representative image showing score 1

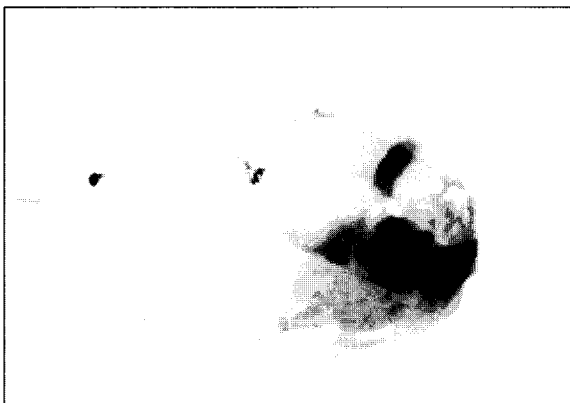


Fig. 5. The representative image showing score 2

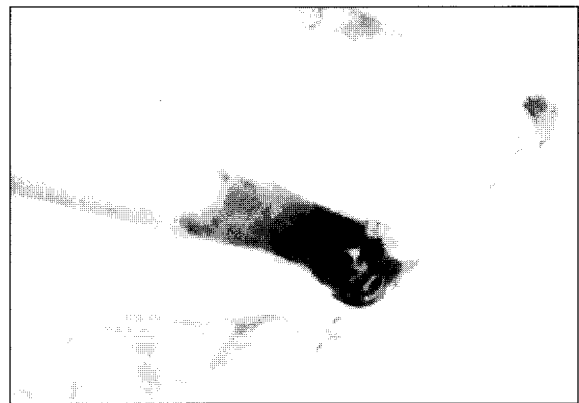


Fig. 6. The representative image showing score 3



Fig. 7. The representative image showing score 4